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A comprehensive BIM platform development based on sustainable construction concept

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Abstract. In recent times, sustainable development has been recognized as a pressing need for the construction industry. It involves balancing economic, environmental, and social factors to promote healthy and stable growth while regulating industry behavior. Building Information Modelling (BIM) has emerged as a revolutionary tool for the industry, primarily focusing on economic and environmental aspects of sustainability. However, the social aspect of sustainability, encompassing the well-being and safety of construction personnel, has not received enough attention. Strengthening attention and reform of social factors in the industry is crucial for promoting the sound development of the construction industry. This study proposes a comprehensive BIM platform based on sustainable construction that takes into account environmental, economic, and social factors. By integrating social factors into BIM, we can promote a culture of safety, improve working conditions, and enhance the quality of life for construction personnel. This will not only benefit workers but also lead to better project outcomes, increased efficiency, and long-term sustainability for the construction industry as a whole.

Keywords: construction, sustainability, BIM, social aspect.

1. Introduction

In recent years, the construction industry in various countries has steadily developed and played an indispensable role in influencing or driving the development of other industries. Through studying and reviewing the current applications, developments, and limitations of BIM in the construction industry in different countries, it is found that the current application of BIM in construction mainly focuses on utilizing BIM to construct three-dimensional models to simulate the construction process, aiming to shorten the construction period and reduce losses. However, there is a lack of a comprehensive information platform that integrates information exchange, modeling, construction processes, and logistics management. Furthermore, there is a lack of consideration by scholars in relevant fields regarding the impact of improving the well-being of all construction personnel on work efficiency and cost control, as well as its relationship with construction process management and BIM. Therefore, this paper proposes integrating environmental, economic and social consideration into a BIM based construction platform development to improve the overall quality of project.

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2. Literature review

Building Information Modeling (BIM) has characteristics such as visualization, parameterization, and high collaborative efficiency, which can optimize the entire lifecycle of a project [1]. BIM represents the physical and functional characteristics of facilities. It is a shared knowledge resource and a process that provides reliable information for all decisions throughout the facility's lifecycle, from concept to demolition. In different stages of a project, different stakeholders collaborate by inserting, extracting, updating, and modifying information in BIM to support and reflect their respective responsibilities [2]. Indeed, experimenting, adjusting, and improving BIM technology can effectively ensure engineering safety and quality, shorten construction periods, and save costs.

In recent years, an increasing number of scholars have discussed the application of BIM technology in project construction process management. For example, Chen Xingxiang used a key large-scale shopping mall in a certain city as an example in 2022 [3]. The project focused on dynamic low-cost simulation of important construction processes and construction practices, including MEP construction detailed design, steel structure construction detailed design, 3D quantity calculation, and clash analysis. It guided project personnel to conduct on-site construction proficiently and safely, reducing potential economic losses due to rework. Based on an information exchange management platform, combined with the Internet of Things (IoT), cloud computing, and other means, responsible personnel could timely upload relevant issues regarding project quality, progress, and personnel safety in the platform to achieve timely rectification. The rectification results would be fed back to the platform promptly.

Yang Linxiao, in 2023, used the Ezhou Huahu Airport project as an example [4]. They utilized forward design for the preparation of the detailed quantities and cost management of sub-items, while retaining the data information of the entire engineering process. BIM components were used as the data carrier for intermediate measurement and progress payment, and cost change management was automatically achieved through BIM model version comparison.

Zhao Quanbin et al., in 2023, used the National (Shandong) and Shandong Free Trade Zone (Jinan) Drug and Medical Device Innovation and Regulatory Service Platform project as an example [5]. At the technical level, they reduced communication barriers among stakeholders by using three-dimensional visualization design results. Moreover, the complete information would become the basis for subsequent operation and maintenance, achieving the information management of the project's entire lifecycle. The concept of collaboration was applied to improve the fault tolerance of prefabricated buildings, effectively reducing construction risks. They utilized secondary development technology to assist in the disassembly of prefabricated components and reasonably divide cast-in-place sections to reduce construction costs. A management level approach was employed with the information platform as the core to achieve integrated interactive collaborative management and form a collaborative working structure among all participating units. The owner could inspect work results and identify issues at any time, establishing cooperative norms and a structured coordination process.

In a case study by Yu-Cheng Lin in 2022, a twelve-story commercial building at the mid-term of its construction phase was examined [6]. The project developed a construction visualized knowledge management platform utilizing BIM and web technology. This platform integrated the organization, creation, sharing, and flow of project knowledge, enabling timely improvements in the construction process and reducing time and cost for problem-solving. All models were created and developed by the general contractor, with key benefits including reduced rework, cost estimation, improved productivity, and enhanced scheduling efficiency. Engineers were required to submit project-related knowledge, experiences, and discussions through the system. All valid information was centrally stored in a database to prevent redundant data collection. After saving and updating content, the system automatically sent the latest project progress information to users. Construction personnel accessed knowledge from the platform, summarized experiences, and learned from domain knowledge. The solutions to project problems were also made available for use in other construction projects.

Combining the above cases, it is evident that the current applications of BIM still focus on individual functions. There is a lack of a comprehensive information platform that integrates information exchange, modeling, construction processes, and logistics management. Furthermore, there is a lack of

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consideration by scholars in relevant fields regarding the multi-dimensional aspects of sustainable development in the engineering industry, including economic sustainability, environmental sustainability, and particularly the stability of social factors. Additionally, current research on BIM technology primarily concentrates on project economics and the environment, with limited attention given to all construction personnel during the construction phase. The consideration of "people" mainly revolves around safety and work efficiency, lacking the consideration of human aspects for all construction personnel. Therefore, there is a need for further examination of the impact of improving the well-being of all construction personnel on work efficiency, cost control, and its relationship with construction process management and BIM. Consequently, this paper proposes a construction sustainable BIM platform that aims to enhance the well-being of all construction personnel, considering aspects such as the environment, economy, and society.

3. Social considerations in the construction period

Li Zhi suggested in 2019 that companies should first strengthen technical skills training, establish skill exchange platforms, foster a spirit of teamwork, and then establish a caring mechanism to create a corporate culture that encourages knowledge sharing and a relaxed and harmonious work environment [7]. Efforts should be made to build platforms for workplace friendships for younger employees and leverage the motivating role of workplace friendships.

Yu Qian, from the perspective of public management in 2019, summarized that the inherent value of construction work itself is not high, opportunities for advancement are limited, young employees struggle to gain recognition from senior leaders in their work and lack approval from their families [8]. The increase in external job opportunities affects the job stability of the "post-90s" generation. It is suggested to strictly control the open and transparent recruitment process, innovate corporate management concepts and models. Additionally, it is important to establish job descriptions and specifications that clearly define daily work rules and activities, optimize the internal promotion system and performance evaluation methods. It is also crucial to regularly update employees on project progress and company development to enhance construction personnel's dependence on the company.

Cao Jia, from a business management perspective in 2019-2020, highlighted several issues [9]. First, there are cases of wage arrears, and migrant workers are concerned about the fairness of wages. The management system for migrant workers is imperfect, and some labor subcontracting companies have low management levels. Poor working and living conditions, as well as a lack of emphasis on professional skills training for migrant workers, lead to dissatisfaction among migrant workers. The proposed solutions include reforming the wage and welfare system for migrant workers, avoiding wage arrears, implementing flexible work arrangements, providing housing for families, establishing effective communication mechanisms for migrant workers, and enriching cultural and sports activities for migrant workers.

Marc A. Campbell and others in 2020 pointed out that companies currently lack a priority focus on the physical, psychological, and social hazards and risks to employees, as well as efforts to change workers' mindset [10]. Issues such as bullying and harassment exist, and employers have inadequate awareness and understanding of health and well-being impairments. Frequent substance abuse issues are also prevalent in the industry. Proposed improvement measures include providing high-quality working and living environments, interactive and inclusive common areas, appropriate workloads, increased emphasis on physical health issues, conducting surveys on the physical and mental health of construction workers and taking appropriate action, organizing team-building activities based on company culture to encourage active sharing of problems and ideas among construction workers, providing practical advice and knowledge to workers, establishing worker assistance programs, and zero tolerance for bullying and harassment. Detailed and standardized contracts should be implemented to protect workers' rights.

Rasaki Kolawole Fagbenro and others in 2023 identified factors that affect the mental health of construction workers, such as concerns about job stability and work safety, conflicts arising from communication, and challenges to personal well-being from various sources [11]. To address the issue

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of poor mental health among construction workers, efforts should focus on promoting awareness of mental health literacy and creating awareness of utilizing leisure time for construction workers, with the aim of improving the physical and psychological work environment. On the other hand, prefabricated construction, with its advantages over traditional construction, has been found to eliminate or at least reduce the impact of stressors associated with the industry, thereby promoting good mental health. Creating a positive physical and psychological work environment, reducing physical pain and fatigue, and promoting a healthy work-life balance for construction workers are crucial.

Therefore, in the development of BIM, it is important to consider social factors such as employee management, work responsibility allocation, personnel training, happiness, and job satisfaction.

4. Platform

Regarding sustainable development, the Brundtland Report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[12]This definition is currently the most influential and widely circulated. Ye Wenhu believes that sustainable development is "development that continuously improves the quality of life per capita and the carrying capacity of the environment, meets the needs of the present generation without compromising the ability of future generations to meet their needs, and satisfies the needs of a region or a country without impairing the ability of other regions and countries to meet their basic needs." [13].

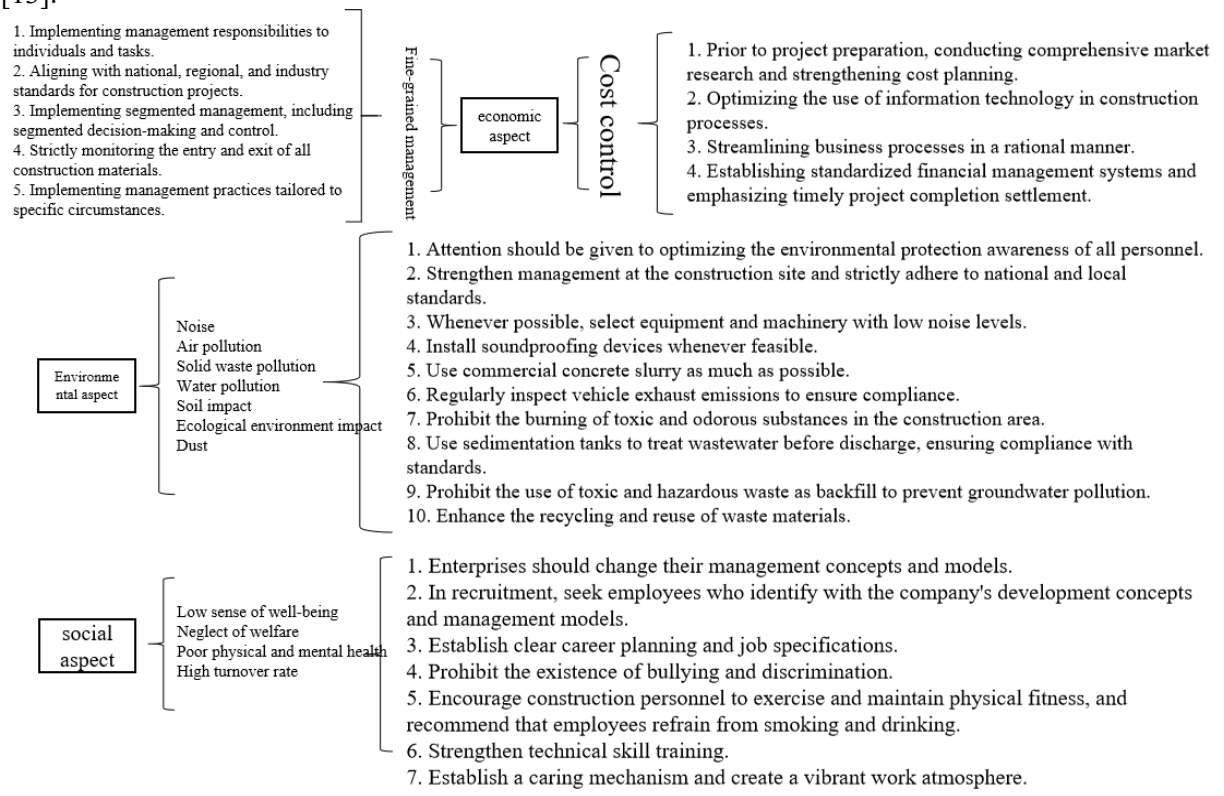

Figure 1. Main problems in various aspects and corresponding solutions.

In exploring the relationship between social impact and BIM, countries have made significant progress in integrating BIM with the economy and the environment, but the integration of BIM with society still needs to be explored. Research on the social impact of construction progress, quality, and other aspects primarily comes from sociologists, psychologists, and business management scholars. Currently, there are no scholars from civil engineering or construction management disciplines who have combined social impact factors with the BIM platform to reduce turnover rates, enhance construction workers' happiness, strengthen industry and social stability, and have a positive impact on project quality,

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cost, and progress. As shown in Figure 1, this paper proposes a sustainable BIM construction platform that balances economic, environmental, and social considerations.

4.1. Economic aspect

From an economic perspective, refined management and cost control are the focal points in the current construction industry. Before project preparation, thorough market research should be conducted, and cost planning should be strengthened, along with the selection of reasonable cost control methods. Furthermore, it is important to optimize the information construction process, enhance on-site construction management, and establish sound management mechanisms. Streamlining business processes, standardizing financial management systems, and attaching importance to completion and settlement are crucial. By combining national, regional, and corporate industry standards, existing construction management processes should be adjusted in real-time to enhance construction management levels. Segment management models for decision-making and control are also necessary measures. Responsibilities and tasks should be assigned to individuals to ensure the efficient and high-quality implementation of construction management plans. Continuous refined management should be applied to all aspects of construction projects, with strict monitoring of the entry and exit of all construction materials, implementing tailored management practices according to the specific conditions of each project.

Specifically, Bluetooth wearable devices can be used to track the positioning and vital signs of construction workers in complex construction environments. Monitoring devices with BIM models can be used to predict potential risks around construction workers and provide timely reminders. By integrating IoT devices with the BIM platform, 24-hour monitoring and optimal scheduling of construction materials, processes, and workflows can be achieved. This aims to improve project risk assessment mechanisms, enhance internal information transmission within enterprises, strengthen preventive measures, standardize material inventory and issuance control, improve reserve fund systems, and ensure timely completion and settlement. The goal is to comprehensively improve the project cost control level of construction enterprises.

4.2. Environmental aspect

Construction activities can have various environmental impacts, including noise pollution, air pollution, solid waste, water pollution, soil pollution, and dust. Therefore, during construction, attention should be given to optimizing the environmental awareness of all personnel and strengthening on-site management in strict compliance with national and local standards. It is advisable to use equipment and machinery with low noise levels whenever possible, and for equipment that generates high noise levels, measures should be taken to install soundproofing devices. Additionally, the use of ready-mixed concrete slurry can help reduce dust generated during the transportation, handling, and storage of building materials such as cement, sand, and gravel, while also mitigating the noise impact from cement mixers. Regular inspections of vehicle exhaust emissions should be conducted to ensure compliance. Burning of toxic and odorous substances should be strictly prohibited in the construction area. Wastewater should be treated in sedimentation tanks until it meets the required standards before being discharged. Lastly, the use of toxic and hazardous waste as backfill should be prohibited to prevent groundwater pollution. Emphasizing the recycling and reuse of waste materials is crucial and should align with the current situation. Making environmental protection the most important consideration during construction promotes the sustainable development of the industry.

A specific application of using the BIM platform for dust prevention involves connecting dust monitoring sensors with the BIM platform. The BIM platform can display real-time dust levels at the construction site and assess their potential impact on the health of nearby residents. It can also provide dust prevention and mitigation measures based on relevant construction cases. Air purifiers can be connected to the BIM platform to automatically activate when dust or air pollution levels are high and deactivate when the situation improves. By integrating surveillance cameras with the BIM platform, optimal locations for solid waste disposal can be planned, and construction workers can be promptly

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alerted when waste piles are full, indicating the need for disposal. The BIM platform can also identify open flames and issue immediate alerts.

4.3. Social aspect

In general, some companies have a higher average employee age and a lower acceptance of new things, resulting in insufficient understanding and awareness of the physical and mental well-being and happiness of construction workers. Additionally, some companies lack comprehensive career development plans for new employees. Some companies not only delay employee wages but also have construction sites located in remote areas with poor working and living conditions. Moreover, some companies have inadequate management systems for migrant workers, which can lead to communication conflicts between migrant workers and supervisory personnel.

To address these issues, companies should change their management philosophy and approach, actively seek employees who identify with the company's development principles and management models during recruitment, and develop clear career plans and job specifications. Bullying and discrimination should not be tolerated, and construction workers should be encouraged to maintain physical fitness through exercise, while avoiding smoking and alcohol consumption. It is crucial to prioritize technical and skills training, establish care mechanisms, and create a dynamic work environment.

Specifically, all construction process management, construction technology, contract, financial management, material management, project cost, construction drawing creation, construction model construction, and other related knowledge materials should be integrated and made available free of charge to all construction workers through the BIM platform. Additionally, all personnel should be able to raise obstacles and difficulties they encounter in their work on the BIM platform, and engineers with relevant professional experience should be able to provide solutions and answers.

5. Conclusion

This paper proposes the establishment of a comprehensive BIM platform based on the concept of sustainable construction. Through literature review, it was found that the current application of BIM in the construction phase mainly focuses on the economic and environmental aspects, but lacks consideration for construction workers. This does not meet the requirements of sustainable construction, which emphasizes the balance between the economic, environmental, and social aspects. The application of BIM should not only be a tool for creating building information models and planning construction processes but should also integrate the economic, environmental, and social dimensions of sustainable development. Therefore, by combining the Internet of Things (IoT), engineering management, and computer science, BIM should be further explored and developed from the perspective of the construction industry. This exploration holds profound significance in improving construction process management, safeguarding the legitimate interests of all construction workers, and enhancing industry competitiveness.

However, at present, the construction industry lacks sufficient discussion and research on the social aspects of the building process. Therefore, the social elements mentioned by the BIM platform in this article are not comprehensive. While our team recognizes the importance of social considerations in the construction phase, we acknowledge that this is not a problem that can be solved within a short period. Rather, it requires the collaborative efforts of the entire industry to conduct further exploration. It is important to note that there are still many areas in need of exploration and refinement.

References

[1] Zhao, Q., Li, J., Geng, Z., et al. (2019). Construction technology and BIM application of the irregular GRCC curtain wall of Xiaogan Cultural Center. Journal of Shandong Jianzhu University, 34(20), 78-83.

[2] National Institute of Building Sciences. United States National Building Information Modeling Standard, Version 1 - Part 1.

[3] Chen, X. (2022). Application research of BIM technology in construction management of super high-rise buildings. Engineering Machinery and Maintenance, 2022(05), 96-98.
[4] Yang, L. (2023). Construction cost management practice based on BIM forward design: A case study of Ezhou Huahu Airport project. Project Management Techniques, 21(04), 14-19.
[5] Zhao, Q., Hao, R., Liu, J. (2023). Application research of BIM technology in medical building projects: A case study of the National (Shandong) and Shandong Free Trade Experimental Zone (Jinan) Drug and Medical Device Innovation and Regulatory Service Platform Project. Project Management Techniques, 21(04), 7-13.
[6] Lin, Y.-C. (2014). Construction 3D BIM-based knowledge management system: A case study. Journal of Civil Engineering and Management, 20, 186-200. https://doi.org/10.3846/13923730.2013.801887
[7] Li, Z. (2019). The influence mechanism of workplace friendship of new generation employees on turnover intention: An analysis based on the highway construction industry. Journal of Jiaozuo University, 33(03), 125-129. DOI: 10.16214/j.cnki.cn41-1276/g4.2019.03.032
[8] Yu, Q. (2019). Factors influencing the turnover of “post-90s” employees in state-owned construction enterprises. D. Chang’an University.
[9] Cao, J. (2020). Analysis and countermeasures of high turnover rate of migrant workers in Tongzhou Jianzong Group Jinsha Branch under the labor subcontracting mode. D. Lanzhou University. DOI: 10.27204/d.cnki.glzhu.2020.001202
[10] Campbell, M., & Gunning, J. (2020). Strategies used to improve mental health and well-being within the UK construction industry. Proceedings of the Institution of Civil Engineers - Management, Procurement and Law, 173, 1-11. https://doi.org/10.1680/jmapl.19.00020
[11] Fagbenro, R. K., Sunindijo, R. Y., Illankoon, C., & Frimpong, S. (2023). Influence of prefabricated construction on the mental health of workers: A systematic review. European Journal of Investigation in Health, Psychology and Education, 13, 345-363. https://doi.org/10.3390/ejihpe13020026
[12] Brundtland, G. H. (1987). Report of the World Commission on Environment and Development: Our Common Future. Oxford University Press.
[13] Ye, W. (1995). Creating a sustainable new civilization: Theoretical considerations. Beijing, China: Peking University Press.