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Analysis of the Application of BIM Technology in Municipal Engineering Construction

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Abstract. With the rapid urbanization process in our country, the scale of urban and municipal infrastructure projects becomes larger and larger, and the project structure is more complex. Traditional management models cannot meet the requirements of the new generation of municipal engineering and require new ideas from technological innovation. Building Information Modeling (BIM) is introduced as a potential digital tool to improve project management by generating three dimensional models with a lot of data. This paper examines the application of technology to municipal engineering construction with an emphasis on the process and effect in three areas, including roads, bridges, and water conservation. Moreover, it explores the future application prospect of BIM in the municipal engineering field, providing valuable information for the industry's transformation.

Keywords: BIM Technology, Municipal Engineering, Construction Application

1. Introduction

Municipal construction is the basis of urban construction and provides many sectors such as road, bridge, water supply, draining, utility tunnel, wastewater treatment plant. The construction quality of this field has a great impact on the operation of the city and the quality of life of the residents. In the past, urbanization has not only expanded but also accelerated the growth of the city, and the scale, complexity, and construction difficulty of municipal engineering projects have increased. Traditional construction management methods are mainly based on the use of 2D drawings and manually operated professional technology, which results in problems such as the low efficiency of information exchange, weak interdisciplinary coordination, low construction predictability, and high risk to safety. Such challenges hinder project progress and quality, and lead to the inefficient investment in human resources and cost overruns.

Since BIM has experienced the digital revolution, the impact on municipal engineering construction management is significant. BIM is more than a 3D-modelling tool, it is an overarching management methodology that encompasses full lifecycle of engineering projects. Through creating digital building models containing geometry, physical properties and function requirements, the BIM facilitated the integration and sharing of information among projects. Especially on construction period, the effectiveness of BIM applications leads to revolutionizing the existing “passive” management to active and quantitative management, and as a result it contributes to improve the quality and efficacy of project management [1].

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Extensive research and practice at home and abroad have fully demonstrated the wide application prospects of Building Information Modeling (BIM) technology in municipal engineering. Although it holds great promise, a lack of of coherent standards, skills and cost is still impeding its development. Accordingly, the features of the application of BIM technology and approach and policies of promoting software engineering of built environment should be critically analyzed in municipal engineering, in order to drive technological innovation and industrial transformation. Based on the recent studies and the international practice, this paper provides and all-round consideration for the importance of BIM technology in the process of the municipal engineering construction. The aim is to offer theory support as well as technical data reference to the practitioners.

Based on theoretical research and practical experience in our country and abroad, this paper carries out a systematic review of the application of BIM technology in municipal engineering construction. It explores the applied scope of the BIM technology, discusses various implementation ways and strategies, and attempts to provide recommendations for promoting the BIM technology in the construction of oil depots.

2. Overview of BIM technology and its construction applications in various municipal fields

BIM – Building Information Modeling: It is the digital technology used in design, construction and management of building construction process. It links building information via digital model so that everyone can share data throughout the project life cycle. This encourages greater comprehension and more appropriate reactions by the engineering professionals, but also co-operation between design/construction teams and between these and their stakeholders. BIM is a 'game changer', radically improving productivity and reducing the cost of designing and building any project. Its strength lies in the creation of a multi-dimensional data model (3D spatial, 4D temporal, 5D cost, etc.) that, robustly, digitally encapsulates shape and contents.

Civil engineering uses are becoming even more and more over such that BIM technology may be easily adjusted to metropolitan engineering. In-city projects are often one-dimensional, but extend over large spatial scales. Moreover they usually concern a number of different subsystems, making the coordination effort higher. What's more, construction activity frequently occurs in urbanized city sites with growing demands for construction logistics and safety. The need for customized workable solutions and methods to adopt BIM in municipal engineering with its unique characteristics may then be indicated.

2.1. Application of BIM technology in municipal road construction

It is multi-discipline to engineer municipal roads, including route planning, subgrade, pavement, traffic facilities and underground pipeline, etc. The traditional two-dimensional design plan can not exactly reflect the network structure of the domains, and it lacks of logical connections, so often resulting in design loopholes and construction discrepancies. The advantage of using BIM technology is the ability to build 3D images of the future building to help architects to think carefully about the optimal design solutions and verify it and make corrections in time.

In practice, professionals use Building Information Modeling (BIM) for optimization of road alignment, profile design and cross sections. Designers can virtually try different options without real construction by generating digital terrain and road models to determine the most optimal design. Also, BIM models continuous to be used for detailed rendering and animation that help in aiding the understanding of design concept by project team and improving the communication efficiency [2].

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Collision detection with Building Information Modeling (BIM) is one such major pre-construction application. Traditional approaches generally do not detect any conflicts between underground pipes until excavation and may require redesign, rework, and additional time and cost. By including BIM models of roads, bridges, and pipelines, and by adopting a mind-set of clash investigation, physical and spatial conflicts ("hard clashes" &"soft clashes") can be detected upfront by computerized analysis and simulation [3]. This approach substantially reduces uncertainties and construction risks [4].

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Utilizing Building Information Modeling (BIM) technology in construction site layout facilitates a more systematic organization of temporary facilities, material storage zones, and mechanical equipment throughout the construction process. This method not only guarantees a structured site layout but also improves construction safety.

With use of Building Information Modeling (BIM)technology, we can make a real 3D data of entire construction site and also confirm by having everything visualized when we start construction. From this model we can determine the best places to put things like work sheds, warehouses and tower cranes, and best means to transport materials around the site.

Different work types rarely interfere with each other according to pre-support, road can be kept non-stop, more times are no longer needed in materials transferring, such as the dangerous goods storage, fire exit and so on, it can also be more arranged in comparative safer personnel. Besides, we can detect or whether the conflicts will occur and the particular potential safety problems in various stages according to the time of construction and guarantee the safety of the construction more effectively and show the higher efficiency of construction [5].

2.2. Application of BIM technology in municipal bridge construction

The construction of bridges involves intricate configurations that necessitate advanced construction methods, precise control, and considerable safety precautions. Building Information Modeling (BIM) technology offers substantial technical assistance for the construction of such intricate bridge structures.

In many applications, BIM technology is developed for more complicated structures, for example, continuous beam bridge. With high-accuracy model to build, visualize the construction images can be simulated. Crucial construction methods including cantilever casting with hanging basket and cast-in-place scaffolding can be explained step by step in the models, offering reference and support for the on-site construction and technical clarification, which greatly avoids potential errors that result from misunderstandings. Furthermore, the models can also be associated with measuring data, e.g. stress and deformation, to be used for the real-time control in the construction phase in order to guarantee the safety of the structure during the whole construction process [6,7].

The development of bridge industrialization has promoted the widespread application of prefabricated assembly technology in bridge engineering. For the precast assembly construction, the Building Information Modeling (BIM) system can provide strong technical support, in which the

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detailed modelling could accurately describe the prefabricated components, and the dimension or parameter calculation methods for each component can be more accurate.

The application of the Building Information Modeling system (BIM) enables optimal management of prefabricated parts, both during design and construction. Each prefabricated component is given a unique ID, with monitoring via QR codes or RFID. Employees simply scan the identifiers using their smart phones to pull up such information as placement instructions, assembly sequences and quality checks to ensure precise execution of the installation procedures.

2.3. Application of BIM technology in the construction practice of municipal water conservancy and related projects

2.3.1. Urban utility tunnel

The confined space of underground utility tunnels presents challenges in coordinating the construction of diverse pipelines such as power, communication, water supply, reclaimed water, gas, and thermal pipelines. Building Information Modeling (BIM) technology plays a crucial role as the central management tool for tunnel construction.

Utilization of laser scanning point clouds; LSPC of existing underground structures o utility tunnels in construction optimization results in BIM models compliant with the principles of topology and data completeness. This model provides a benefit not only during the construction phase but also as a resource for post construction operational and maintenance efforts [8].

Volumetric construction management requires integration of BIM models, detailed design, construction sequencing and simulation, along with clash detection for complex elements such as utility tunnel junctions, hoisting openings and vents. In the utility tunnel construction, the BIM technology cures the cross-operation problem effectively to improve installation sequences. In addition, this can be applied to post-construction operation and maintenance simulations, thus providing the ability to develop rooted operational and maintenance strategies [9,10].

2.3.2. Municipal wastewater treatment plant

Sewage treatment plants are characterized by intricate structures comprising multiple tanks, process pipelines, and equipment, necessitating stringent measures for corrosion and seepage control. The utilization of Building Information Modeling (BIM) technology has proven highly effective in enhancing the construction of these facilities.

The integration of civil structures, process equipment, pipelines, electrical instruments, and other disciplines through Building Information Modeling (BIM) facilitates thorough collision detection to optimize equipment installation space and pipeline routing, thereby preventing clashes. This is especially vital for plants with densely packed pipelines [11].

Enhancing Design and Prefabricated Construction: The utilization of Building Information Modeling (BIM) models for the detailed design of plumbing and drainage pipelines allows for accurate placement of pipe supports, hangers, and sleeve reservations. This enables the generation of fabrication drawings that streamline factory prefabrication and on-site assembly of pipeline modules. By minimizing on-site welding and cutting tasks, this methodology improves construction efficiency and quality. The application of BIM extends across all stages of the construction process, encompassing preparation, process control, and project handover [11,12].

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3. Application of BIM technology in whole-process construction consultation and collaborative management

The utility of Building Information Modeling (BIM) extends beyond technical applications to revolutionize project management paradigms. In the construction phase, professionals leveraging BIM models as central repositories of information can streamline cost management (5D), schedule management (4D), and uphold quality standards.

Utilizing a cloud-based Building Information Modeling (BIM) collaborative management platform eradicates information silos among stakeholders, including owners, designers, contractors, supervisors, and consultants. By operating on a unified platform and sharing a common model, all participants facilitate precise and efficient information transmission, ultimately fostering genuine collaborative efforts.

Decision Support: Integrating models with real-time data offers project managers intuitive decision-making support. By comparing 4D simulations of planned progress with actual progress, deviations can be promptly identified, causes analyzed, and corrective measures implemented promptly [13].

The Foshan Lighthouse Science and Technology Innovation Building project, situated in the High-Tech Zone of Foshan City, Guangdong Province, exemplifies the implementation of a BIM-based collaborative management approach. This project is characterized by comprehensive consulting services and the utilization of BIM technology to streamline implementation processes. Specifically, BIM technology was instrumental in conducting structural analysis, selecting materials, and comparing design schemes during the facade lighting design phase. To optimize efficiency and reduce labor costs, BIM duct prefabrication technology was employed due to the substantial volume of ducts involved. The integration of BIM with 3D scanning technology facilitated enhanced on-site verification and model accuracy. Furthermore, the synergistic application of BIM and smart construction technologies enabled the establishment of an intelligent on-site monitoring system, thereby ensuring efficient and intelligent management throughout the construction lifecycle.

The Foshan Castle Howard Johnson Hotel Project saw the establishment of a BIM forward design team by RuiZhu TianYuan. They utilized domestic digital dimension design software for integrated modeling across all disciplines. Through a digital dimension collaborative management platform, seamless multi-disciplinary coordination and integration were achieved, facilitating collaboration among upstream and downstream disciplines. Furthermore, the application of BIM design integration allowed for real-time extraction of key indicators to aid the client in project quantity control.

Integrating the BIM design team with the construction team expands the utilization of the BIM design model into the construction phase. This integration involves enhancing the design model to align with construction specifications and leveraging the BIM model for visual construction briefings, thereby establishing a seamless connection between design and construction processes. Consequently, this integrated approach significantly decreases civil engineering change rates to as minimal as .6% and enhances project communication efficiency by 30%.

4. Conclusions and prospects

Building Information Modeling (BIM) technology is considered a groundbreaking innovation in engineering construction, leading to significant changes in conventional practices in municipal engineering projects. This study examines its utilization in road construction, bridge building, utility tunnel development, and wastewater treatment facility construction. The analysis illustrates that

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BIM technology, utilizing key features like 3D visualization, clash detection, construction simulation, and collaborative management, adeptly tackles various construction obstacles. It notably improves project quality, cost management, construction schedules, and safety measures, ultimately providing considerable benefits.

The application of BIM technology in municipal engineering construction has achieved remarkable results, yet it still faces several challenges during the promotion phase.

• The initial investment cost is high. The application of BIM technology requires corresponding expenditures on hardware, software, and personnel training, which may be difficult for some small and medium-sized projects to bear.

• The industry standards lack completeness. Currently, the BIM standard system in the municipal engineering field is not yet fully developed, particularly lacking unified standards in areas such as data exchange and model delivery, which hinders the large-scale application of BIM technology.

• There is a shortage of professional talent. The application of BIM technology requires interdisciplinary professionals proficient in both engineering and information technology. Currently, the scarcity of such talent has become a critical factor hindering the widespread adoption of BIM technology.

• The organizational management model should undergo transformation. The application of BIM technology necessitates changes to traditional project management models and workflows, involving modifications to organizational structures, working methods, and collaboration approaches, which present significant implementation challenges.

In the future, the development of BIM technology will exhibit the following trends:

• Enhanced integration with cutting-edge technologies: Building Information Modeling (BIM) is poised to deepen its alignment with emerging technologies like the Internet of Things (IoT), unmanned aerial vehicles (UAVs), laser scanning, artificial intelligence (AI), and digital twins. Through the utilization of IoT sensors for live data collection on-site, BIM models can be continuously revised to generate digital twins that accurately reflect the current status of engineering projects. This facilitates instantaneous monitoring, intelligent preemptive alerts, and informed decision-making throughout construction operations.

• Standardization and Platformization: The industry BIM standards will be progressing and become more and more mature, realizing the interconnection between data. Cloud collaborative environments will be a norm in project management, facilitating real time coordination with all participants.

• Extensive penetration prepared from construction to operation and maintenance:The precision and information rich BIM model will pass directly from construction to the operations side, forming the core infrastructure of smart operation & maintenance. This optimizes the value of civic infrastructure over the asset's lifecycle.

Although there are certain problems faced by BIM technology such as expensive cost, non-unified standards and no talents, but with the maturity improvement of the technology, the normalization work and interface coordination with other advanced technology, BIM technology will significantly improve its popularization and application in municipal engineering. Such development will promote the digitalization and intelligentization of urban construction, which will in turn support smart city construction.

References

[1] Wu B, Liu HH, Li AR, Huang ZQ. (2021) Application and Innovation of BIM Technology in Municipal Projects. IOP Conference Series: Earth and Environmental Science, 787 (1).

DOI: 10.54254/2755-2721/2025.GL27615

[2] Gan W, GeYQ. (2023) Application Strategy of BIM Technology in Municipal Road Design. Journal of World Architecture, 7 (3).
[3] Yang Y. (2021) Discussion on Municipal Road Design Optimization based on BIM Technology. Journal of World Architecture, 5 (3): 1-4.
[4] Liu B, Cai TX, Xiao S, Fu HF, Chu WW. (2019) Research on application of BIM technology in municipal road construction. IOP Conference Series: Earth and Environmental Science, 330 (2): 022078-022078.
[5] Zhao WJ. (2025) Application techniques of BIM in municipal engineering construction. Construction technology development, 52 (08): 60-62.
[6] Luo QW. (2025) Research on construction control technology of continuous beam bridge based on BIM model for municipal highway. Construction machinery technology and management, 38 (03): 93-95.
[7] Meng W. (2024) Design Strategy of Municipal Roads and Bridges Using BIM Technology. Journal of World Architecture, 7 (6): 64-69.
[8] Yang L, Zhang FS, Yang F, Qian P, Wang QK. (2023) Generating Topologically Consistent BIM Models of Utility Tunnels from Point Clouds. Sensors (Basel, Switzerland), 23 (14).
[9] Li Y, Yang J Shen XW, Ma YY. (2019) Application Research on Construction Management of Urban Underground Utility Tunnel Based on BIM. IOP Conference Series: Earth and Environmental Science, 295 (4): 042133-042133.
[10] Han R, Shao D, Liu X. (2020) Maintenance Engineering for Urban Utility Tunnel using 3D Simulation. International Journal of Performability Engineering, 16 (7): 1118.
[11] Fu XC, Zhang Y. (2014) Application of BIM technology in municipal sewage treatment engineering construction. Tianjin Construction Technology, 24 (01): 63-65.
[12] Deng X. (2025) Application of BIM technology in water supply and drainage deepening design. Smart buildings and smart cities, (07): 95-97.
[13] Yu HZ, Li WL, Gao JZ, Liao YX. (2024) Research on the Application of BIM Technology in the Whole-Process Consulting of Municipal Engineering. Academic Journal of Engineering and Technology Science, 7 (6).