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Research on the Application of BIM Technology in the Whole-Process Consulting of Municipal Engineering

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Abstract: *Whole-process consulting spans the entire lifecycle of a project. By establishing BIM models for municipal engineering, a unified layout of underground pipelines can be achieved, effectively assisting in the design process. Additionally, conducting collision checks on pipelines helps optimize design solutions and allows for timely adjustments to the position and routing of pipelines. Site layout simulations enable the rational planning of construction areas, reducing the need for secondary transportation and handling, ultimately saving costs. Construction visualization simulations make complex processes like pipe jacking more intuitive and vivid during construction briefings. Real-time monitoring of the site can be achieved remotely through periodic drone flyover tours of the BIM model. Progress management is facilitated through the use of the model, and cost analysis is integrated with construction pricing information. Finally, the complete as-built model is handed over to the Smart Urban Construction CIM system, ensuring ease of future maintenance and management.*

Keywords: *Municipal Engineering; BIM Technology; Comprehensive Renovation*

1. Background

As the urbanization process progresses, urban traffic volumes have increased sharply, making road improvement and renovation imperative. Municipal road engineering projects typically have short construction cycles, involve a wide range of specialties, and feature complex nodal engineering, narrow construction sites, low management efficiency, low accuracy of underground pipeline data, and untimely data transmission and updates[1]. These issues cause significant difficulties in road improvement and renovation projects, as underground obstacles often lead to water and power outages or explosions during construction, resulting in project rework and delays[2]. To promote the transformation and upgrade of the construction industry and support its high-quality development, integrating BIM technology into municipal engineering construction allows for the early formation of a three-dimensional underground pipeline distribution during the survey and design stages. This enables the preparation of construction plans for obstacle areas in advance, reduces idle time and rework, prevents accidents, improves construction management efficiency, and ensures project quality[3,4].

2. Analysis of Current Issues and Advantages of BIM Technology Application

2.1. Current Issues in Municipal Engineering

Municipal engineering projects often take place along city roads and underground, involving numerous public departments such as water supply, drainage, landscape irrigation, electricity, telecommunications, gas, heating, civil defense, and military communications, among others. The underground pipelines are intricate and complex, making tasks such as pipeline relocation and earthwork excavation both challenging and inefficient. This complexity is visually represented in Figure 1, which illustrates the dense and interconnected nature of underground pipelines and utilities, emphasizing the challenges faced during construction. The project's execution largely depends on municipal roads, which are typically long and narrow. These roads serve both residents and vehicles, and fully closing them for construction disrupts traffic, causing significant congestion. Carrying out construction in sections slows progress and poses safety risks for both pedestrians and vehicles. Overall, the urban construction environment is complex, and the construction pace is slow.

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Due to the involvement of multiple stakeholders in underground pipelines and the fact that the underground areas are not visible, the generally outdated ground-penetrating radar technology is significantly influenced by the materials of various underground pipelines, often resulting in unidentifiable situations. Additionally, many underground projects are old and lack relevant engineering records, further complicating the accurate positioning of existing underground pipelines, directly affecting construction efficiency. The construction process involves numerous related property owners, and there is a lack of unified coordination and command among them. Property owners operate independently, leading to conflicts in construction timelines, elevation conflicts in construction design, numerous issues with construction management methods, and frequent changes in construction plans.

Figure 1: Complex Pipeline Relationships at the Construction Site

2.2. Advantages of Applying BIM Technology

Considering the key challenges and difficulties of road construction sites, the plan is to use BIM technology to establish a comprehensive three-dimensional (3D) visualization model of the road pipeline network. This aims to address a series of challenges, including the complexity of underground pipelines, narrow construction spaces, and difficulties in pipeline positioning during road renovation projects. Safety and Civilized Construction: By utilizing 3D visualization technology, key information such as the location, route, and depth of underground pipelines can be clearly communicated to ensure the safety and quality of on-site construction. This approach effectively minimizes the risk of accidents and ensures a safer working environment. Quality Management: Simulation models for key areas or complex engineering nodes allow for the transformation of traditional construction plans into 3D animated simulations. This approach verifies the feasibility of the construction plans, identifies critical and challenging areas, optimizes the construction approach, prevents operational risks, and guides on-site activities. As a result, it enhances overall project quality. Progress Management: By creating models in advance, site layout and planning can be optimized before construction begins. The 3D model helps realistically recreate the surrounding environment of the construction site, allowing for an efficient and accurate simulation of the site’s layout. This ensures smooth site transportation and orderly construction, effectively resolving space limitations, minimizing traffic disruptions, and improving construction efficiency.

Cost Management: Traditional geological maps often pose difficulties in data retrieval for earthwork calculations, involving repetitive tasks, and are time-consuming and labor-intensive, leading to cumulative inaccuracies and deviations from actual conditions. Topographical maps also lack visual clarity, making them unsuitable for guiding on-site earthwork coordination. BIM technology allows for quick and accurate calculation of earthwork quantities for this project, generating detailed earthwork construction drawings that facilitate on-site operations.On-Site Management: BIM technology enhances the construction process by providing clear communication tools. The 3D visualization of underground pipelines and above-ground building environments offers more intuitive, comprehensive, and accurate project information. This enables clear understanding of construction conditions and facilitates communication, thereby significantly improving project efficiency.

3. BIM Technology Application Plan

From the initiation of municipal engineering projects, BIM technology is introduced for full-process consultation, starting from the survey and design phase, extending through construction management, and culminating in the digital preservation of information during completion, acceptance, and delivery. This approach leverages the technical advantages of BIM technology throughout the entire process.

3.1. Survey and Design Phase

3.1.1. Comparison Between the Existing Municipal Engineering Model and the Post-Design Completion Model

The existing municipal road reconstruction model is designed to accurately reflect the current conditions of the construction area, serving as a data foundation for renovation planning and site layout during construction. This model incorporates terrain, roads, bridges, underground pipelines, markings, and signage, all based on municipal road drawings and pipeline detection data, ensuring a precise representation of the actual site conditions. Advanced techniques, such as parametric modeling and laser scanning, are used to enhance accuracy. Figure 2 of the Existing Municipal Road demonstrates how laser scanning technology captures detailed data of the existing road and its underground utilities, providing essential input for the model.

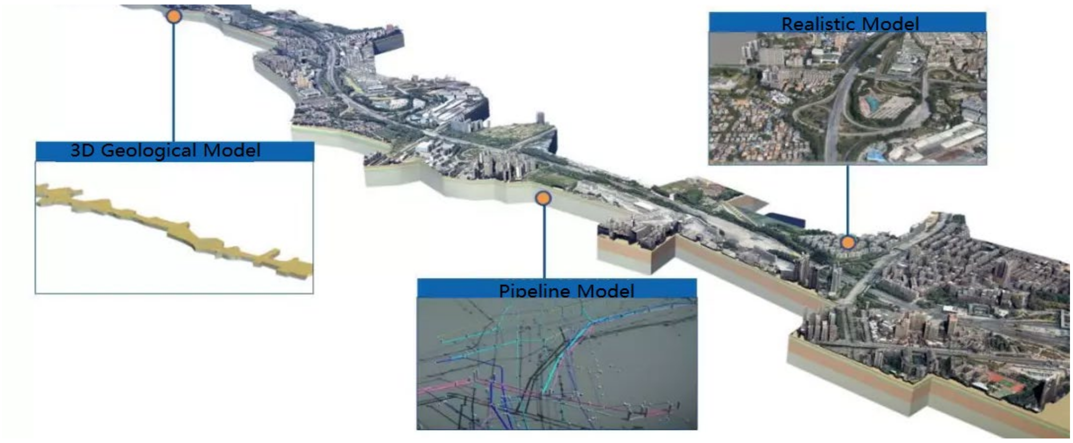

Figure 2: 3D Scanned Model of the Existing Municipal Road

3.1.2. Visualization and Review of Construction Drawings:

During the creation of the BIM model, the various design drawings provided by the design team are reviewed and audited. As the modeling process progresses, any discrepancies, omissions, or conflicts in the drawings are identified. A report detailing these issues, verified through BIM analysis, is then provided to the design team. Upon confirmation and subsequent design optimization by the designers, the BIM model is updated and adjusted accordingly. This process ensures that the BIM model accurately and comprehensively reflects the design plan and intent.

By proactively addressing design issues during the modeling phase, this approach aims to minimize on-site changes during the construction phase caused by design errors. It helps prevent project delays and cost overruns, ensuring that construction progresses smoothly and adheres to the planned schedule and budget. Additionally, this BIM-based review process promotes collaboration and communication among the design, engineering, and construction teams, leading to a more efficient and integrated project delivery. During the creation of the BIM model, design drawings are continuously reviewed for errors, omissions, and inconsistencies. A report is generated, and the design is revised and optimized accordingly. The updated BIM model ensures that the design is accurately and fully reflected, reducing the likelihood of on-site changes that could delay progress or increase costs.

3.1.3. Underground Pipeline Collision Detection and Comprehensive Layout

Underground Pipeline Collision Detection: Municipal road projects often involve a complex network of existing underground pipelines. Due to the lack of accurate information on the actual spatial layout of these pipelines, design drawings may sometimes be inadequate, leading to collisions and design modifications during actual construction. BIM technology integrates the existing underground pipeline model with the redesigned model to identify potential conflicts during pipeline relocation. A collision detection report, verified through BIM analysis, is then provided to the design team. After the design team confirms and optimizes the pipeline layout plan, the BIM model is updated to ensure that no collisions occur during the pipeline relocation process. This proactive approach helps minimize unexpected changes, ensuring that construction proceeds smoothly without interruptions.

Due to the complexity of underground municipal pipeline networks and the narrow and challenging working conditions at the construction site, construction efficiency can be significantly affected. BIM

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technology is employed to optimize the comprehensive layout of pipeline relocation plans. It enables adjustments to pipeline routes, spacing, and cross-sectional arrangements to minimize conflicts. Figure 3 illustrates how BIM identifies and resolves conflicts between the proposed design and the existing conditions, ensuring a seamless integration of new pipelines.

Without altering the relocation plan, BIM helps maximize the available construction workspace, optimize the division of construction segments, and determine the sequence of demolition, modification, and expansion for each system's pipeline before and after construction. This optimized layout approach not only enhances construction efficiency and reduces the difficulty of operations but also ensures that the final outcome is economically efficient and aesthetically pleasing. By visualizing and coordinating pipeline placement digitally, construction teams can plan for an efficient, orderly process that aligns with both design and field requirements, ultimately improving project delivery and quality while minimizing costs and disruptions.

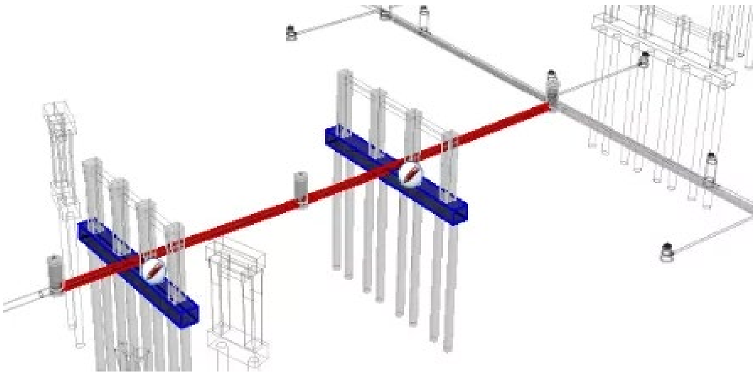

Figure 3: Detection of Collisions between the Design Model and the Existing Model

3.2. Application during the Construction Phase

3.2.1. Optimization of Construction Site Layout

3D Construction Site Layout: Due to the narrow and complex environment of municipal road renovation sites, there is often a conflict between the space needed for construction and the requirements for traffic flow, resulting in slow project progress. BIM technology is employed to model the current construction site, creating a 3D visualization of various elements such as construction barriers, work zones, equipment placement, material storage, transportation routes for large construction vehicles, and traffic conditions during different stages of construction. This 3D simulation allows for the visualization and analysis of different site layout plans, enabling comparison and selection of the most optimal arrangement for each phase of construction. By optimizing site usage and logistics, the approach aims to minimize disruptions and maximize efficiency.Visual Simulation of Transportation Routes:For narrow construction sites where the transport of materials, equipment, and vehicles may face challenges like collisions or obstructions, BIM technology provides a solution through visual simulations. Accurate 3D models of materials, equipment, and vehicles, designed to match their real dimensions and shapes, are created and used to simulate transportation paths as per the planned routes. By identifying potential collisions or bottlenecks during these simulations, transportation methods and routes can be optimized. This ensures that the most efficient transport path is established, improving the flow of materials and equipment on site, enhancing construction efficiency, and reducing project duration.

Additionally, this simulation minimizes the risk of component damage and the need for rework due to transportation collisions. It ensures that resources are used effectively, leading to cost savings and improved overall project performance. Through precise planning and real-time adjustments based on the simulated scenarios, the construction process can proceed in an organized and efficient manner, addressing both spatial and logistical challenges. Applications in the Construction Phase

3.2.2. Visual Review of Construction Drawings through BIM: Ensuring Precision and Minimizing On-Site Modifications

In the process of construction, the use of Building Information Modeling (BIM) has become a critical tool for the visualization and review of design drawings, ensuring precision across multiple engineering disciplines. This approach involves the thorough audit of architectural, structural, mechanical, electrical, and plumbing drawings provided by the design team. As the BIM model is built, it allows for the simultaneous detection of issues such as design inconsistencies, omissions, errors, and clashes between different systems, all of which can significantly affect construction outcomes. Once potential problems are identified, a detailed report is compiled, highlighting the issues discovered through the BIM audit. This report is then shared with the design team, allowing for feedback, correction, and design optimization. Upon confirmation and revision by the design team, the BIM model is continuously updated to incorporate these changes, ensuring it remains an accurate and complete representation of the design's intent. This iterative process helps to refine the model to the highest level of precision, addressing all design-related problems before they manifest on-site.

The use of BIM at this stage plays a crucial role in preventing costly on-site modifications and time-consuming redesigns that could result from unforeseen issues in the drawings. By addressing discrepancies early, BIM ensures a smoother transition from the design to the construction phase, minimizing delays and reducing the risk of budget overruns. Figure 4 demonstrates how BIM is utilized to visualize and plan key construction activities, such as the lifting and assembly of bridge segments, ensuring precision and avoiding potential conflicts during execution.

Moreover, this proactive approach enables better communication among project stakeholders, enhances coordination between different trades, and contributes to the overall efficiency of the project. In turn, this ensures that the project progresses as scheduled and within the projected financial constraints, leading to higher-quality project delivery and improved resource management.

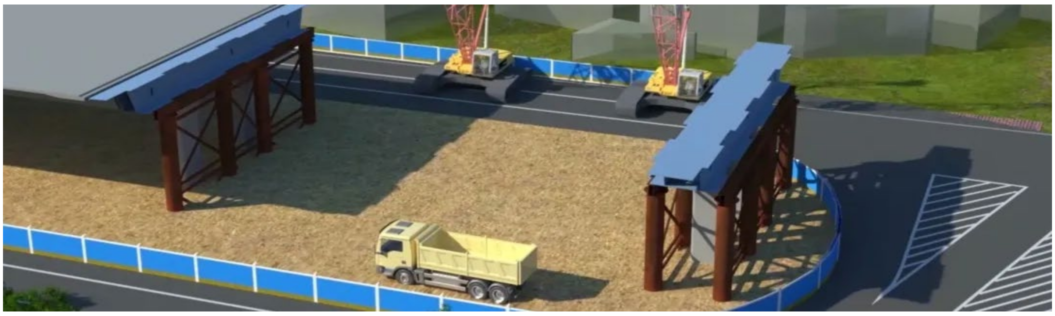

Figure 4: Simulation of Bridge Segment Lifting and Installation

3.2.3. Drone-Based Real-World and BIM Model Visualization for Enhanced Project Management

Given the extended, narrow work area of a municipal road renovation project following the road alignment, it is often challenging for stakeholders—such as owners, supervisors, and other management personnel—to fully grasp the overall project status and progress. By leveraging drones to regularly capture aerial images of the construction area, real-time models are created to visually present the progress and layout at various stages. This approach assists project managers in understanding the project as a whole. The real-world model, equipped with measurement functions, allows technical staff to take precise measurements of elements like pipe dimensions, angles, and depths. This data helps them develop more accurate construction plans or make adjustments based on the actual site conditions. Drone aerial photography also captures accurate terrain data. Within the real-world model, selected areas can be outlined to automatically calculate fill and excavation volumes, ensuring precise and reliable data. This approach prevents the inaccuracies and inefficiencies commonly associated with manually estimating earthwork quantities from 2D terrain maps. Following the completion of the municipal road renovation model, an on-ground route walkthrough can be conducted. Through a walkthrough video, stakeholders can fully visualize the renovated road, including pavement, signs, markings, green spaces, and the overall aesthetic. This visual representation provides a comprehensive view of the project's final appearance and quality.

Using the completed model of the underground utilities, a virtual walkthrough can illustrate the paths, depths, and systems of the renovated underground pipelines. This visualization aids in post-completion maintenance and management by offering an in-depth view of the underground layout, making future operations and upkeep of underground utilities more efficient and reliable.

3.2.4. 4D BIM Model-Based Schedule Management

Integrating the construction schedule into the BIM model creates a 4D construction model that facilitates the simulation of the entire project timeline, allowing project managers to check the sequencing and rationality of construction processes. This 4D model not only enhances planning accuracy but also provides a dynamic tool to compare planned vs. actual progress. By overlaying the

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BIM schedule with real-time site conditions, stakeholders can monitor the project timeline in detail. The model can generate animated simulations of the construction sequence, visualizing each stage of progress and offering milestone alerts to flag critical phases and deadlines. To enhance this process, drones are deployed regularly to capture aerial images of the construction area, documenting the project's visual progress from initiation to completion. These drone-captured images are then compared with the 4D schedule simulation to identify any discrepancies in real vs. planned progress. By examining these differences, the team can identify areas where the project may be lagging or progressing faster than expected. This continuous tracking mechanism allows managers to make timely adjustments, ensuring alignment between the schedule and actual site conditions and helping to mitigate potential delays or inefficiencies. Moreover, this integration of BIM and drone data provides a comprehensive visual record, contributing to a transparent, data-rich environment that improves decision-making, fosters proactive risk management, and promotes overall efficiency in project execution.

3.2.5. 5D BIM Model-Based Cost Management

Integrating cost information at each phase of a municipal road renovation project into the BIM model creates a 5D management model. This model allows for precise quantity takeoff, review, and measurement within the BIM environment, enabling automated extraction of quantities and contract packages by phase. The 5D BIM model facilitates the seamless implementation of cost management, supporting both project budgeting and control functions. At regular intervals, the model can generate detailed reports on quantities and associated costs for each construction phase. These reports assist in on-site material and labor tracking and streamline interim payment and settlement processes. By accelerating the approval and payment process for progress payments, the model ensures smoother cash flow and financial management. Additionally, the comparison of the BIM model's projected quantities with actual quantities on site provides insights into any discrepancies, allowing the team to detect inefficiencies or areas of overspending promptly. This analysis highlights potential cost overruns or inefficient construction practices, guiding the project team to undertake in-depth reviews of specific processes. By identifying areas where cost-saving adjustments can be made, the team can apply lessons learned to optimize construction sequences and refine future planning, ultimately driving down construction costs. The 5D BIM model thus not only enhances financial oversight but also fosters continuous improvement by creating a feedback loop that integrates cost data with on-site performance. This approach leads to a more agile, data-driven project management environment, allowing for proactive adjustments that support overall project efficiency and financial health.

3.2.6. BIM Model-Based On-Site Collaborative Management

The BIM model serves as a centralized source of project information, encompassing design, construction, and operational data. With BIM as the foundation, this approach aims to foster high-level integration and data sharing among all project stakeholders—owners, contractors, supervisors, designers, and consultants. By enabling real-time resource sharing, the BIM model significantly enhances communication, coordination, and construction efficiency, facilitating effective collaboration across all project phases.On-site, BIM engineers leverage BIM technology to provide dynamic visualization of design schemes, ensuring that stakeholders can clearly understand and validate design intentions. Multi-disciplinary coordination is streamlined through the BIM model, allowing experts from various fields to work together seamlessly. Key construction strategies, such as major installation sequences, can be visualized and reviewed collaboratively, optimizing planning and ensuring alignment. Additionally, the BIM model supports critical on-site functions, including progress tracking, cost management, quality control, and change management, making it an indispensable tool for comprehensive on-site management.In instances of unexpected challenges or construction obstacles, the BIM model enables feasibility analysis and comparison of alternative construction plans. Through simulations and scenario analysis, project teams can evaluate various solutions, aiding in swift and informed decision-making. This flexibility not only mitigates risk but also ensures that the project adapts efficiently to evolving circumstances.

By fostering a cohesive, data-driven environment, BIM-based collaborative management enhances project delivery, minimizes delays, and supports the consistent achievement of quality and cost objectives. This integrated approach transforms project execution, empowering all stakeholders to contribute effectively and make informed decisions based on real-time, accessible project data.

3.3. Integrating Digital Outcomes into CIM Platform

3.3.1. Seamless Integration of BIM Data into the CIM Platform for Enhanced Urban Management and Infrastructure Maintenance

As construction progresses, project teams continually update the BIM model with data like construction dates, contractor information, and material specifications, creating a comprehensive digital record. Upon completion, this as-built model is submitted to Baotou's digital city archives, capturing the full design, construction, and completion details of the road and infrastructure. Transitioning this model to the city’s Construction Information Modeling (CIM) platform provides long-term value to urban management by improving data accessibility and support. To ensure CIM compatibility, the model undergoes “lightweighting” and format conversion, preserving accuracy while optimizing its structure. This adaptation integrates the BIM model into the city’s digital infrastructure, enriching the 3D city view with details of the road network, underground pipelines, lighting, and landscaping. Officials and stakeholders can visualize infrastructure layouts and access detailed information on road conditions, utilities, and green spaces, enabling data-driven insights and efficient maintenance planning.

3.3.2. Construction Data Integration and Digital Archiving

Throughout the construction phase, the integration of comprehensive information within the BIM model allows for real-time updates, ensuring the model accurately reflects the project’s evolution. By logging data such as dates, responsible entities, and material specifics directly into the BIM model, the construction process is effectively documented. This documentation is invaluable for the creation of as-built records, as it offers a verifiable history of the construction steps and materials used, ultimately enhancing transparency and accountability. Once the project reaches completion, the as-built BIM model is transferred to Baotou’s digital city construction archive. In this archive, it serves as a permanent record, preserving the intricate details of the project for future reference. As part of this archival process, the model undergoes a standardization process to ensure compatibility with the digital city's requirements. This archived model not only supports municipal oversight but also facilitates future renovations, upgrades, or repairs by providing precise, historical data on construction elements and conditions at the time of completion.

3.3.3. Adapting the Model for CIM Platform Integration

To ensure compatibility with the city’s CIM platform, the BIM model must undergo a process of lightweighting, whereby extraneous details are removed or simplified to reduce file size without compromising essential information. This step makes the model more manageable within a city-scale digital environment. Following this, a format conversion process aligns the BIM model with the CIM platform’s standards, allowing the model to be seamlessly imported and utilized within the city’s broader information system. This adaptation not only allows the model to fit within the digital infrastructure of Baotou but also ensures that its data can be efficiently accessed and utilized by city management teams.

The streamlined model is then integrated into Baotou’s CIM platform, where it becomes part of a living database that includes a multitude of urban infrastructure elements. This integration ensures that the city's operational platform can leverage BIM data for a unified view of urban systems, such as transportation networks, utility layouts, lighting, and landscaping.

3.3.4. Enhanced Visualization and Data Retrieval for City Management

With the BIM model fully integrated into the CIM platform, city officials have access to a dynamic, three-dimensional representation of the road, pipelines, lighting systems, and landscaping. This 3D model allows users to interactively explore the infrastructure, gaining a clear understanding of each element’s spatial positioning and relationship to other structures. The model’s high level of detail enables precise navigation through different components, offering a unique perspective on the completed project’s layout and connectivity within the broader urban framework. Beyond visualization, the CIM platform provides a powerful data retrieval mechanism. By selecting specific elements within the model, users can access detailed information, including maintenance records, material specifications, and installation data. This capability is crucial for supporting day-to-day operations, as city management can quickly retrieve relevant information to address any maintenance issues or plan for future upgrades. For example, information on underground pipelines can aid in routine inspections or repairs, minimizing the risk of disruptions due to insufficient data.

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3.3.5. Supporting Proactive Maintenance and Efficient Operations

One of the significant advantages of integrating the BIM model into the CIM platform is its support for proactive maintenance and operational efficiency. City management teams can use the model's detailed data to implement predictive maintenance strategies, identifying potential issues before they escalate. For instance, information on road materials and construction dates can help predict when certain sections might require repairs, allowing for timely interventions that prevent more costly deterioration. Similarly, underground pipeline data assists in scheduling routine inspections based on material lifespans and known stress factors.The CIM platform's data visualization and retrieval capabilities also improve resource allocation by allowing city officials to make informed decisions on where to allocate maintenance funds and personnel. This targeted approach ensures that city resources are used efficiently, addressing the most pressing needs while minimizing waste. As a result, Baotou's urban management system can achieve higher levels of operational efficiency and cost savings, benefiting both the city and its residents.

3.3.6. Long-Term Benefits of a Data-Driven Urban Management System

The integration of BIM models into a city-wide CIM platform provides lasting benefits beyond immediate project management. By establishing a digital infrastructure that encompasses detailed information on various urban assets, Baotou lays the groundwork for a fully connected city management system. This platform can support other digital initiatives, such as smart traffic management, energy optimization, and environmental monitoring, by linking real-time data feeds to static infrastructure information. For future urban development projects, this digital archive will serve as a foundational resource, offering city planners and engineers a comprehensive understanding of existing infrastructure. Having detailed records of previous projects allows for more accurate forecasting and risk assessment, supporting sustainable and efficient c ity growth.The inclusion of comprehensive data within Baotou's CIM platform represents a forward-thinking approach to city management, where the fusion of BIM and CIM technologies transforms traditional project data into actionable insights for long-term urban planning and operations. By embracing this data-driven model, Baotou positions itself as a leader in smart city development, leveraging digital tools to improve quality of life for its residents and ensuring a resilient, well-maintained urban environment for the future.

4. Conclusion

Applying BIM technology in municipal engineering projects enables the simulation of construction site layouts and collision detection, which optimizes pipeline arrangements and minimizes potential errors and rework. By modeling construction plans, the most effective options can be identified, supporting informed decision-making, improving construction quality and safety, and reducing the need for design changes. In the completion and maintenance phases, digital assets allow for dynamic monitoring and operational management, enabling real-time asset tracking and routine maintenance checks to ensure the long-term condition of project assets.

This project highlights BIM technology as a demonstration in municipal road engineering, promoting technological advancement and establishing an expandable project management framework. This approach provides valuable experience for similar projects, strengthens the informational advantage of municipal engineering, and supports the construction industry's transformation and modernization.

References

[1] Song Zhiguang, Yu Haizhou, Dang Jianping, et al. A Literature Review on Cost Control in Municipal Engineering Construction [J]. Inner Mongolia Science Technology and Economy, 2020(07): 28-30.

[2] Yang Jie, Yang Haitao, Luo Chenhao, et al. Research on Forward Design of Water Supply and Drainage Engineering Based on BIM[J]. China Municipal Engineering, 2018(04): 71-74.

[3] Song Zhiguang, Yu Haizhou, Dang Jianping, et al. A Literature Review on BIM Technology[J]. Inner Mongolia Science Technology and Economy, 2020(08): 84-85.

[4] Xu Saiying. Towards Open BIM Municipal Projects[J]. China Highway, 2020(11): 138-141.