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Editorial

Editorial for the Special Issue "Modern Digital Technologies for the Built Environment of the Future"

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1. Introduction

The construction sector has long been perceived as one of the least digitized branches of the economy. That perception is changing rapidly. Over the last decade, Building Information Modeling (BIM) has moved from a specialist technique into a widely accepted standard, Geographic Information Systems (GIS) have become an essential component of infrastructure planning, and artificial intelligence (AI) has been incorporated into the daily practice of design, inspection, and facility management. Digital Twins (DT), once limited to manufacturing and aerospace, now represent a realistic horizon for buildings and civil infrastructure as well. This Special Issue of *Infrastructures*, titled "Modern Digital Technologies for the Built Environment of the Future", was conceived against this background. Its aim was to collect contributions that reflect both the breadth and depth of the ongoing transformation in this field, covering building, technical, transmission, and green or blue infrastructure elements, and bringing together studies on topics ranging from early conceptual design to long-term asset management.

The Special Issue closed with eight accepted contributions, including seven original research articles and one systematic review. The authors come from research centers from Europe, North America, Asia, and Australia, which confirms the international relevance of the topic. Taken together, the collected papers form a coherent panorama of current methods, open problems, and emerging research directions in construction informatics.

2. Overview of the Contributions

This Special Issue [1] opens with the work of Mitera-Kiełbasa and Zima 1, who address the challenge of automating the preparation of Exchange Information Requirements (EIR) for construction projects under the ISO 19650 standard [2]. Using Word2Vec for text vectorization and Support Vector Machines (SVMs) for classification, the authors achieve an average F1 score of 0.7, demonstrating that natural language processing can meaningfully support information management in BIM-based project delivery. The authors also highlight the current limits of text generation methods in this domain and indicate large language models (LLMs) as a promising direction for further work.

Christenson 2 focuses on the epistemological role of digital modeling. Based on a case study of the Federal Archive Building in New York City, the author argues that parametric analysis should be regarded not only as a tool for geometric representation but also as an instrument for generating architectural hypotheses. This paper invites a rethink of the purpose of digital models of existing buildings, and lays groundwork for later contributions in this Special Issue that revisit the representation of heritage and existing structures.

Renganathan and colleagues 3 examine the early conceptual design phase, in which traditional BIM workflows are often too rigid. By integrating Virtual Reality (VR) with BIM

Check for updates

Received: 24 April 2026
Accepted: 27 April 2026
Published: 28 April 2026

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in a structured framework, validated through a pilot study, the authors show measurable improvements in spatial cognition, emotional engagement, and iterative decision making. Their contribution illustrates how immersive technologies can complement data-driven methods and support more human-centered design practice.

Singh and co-authors 4 shift the focus to sustainable construction procurement and the adoption of blockchain technology. Combining a systematic literature review, expert consultation, Fuzzy DEMATEL, k means clustering, and social network analysis, the study identifies decentralization, data security, quality, and project cost as key drivers, while system stability, overall project performance, and customer satisfaction emerge as central nodes in the adoption network. The authors demonstrate how hybrid artificial intelligence-based methods can inform strategic decisions about technology adoption in this sector.

Borkowski, Kochański, and Rukat 5 provide a thorough review of the evolution of convolutional and recurrent neural networks in the context of BIM, organized along three axes: computer vision coupled with BIM models; sequence and time series modeling for cost, energy, and risk prediction; and the integration of deep learning outputs with the semantics and topology of Industry Foundation Classes (IFC) models. The paper also introduces Bimetria, a practical tool that combines convolutional networks with optical character recognition to generate estimated three-dimensional models from two-dimensional drawings. This contribution positions mature convolutional and recurrent architectures alongside emerging attention- and graph-based models, and raises fundamental questions about benchmarks, synthetic data, and explainability in the AECOO (Architecture, Engineering, Construction, Owner, Operator) domain.

Hanson, Liu, and Christenson 6 reflect on existing building representation by proposing a method that promotes epistemic resilience rather than epistemic closure. Implemented in Autodesk Revit, their parametric reference frame foregrounds reciprocal relationships between orthographic views and deliberately sacrifices efficiency in favor of interpretive depth. Their study expands the role of BIM beyond documentation and situates it as an instrument of architectural knowledge production, with implications for software development, pedagogy, and critical representation.

Kwast-Kotlarek and Szóstak 7 present an integrated RACI (Responsible, Accountable, Consulted, Informed), Analytic Hierarchy Process (AHP), and BIM methodology for projects with high functional complexity and conservation constraints. The approach is validated on a higher education conservation project with a BIM execution plan and scan to BIM procedures. The authors demonstrate that coupling a responsibility matrix with AHP-based decision making and BIM data reduces accountability gaps, improves interdisciplinary coordination, and supports transparent, data-driven design under the design build model.

The Special Issue closes with a systematic review by Karkan and colleagues 8, who critically evaluated 77 studies on deep learning-based visual inspection of concrete bridges using two-dimensional images. Their review maps classification, object detection, and segmentation models, and identifies transfer learning, data augmentation, and careful dataset composition as key success factors. The authors also outline future directions, including tighter integration with BIM, edge computing for real-time monitoring, and the development of richer annotated datasets for better generalizability.

3. Common Threads and Future Directions

Read as a whole, the contributions in this Special Issue point toward several converging trends. First, BIM is increasingly understood not as a single technology but as a semantic and geometric backbone onto which artificial intelligence, Virtual Reality, blockchain, and structured decision making methods can be grafted. Second, there is growing awareness

that the value of digital models lies not only in geometric accuracy but also in their capacity to support knowledge production, critical inquiry, and transparent governance. Third, interoperability, standardization, and the quality of domain-specific datasets remain persistent bottlenecks that no single study can resolve on its own.

On behalf of the Guest Editorship, I would like to thank all the authors for their valuable contributions, the reviewers for their rigorous and constructive feedback, and the *Infrastructures* Editorial Office for their continuous support throughout preparations for this Special Issue and its Reprint. I hope that the collected papers will inspire further interdisciplinary research and contribute to a more mature and responsible digital transformation of the built environment.

Conflicts of Interest: The author declares no conflicts of interest.

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