
Editorial: Smart systems and advanced technologies for next-generation sustainable construction

The construction industry stands at a critical juncture. Digital transformation, advanced technologies and sustainability imperatives converge to reshape how we design, build and manage the built environment. The paradigm shift brought by Industry 4.0 and the emerging Industry 5.0 framework represents governing foundations for progressive changes embracing society, knowledge, economy and people (Rahimian *et al.*, 2021; Sheikhhoshkar *et al.*, 2025a). Smart systems, artificial intelligence (AI), blockchain and Internet of Things (IoT) technologies promise to address longstanding challenges in construction project delivery, operational efficiency and environmental performance. Scientific advances and innovative technologies in architecture, engineering and construction are key factors in helping countries move towards developing smarter and more sustainable communities (Najafi and Rahimian, 2025). These technologies emerge not as isolated solutions but as interconnected capabilities that, when properly integrated, can fundamentally transform construction practices and outcomes.

This transformation occurs against the backdrop of pressing global challenges. The built environment contributes significantly to carbon emissions and resource consumption. Construction projects continue to face delays, cost overruns and safety concerns. Buildings often fail to deliver optimal thermal comfort and energy performance. Cities struggle to implement smart technologies while ensuring data security and privacy. These challenges demand systematic responses that combine technological innovation with human-centered design, regulatory adaptation and institutional capacity building. The nine pillars supporting Industry 4.0 include the integration of extended reality (Potseluyko *et al.*, 2022; Rahimian *et al.*, 2019), digital twins (Adu-Amankwa and Rahimian, 2025; Bakhshi *et al.*, 2024), mainstream building information models (BIM) (Bakhshi *et al.*, 2022), computer vision (Pour Rahimian *et al.*, 2020), the IoT (Okonta *et al.*, 2025), blockchain (Basheer *et al.*, 2024), machine learning (Seyedzadeh *et al.*, 2020) and linked data (Matarnah *et al.*, 2022). These technologies provide unprecedented opportunities to tackle challenges and drive tangible, evidence-based innovations in the built environment (Sheikhhoshkar *et al.*, 2025b).

The Sustainable Development Goals (SDGs) provide a framework for understanding these imperatives (United Nations, 2015). SDG 9 calls for resilient infrastructure and innovation. SDG 11 emphasizes sustainable cities and communities. SDG 12 addresses responsible consumption and production. SDG 13 focuses on climate action. Scholars have increasingly argued that addressing these challenges requires approaches that transcend disciplinary silos and linear problem-solving models, prioritizing systems-oriented, context-sensitive and reflexive modes of inquiry (Elkington, 2018; Geels, 2019). This special issue demonstrates how smart systems and advanced technologies contribute to these goals through improved project management, enhanced building performance, safer construction practices and more efficient resource utilization. The contributions span multiple scales and domains, from individual building components to urban systems and from construction site operations to facility management.

The seventeen papers in this issue explore diverse yet interconnected dimensions of smart and sustainable construction. Purushothaman *et al.* (2026) examine interactions among causes of construction delays through systematic literature review and causal loop analysis, identifying critical factors that affect project scheduling and revealing how delay causes



operate in coherence rather than isolation. [Hosseini et al. \(2026\)](#) develop a biomimetic kinetic façade methodology that integrates form and behavior for real-time daylight control, demonstrating that simpler shapes with appropriate kinetic behavior can outperform complex forms in visual comfort and daylight performance. [Kima et al. \(2026\)](#) enhance understanding of safety climate in small and medium construction enterprises through integrated quantitative and qualitative analysis, establishing practical frameworks and leading indicators for sustainable safety environments.

[Abbasnejad et al. \(2026\)](#) investigate Industry 4.0 technology integration in transportation infrastructure construction, revealing BIM dominance while identifying critical adoption challenges including high costs and lack of standardization. [Singh et al. \(2026\)](#) propose a comprehensive roadmap for implementing blockchain-enabled smart contracts in sustainable construction by combining the technology-organization-environment-social framework with advanced fuzzy methodologies. [Ameyaw et al. \(2026\)](#) explore barriers to smart contract adoption through an international survey, finding that limited practitioner knowledge, resistance to change and weak governmental support constitute major obstacles. [Rethnam and Thomas \(2026\)](#) present a physics-informed deep learning framework for urban building thermal comfort modeling that couples environment modeling with dynamic thermal simulations, demonstrating how ignoring urban context can lead to 70% inaccuracy in discomfort hour estimates.

[Albalkhy et al. \(2026\)](#) conduct a systematic literature review on lean construction and IoT integration, developing a comprehensive matrix with 54 interactions that reveals data transfer and real-time information sharing as having the highest interaction levels with flow principles. [Elghaish et al. \(2026\)](#) examine predictive digital twin technologies for achieving net zero carbon emissions through a mixed literature review, revealing asymmetric research attention across IoT, digital twins and AI components while emphasizing integration necessity. [Gharaibeh et al. \(2026\)](#) develop a framework for monetizing BIM benefits through comprehensive industry engagement in Sweden, providing decision-makers with systematic methods to evaluate BIM feasibility against costs. [Yitmen et al. \(2026\)](#) explore Construction 5.0 opportunities and challenges using structural equation modeling, demonstrating how human-centric technology adoption, resilience and sustainability overcome implementation challenges for smart, sustainable and resilient buildings.

[Aghili et al. \(2026\)](#) provide a data-driven fault detection framework for hospital HVAC systems using LSTM and GRU models, achieving over 90% accuracy in identifying temporal relationships critical for system reliability. [Alinejad et al. \(2026\)](#) present a deep neural network for land coverage prediction that distinguishes building types to enhance wind loading estimation, achieving 90% validation accuracy and up to 55% error reduction in wind speed calculations. [Larbi et al. \(2026\)](#) evaluate drivers for adopting integrated digital delivery through mixed-methods systematic review, identifying 30 drivers across 6 classes and demonstrating their contribution to achieving SDGs 9, 11 and 13. [Ali et al. \(2026\)](#) identify challenges to smart real estate technology adoption through PEST analysis, uncovering regulatory ambiguity, high costs and societal resistance as critical obstacles to AI and blockchain implementation.

[Mohammadi et al. \(2026\)](#) integrate immersive VR technologies with multimodal IoT-enabled sensors for real-time thermal comfort assessment, demonstrating through 92 participants that the framework enables comprehensive visualization and HVAC system interaction while maintaining effectiveness across different user experience levels. [Lnenicka et al. \(2026\)](#) analyze cybersecurity and data protection practices in smart cities through content analysis and the Delphi method, providing 39 validated recommendations across 6 categories while revealing that smart economy and governance components receive greater security attention than smart living and environments. Together, these contributions demonstrate how smart systems and advanced technologies address construction challenges through multiple pathways: improved project planning and delay management, enhanced building envelope performance, strengthened safety culture, integrated digital delivery, predictive analytics and secure data management.

Several cross-cutting themes emerge from this collection. First, technology adoption requires more than technical capability. It demands organizational readiness, regulatory support, professional competence and cultural change. Second, integration matters more than isolated innovation. The most significant advances come from combining technologies such as BIM with IoT, AI with digital twins or VR with sensor networks. The framework presented by Sheenan *et al.* (2026) illustrates how real-time data and autonomous monitoring can enhance construction efficiency and resource management. Third, human factors remain central. Whether addressing construction worker safety, building occupant comfort or user acceptance of new technologies, success depends on understanding and supporting human needs and behaviors. The European Commission's Industry 5.0 framework extends this evolution by integrating human-centric innovation, resilience and sustainability to align technological advancements with societal and environmental needs (Najafi *et al.*, 2025). Fourth, context shapes implementation. Geographic location, institutional frameworks, project types and organizational characteristics influence how technologies perform and what benefits they deliver.

Looking forward, the research pathways suggested by this issue point toward several priorities. Standardization frameworks are needed to enable interoperability and reduce adoption barriers. Case studies demonstrating real-world implementation and measured outcomes can build evidence and confidence. Research examining the interactions between different technologies can guide integration strategies. Studies investigating the social and organizational dimensions of technology adoption can improve implementation success. Work addressing data security, privacy and ethical considerations becomes increasingly important as smart systems proliferate. Investigation of how emerging technologies contribute to specific SDGs can strengthen the evidence base for sustainability claims. Developing digital maturity becomes a question of capacity building, knowledge transfer and professional transformation, aligning closely with SDGs related to innovation, education and institutional resilience.

This special issue advances Smart and Sustainable Built Environment's mission to foster knowledge exchange among researchers, practitioners and policymakers. The contributions demonstrate that smart systems and advanced technologies offer genuine potential to address construction industry challenges and advance sustainability goals. Realizing this potential requires sustained effort across multiple fronts: developing and refining technologies, building organizational capabilities, adapting regulatory frameworks, educating professionals and maintaining focus on human needs and environmental limits. The papers assembled here provide valuable insights, methods and evidence to inform these efforts. They reinforce the understanding that sustainable construction emerges not from any single technological breakthrough but from the systematic integration of technical innovation, institutional learning and human-centered design.

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