2026 European Conference on Computing in Construction
Corfu, Greece
July 12-15, 2026

ACTOR-NETWORK THEORY FOR EVALUATING BIM-AI IMPLEMENTATION IN DESIGN FIRMS

Federica Crosato1, Alireza Borhani2, and Luciana Burdi2
[1]Iuav University of Venice, Venice, Italy, IT
fcrosato1@iuav.it
[2]Massachusetts Port Authority, Boston, Massachusetts, MA
aborhani@massport.com, lburdi@massport.com

Abstract

Artificial Intelligence (AI) is assuming a central role in the AECO industry, supporting automation, workflow optimization, and decision-making. Despite rapid technological advances, the use of AI in design practice remains underexplored, particularly regarding the sociotechnical dynamics that favor or hinder its adoption within BIM processes. This study introduces Actor-Network Theory (ANT) to the field of BIM-AI research, focusing on design firms. The goal is to develop an ANT-based method to guide researchers in analyzing how actor networks can be mobilized to support the implementation of AI in BIM design workflows.

Introduction

In recent years, Building Information Modeling (BIM) has become a central component of information management in the construction sector, supported by increasingly sophisticated software technologies (Eastman et al., 2008). Understanding how AI may influence BIM processes requires examining the technological maturity of design firms and their ability to select, integrate, and coordinate heterogeneous digital tools. In particular, mapping internal information flows is essential for assessing how new technologies modify or optimize the circulation of data across departments, operational staff, clients, and external consultants (Cavka et al., 2015). Although the literature recognizes the strategic importance of BIM, its effectiveness depends on the clear definition of project objectives and BIM uses, which guide responsibilities and workflow organization (Raj et al., 2025). At the same time, organizational change is shaped by external environmental, economic, and policy conditions (Pettigrew, 1987), and the availability of standards, protocols, and best practices remains a key enabler of BIM implementation (Hochscheid & Halin, 2018), supporting more advanced environmental and performance analyses (Alnaser et al., 2024). AI tools encompass a broad domain of techniques dedicated to automation, with machine learning (ML) and deep learning (DL) representing the most widely adopted approaches (Alves et al., 2025). Despite their potential, the effective integration of AI in the AEC sector depends on professionals' perceptions, competencies, and attitudes (Albukhari et al., 2025). As highlighted in a recent AIA report (2024), AI is now used across a wide spectrum of activities - from chatbots supporting operational tasks to the generation of visual content in early design phases (Xu et al., 2024), as well as linguistic analysis, text revision, and automated transcription of meetings and workplace communications. AI therefore influences both the technological dimension and the organizational processes of design firms (Wang et al., 2025), making it essential to identify the factors that enable or hinder its adoption. Despite growing interest in AI applied to BIM, the existing literature remains fragmented. Current studies tend to focus on specific applications (Al-Muntaser et al., 2024), project-based case studies (Attia, 2025), perceived risks (Bolpagni et al., 2021), or benefits (Chen et al., 2024; Alves et al., 2025; Albukhari, 2025). However, a qualitative sociotechnical perspective capable of systematically examining the drivers of BIM-AI integration - and how these are translated into professional practice - has not yet been developed. In particular, a holistic framework that guides researchers in studying the BIM-AI domain is still lacking. Actor-Network Theory (ANT) offers a promising lens for addressing this gap. ANT conceptualizes both "non-human" actors (artefacts, processes, standards, regulations) and "human" actors (roles, professionals, institutions) as entities capable of shaping action within a network (Latour, 2005). This perspective enables researchers to examine how technology implementation is translated and adapted within specific institutional, organizational, or project contexts. Previous studies have applied ANT to analyze BIM maturity development (Edirisinghe, 2021), planning practices (Rydin, 2013), BIM implementation in large organizations (Lindblad & Vass, 2015), municipal land-allocation processes involving BIM, GIS, and Digital Twins (Hamarashid, 2021), sustainability certification networks (Frank et al., 2022), and collaboration in industrialized housing (London & Pablo, 2017). Yet, despite these contributions, the perspective of design firms - particularly regarding the integration of AI into everyday BIM-based practice - remains underexplored. This study addresses this gap by investigating and systematizing the key components influencing the integration of AI into BIM processes in design firms. By adopting a structured methodology, the research aims to clarify how technological, organizational, and environmental conditions shape AI adoption. More specifically, the literature review conducted in this study seeks to: (1) identify existing frameworks for BIM implementation; (2) examine current applications of AI in design; (3) extract the key factors relevant to design firms; and (4) develop an ANT-based diagram to guide future data collection and analysis.

Methodology

This paper presents the initial phase of a broader research project that investigates BIM-AI implementation in design firms from a comparative international perspective. The study is structured into two sequential phases. The first phase - reported in this article - consists of a systematic literature review aimed at identifying existing frameworks, methodological approaches, and thematic areas relevant to BIM-AI integration. Guided by this objective, the present contribution addresses two research questions:

How is BIM implementation conceptualized within design firms?

What are the key components for evaluating BIM-AI implementation in design?

To answer these questions, the study adopts a qualitative methodology grounded in a structured literature review articulated into four phases (Figure 1). The first phase involved planning and defining the review protocol, including research questions, keywords, and inclusion criteria:

- Types: articles and conference papers;
- Period: 2010-2025;
- Language: English;
- Open access;
- Keywords: Table 1.

Table 1: Keywords used in the literature reviews

"BIM implementation" OR "BIM adoption"	AND	"design firm" OR "design firms" OR "design organization" OR "design organizations" OR "SME"
"AI implementation" OR "AI adoption"	AND	"design firm" OR "design firms" OR "design organization" OR "design organizations" OR "SME"

Applying these criteria, 132 documents were initially identified. After screening for relevance, 18 publications focusing on BIM implementation in design firms and 23 addressing AI in design were selected for in-depth analysis. The subsequent sections examine the research methods and thematic areas emerging from these studies. Based on this analysis, the factors related to AI within BIM-based design processes are extracted, categorized, and used to support the construction of the actor-network that informs the ANT-based framework proposed in this research.

Figure 1: Synthesis of methodology

BIM implementation in design firms

BIM implementation is commonly defined as the set of organizational activities undertaken to prepare for, initiate, or enhance digital deliverables and related workflows (Succar & Kassem, 2015). As a consolidated methodology and a driver of innovation in the construction sector (Eastman et al., 2008), BIM has become a central component of contemporary design practice. However, its interpretation and application remain highly heterogeneous across countries and even among firms operating within the same market (El Masry & Chronéer, 2025). The reviewed studies confirm this variability, showing that BIM implementation in design firms has been examined through a wide range of methodological approaches (Table 2). A substantial portion of the literature adopts survey-based methods to assess readiness, perceived benefits, barriers, and organizational needs. Examples include studies on BIM usage in Hong Kong (Chan, 2014), BIM adoption in Indian architectural firms using the TOE framework (Ahuja et al., 2016), BIM-Lean integration and standardization practices (Bolpagni et al., 2017), knowledge and skills gaps (Abd Hamid et al., 2020), maturity factors in Italian firms (Troiani et al., 2020), and barriers and benefits in Algerian practices (Tehami & Seddiki, 2023). Large-scale surveys, such as Wang et al. (2022), extend this perspective by examining national trends and regulatory pressures through TOE, DOI, and time-series analyses involving over one thousand Chinese firms. Sadeh et al. (2021) further show how MSMEs perceive BIM benefits across operational and informational dimensions while facing persistent constraints related to expertise and interoperability. Other contributions adopt mixed-methods or qualitative approaches to explore organizational dynamics in greater depth. Liu et al. (2020) combine questionnaires and interviews to investigate micro-level BIM implementation in UK design firms, while Tong et al. (2021) develop an organizational readiness framework integrating the MIT90s model and BIM maturity literature. Action Research (AR) is used to examine BIM as an organizational transformation process, as in Arayici et al. (2011) for an architectural SME and in Hochscheid & Halin (2020) for French architecture firms. Additional studies explore collaboration between BIM and Lean experts (Davoudabadi et al., 2022), obstacles to BIM implementation in Middle Eastern contexts using Grounded Theory (Altassan et al., 2023), and multi-level workflow analysis through process mapping and Social Network Analysis (Bonanomi, 2019). Taken together, these contributions show that BIM implementation in design firms is not a uniform or linear process but a complex organizational transformation, typically examined in the early and intermediate stages of digital transition. The literature increasingly recognizes the value of socio-technical perspectives, often supported by mixed methods (Figure 2), to understand the interplay between practices, technologies, and organizational structures. Within this context, the introduction of Actor-Network Theory (ANT) represents an innovative and still underexplored contribution, offering a framework capable of capturing the heterogeneous networks of human and non-human actors that shape BIM implementation in design firms.

Table 2: Research methods of design-firm studies

Research methods	Authors
Literature review + questionnaire	Chan (2014), Ahuja et al. (2016), Bolpagni et al. (2017), Abd Hamid et al. (2020), Troiani et al. (2020), Tehami & Seddiki (2023), AlBalkhy et al. (2023), Sadeh et al. (2021)
TOE framework + DOI	Wang et al. (2022)
Literature review + questionnaire + interviews	Liu et al. (2020)
Organizational readiness framework + MIT90s framework + BIM maturity literature + interviews	Tong et al. (2021)
Literature review + interviews	Travaglini et al. (2014)
AR + case study	Arayici et al. (2011)
AR + case study + interviews	Hochscheid & Halin (2018, 2020)
Secondary research + case study + interviews	Davoudabadi et al. (2022)
GT + interviews	Altassan et al. (2023)
Literature review	Bonanomi (2019)

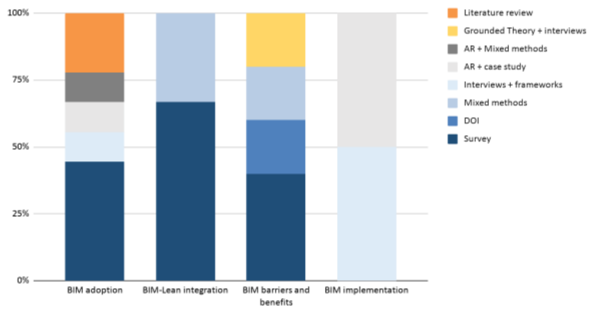

Figure 2: Thematic areas identified across the selected studies

AI application in design

The rapid growth of interest in AI-based solutions in recent years is largely driven by the widespread availability of tools such as ChatGPT, Claude, and Gemini, which have popularized AI among a broad audience despite being primarily individual, user-oriented systems. In contrast, organizations require AI solutions capable of operating within structured workflows, supporting collaborative environments, and integrating with existing information systems. Ma et al. (2025) highlight three organizational conditions that strongly influence AI adoption: collaboration with advanced technology providers, internal R&D capabilities, and continuous staff training. Similarly, Aiudi et al. (2025) show that AI reshapes SMEs' strategic decision-making by increasing decision speed and formalization, although financial, technical, and cultural constraints still limit full integration. These findings indicate that effective AI implementation requires formalized workflows, clear access and usage permissions, alignment with organizational objectives, appropriate technical enablers, human-centered considerations, and external support structures (Proietti, 2025). Within the design domain, AI is progressively shifting practice from intuition-based decision-making toward data-driven and performance-oriented processes. Applications include spatial planning, parametric modeling, generative design, and performance-based analysis, enabling designers to explore broader solution spaces while simultaneously addressing functional, structural, and environmental constraints (Albukhari, 2025). Recent studies highlight the growing influence of generative AI in early design phases, where it supports concept exploration, layout generation, and the rapid production of multiple alternatives, accelerating the translation of project requirements, site conditions, and user intentions into visual and formal proposals (Jang et al., 2025). BIM-based datasets provide a structured foundation for machine learning and deep learning models, supporting applications ranging from facility management and sustainability assessment to energy optimization, cost prediction, Heritage BIM, object-based modeling, and generative design (Alves et al., 2025). Empirical studies confirm this trend: AI-enabled BIM environments can assist designers in evaluating radiation exposure, sun hours, shadow performance, LEED-related indicators, and energy consumption at early stages (Al-Muntaser & Ashur, 2024). Despite these advancements, AI applications remain unevenly distributed across design phases, with design development and construction documentation still comparatively underexplored (Jang et al., 2025). This diversification of AI applications is illustrated in Figure 3, which synthesizes the breadth of AI research across the AEC and design domains in selected studies. The largest segments correspond to consolidated areas such as AI for decision-making and management, AI-BIM for performance simulation, and generative design workflows, confirming the centrality of AI in supporting analytical and early-stage design tasks. Other segments represent emerging or specialized domains - including bio-inspired computational design, knowledge-driven generative modeling - indicating a progressive expansion of AI beyond purely technical tasks toward cognitive, pedagogical, and biomimetic applications. The presence of categories such as AI for construction processes, computer vision for the built environment, and AI for BIM lifecycle management demonstrates that AI is increasingly being applied across the entire project lifecycle.

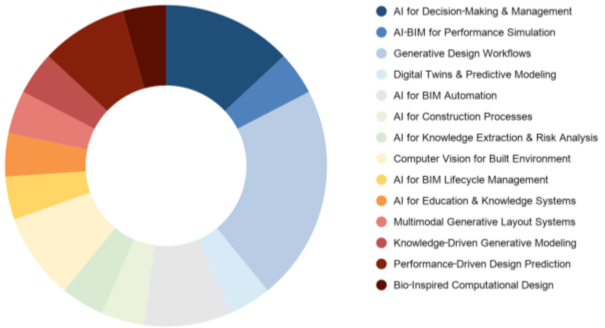

Figure 3: AI Application in design in selected studies

BIM-AI key factors

To compare how the selected studies address the factors influencing BIM-AI implementation, each publication was coded using a four-level scale reflecting the degree of thematic relevance: primary focus (3), substantially discussed (2), mentioned (1), and not addressed (0). This coding system enables a comparative reading of the literature by showing not only whether a theme appears, but also the extent to which it is developed within each study. Figure 4 synthesizes these results, illustrating the relative prominence of the key factors across the corpus and highlighting the thematic patterns that characterize current research on BIM-AI integration in design firms.Technology stands out as the most emphasized factor, with the highest proportion of "Primary" coding (60%), confirming that technological readiness - particularly in terms of tools, systems, and digital infrastructures - remains the dominant concern in the literature. Closely related factors such as interoperability-compatibility- complexity and information management also receive high levels of attention, reflecting persistent challenges associated with fragmented digital ecosystems, inconsistent modelling practices, and limited standardization. In the context of AI, these technological constraints become even more critical, as AI-enabled processes depend on structured, accessible, and high-quality data. Organizational factors display a similarly strong presence. Roles and expertise, training, and top management commitment register substantial levels of primary and secondary coding, indicating that human capital, leadership, and internal capability-building are consistently recognized as essential enablers of digital transformation. These findings align with prior research showing that BIM adoption - and, by extension, BIM-AI integration- depends heavily on organizational vision, staff competencies, and structured change management processes. In contrast, market-related factors such as client demand, standards and policies, and market pressure appear with more variability. Their uneven distribution suggests that external influences on BIM-AI adoption differ significantly depending on national regulatory environments, procurement cultures, and the maturity of the surrounding ecosystem. Nonetheless, when these factors are addressed, they emerge as decisive drivers - particularly in contexts where mandates, standards, or procurement requirements act as catalysts for digital transformation. Project-related factors, including project delivery systems, lean principles, and process and project management, appear less frequently in the literature. Their lower coding values highlight a gap in current research, despite the fact that contractual structures, coordination routines, and project governance models can significantly influence how digital tools are mobilized within project networks. Similarly, pilot projects and external partners show the lowest levels of primary coding, indicating that empirical experimentation and inter-organizational collaboration remain underexplored dimensions of BIM-AI research.

Table 3: Coding scale for thematic relevance

Code	Label	Color
3	Primary focus	
2	Substantially discussed	
1	Mentioned	
0	Not addressed	

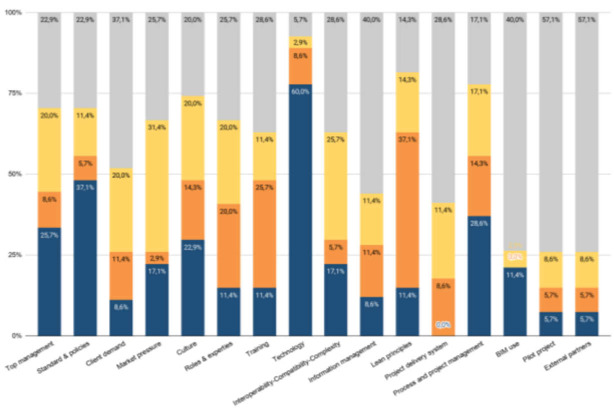

Figure 4: BIM-AI Key factors of the selected studies

The ANT diagram

This study proposes a socio-technical methodology based on ANT to study the BIM-AI implementation in design firms. The proposed ANT diagram is structured into four macro-areas that synthesize the main key factors identified in the literature. These key factors are organised into stakeholders characteristics ("human"), market, project, and technology characteristics ("non-human") (Figure 5), and are further articulated into two additional subgroups:

1. Stakeholders characteristics: internal and external;
1. Market characteristics: standard & regulations and environmental & socio-cultural factors;
2. Project characteristics: project delivery systems and project management;
3. Technology characteristics: BIM and AI.

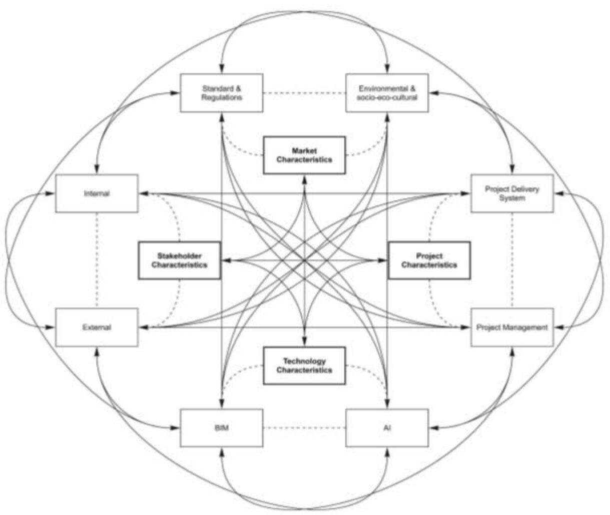

Figure 5: ANT diagram

This structure supports future analysis and enables the examination of social composition and decomposition of key actors. Also, the ANT diagram helps the research team to use the connections between the identified actors as a basis to formulate the questions for semi-structured interviews and case studies.

Stakeholder characteristics

As part of the ANT diagram development, the research team classified stakeholders involved in design, construction, and operation processes. Table 4 provides a summary of the identified human actors categorized into an "Internal stakeholders" and "External stakeholders".

Table 4: Stakeholder characteristics components

Internal stakeholders	External stakeholders
Public/Private owners	Local/National authorities
Trade unions	Regulatory/Permitting agencies
Architect	Insurance companies
Engineer	Financial institutions
Project manager	Environmental agencies
BIM professionals	Public community
General contractor	Technology vendors
Consultants	Real estate stakeholders
Surveyors/GIS experts	Utility providers
Fabricators/Suppliers	Academic/Professional training providers
Facility operators	
ICT/IT department	

Market characteristics

Table 5 provides a summary of the identified Market characteristics ("non-human" actors) categorized into "Standard & regulations" and "Environmental & socio-cultural factors".

Table 5: Market characteristics components

Standard & regulations	Environmental & socio-cultural factors
National legislation	Sustainability & environmental policies
Mandatory regulations	Education & training culture
Technical standards/codes	Professional/Digital readiness
BIM standards	Cultural attitudes
Design and construction guidelines	Local demand
Facility management protocols	Economic factors
Government Digitalization Programs	
Data Management Standards	

Project characteristics

Although the literature has extensively examined organizational, technological, and human-related factors, the role of the Project Delivery System remains relatively underexplored. For this reason, its inclusion among the key components of the network represents a relevant and innovative contribution. Table 6 reflects this advancement by categorizing project characteristics into "Project management" and "Project delivery system".

Table 6: Project characteristics components

Project management	Project delivery system
Project objectives	Design Build (DB)
Design management	Design Bid Build (DBB)
Quality control	Construction Manager at Risk (CM@R)
Model-based coordination practices	Integrated Project Delivery (IPD)
Lean principles	
Integrated information flows	
Decision-making	

Technology characteristics

Table 7 provides a summary of the identified Technology characteristics ("non-human" actors) categorized into "BIM" and "AI".

Table 7: Technology characteristics components

BIM Use Case	AI General use
Concept	Generation, review and synthesis of texts and documents
Rendering	Generation of images and graphic content
Design and Modelling	Transcription and analysis of meeting notes

Analysis and Simulation	Workflow automation
Collaboration & Coordination	Data analytics & BI
Time Scheduling (4D)	**AI Domain-specific use**
Cost Estimation (5D)	Generative design and design optioning
	Automated documentation
	Visual programming & parametric modeling
	Security, analytics and computer vision
	Rendering
	Model coordination
	Scan-to-BIM

Discussion

The literature on BIM implementation within design firms has predominantly examined barriers, adoption levels, benefits, and internal organizational dynamics. While these studies offer valuable insights, they often adopt an inward-looking perspective that frames BIM primarily as a technical or managerial issue. By contrast, the ANT lens adopted in this study shifts attention toward the heterogeneous network of relations that shape the implementation of new processes, technologies, and standards. Through ANT, BIM-AI integration emerges as a socio-technical reconfiguration involving negotiations, translations, and alignments among multiple actors. The ANT diagram developed in this research operationalizes this perspective by making visible the connections across stakeholder groups, technological components, market conditions, and project characteristics. These connections provide the analytical basis for investigating how specific relationships influence BIM-AI adoption. For example, linking internal stakeholders (e.g., BIM professionals) with AI general uses (e.g., workflow automation) highlights how modelling practices may be reshaped by automated processes and what organizational conditions support such transitions. Similarly, connecting standards and regulations with AI domain-specific uses (e.g., security and analytics) underscores the importance of protocols, data governance, and regulatory frameworks in enabling responsible AI integration. The interplay between project management practices (e.g., lean principles) and AI-enabled analytics illustrates how information flows, decision-making routines, and continuous improvement processes evolve when AI tools are introduced. Likewise, examining project delivery systems alongside BIM-AI objectives clarifies how contractual structures and collaboration models influence technological adoption. Finally, connecting internal stakeholders with AI domain-specific uses supports an investigation of how organizations plan to embed AI within BIM workflows, redistribute responsibilities, and develop new competencies. Overall, these insights address RQ1 by showing that BIM implementation in design firms is best understood as a dynamic socio-technical process and by demonstrating how ANT can structure their analysis. They address RQ2 by identifying the key factors that influence BIM-AI integration. These findings provide a structured foundation for the empirical phase of the research, where the ANT-based framework will be tested and refined across different organizational contexts.

Conclusions

This study proposes an ANT-based diagram to support researchers in analyzing how AI becomes integrated within BIM processes in design firms. The main contribution lies in the development of a structured methodology that applies an ANT lens to interpret the sociotechnical relationships that enable or hinder BIM-AI implementation. By positioning human and non-human actors at the same analytical level, ANT provides a robust and transferable framework capable of capturing how technologies, standards, roles, and organizational routines interact during implementation. The proposed diagram serves as the conceptual foundation for the next phase of the research, which will involve empirical investigations through semi-structured interviews and case studies across different organizational contexts. This subsequent phase will allow the research team to test and refine the framework, assessing its ability to identify enabling conditions, tensions, and translation processes within BIM-AI networks. The expected outcomes will advance current knowledge on BIM implementation by offering an interpretative tool that supports both academic inquiry and professional practice in the AECO sector. Overall, the study contributes a novel sociotechnical perspective to the emerging field of BIM-AI integration and provides a methodological pathway for future empirical work.

Acknowledgments

This doctoral research is funded under the Italian National Recovery and Resilience Plan (PNRR) by the European Union through the NextGenerationEU, and co-funded by a design firm. The author wishes to express her gratitude to the organization that hosted the research stay abroad for the support provided to the activities.

References

Abd Hamid, A. B., Embi, M. R., Mohd Taib, M. Z., & Abdul Razak, A. H. N. (2020). Enhancing the knowledge and proficiency for interior designers in Malaysia through the implementation of Building Information Modelling. IOP Conference Series: Materials Science and Engineering, 713, 012047.

Ahuja, R., Jain, M., Sawhney, A., & Arif, M. (2016). Adoption of BIM by architectural firms in India: Technology-organization-environment perspective. Architectural Engineering and Design Management, 12(4), 311–330.

Aiudi, A., Francioni, B., Kyrdoda, Y., & Amerio, S. (2025). The role of artificial intelligence in international strategic decision-making for SMEs. Journal of Strategy and Management. Advance online publication.

Al-Muntaser, N. S., & Ashur, S. A. (2024). Assessment of the integration of artificial intelligence (AI) into Building Information Modeling (BIM) for smart construction management and decision-making. In Proceedings of the 2024 ASEE North Central Section Conference. American Society for Engineering Education.

AlBalkhy, W., Chaize, E., Morael, V., Lafhaj, Z., & Iordanova, I. (2023). Lean construction and Building Information Modeling (BIM) in design management: Survey results from French companies. In Proceedings of the 31st Annual Conference of the International Group for Lean Construction (IGLC31) (pp. 220–229).

Albukhari, I. N. (2025). The role of artificial intelligence (AI) in architectural design: A systematic review of emerging technologies and applications. Journal of Umm Al-Qura University for Engineering and Architecture. Advance online publication.

Alnaser, A. A., Hassan Ali, A., Elmousalami, H. H., Elyamany, A., & Gouda Mohamed, A. (2024). Assessment framework for BIM-Digital Twin readiness in the construction industry. Buildings, 14(1), 268.

Altassan, A., Othman, M., Elbeltagi, E., Abdelshakor, M., & Ehab, A. (2023). A qualitative investigation of the obstacles inherent in the implementation of Building Information Modeling (BIM). Buildings, 13(3), 700.

Alves, T., Goia, F., Mahdjoubi, L., Delgado, J. M. D., Vieira, A. S., & Bragança, L. (2025). Towards an integrative framework for BIM and artificial intelligence capabilities in smart architectural and urban design. Sustainable Cities and Society, 113, 105010.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. (2011). BIM adoption and implementation for architectural practices. Structural Survey, 29(1), 7–25.

Attia, A. R. (2025). The impact of integrating artificial intelligence and Building Information Modeling (BIM) systems on the development of construction methodologies. Journal of Umm Al-Qura University for Engineering and Architecture. Advance online publication.

Bolpagni, M., Burdi, L., & Ciribini, A. L. C. (2017). The implementation of Building Information Modelling and Lean Construction in design firms in Massachusetts and its correlation with client's requirements. In K. Walsh, R. Sacks, & I. Brilakis (Eds.), Proceedings of the 25th Annual Conference of the International Group for Lean Construction (IGLC) (pp. 235–242).

Bolpagni, M., Bartoletti, I., & Ciribini, A. L. C. (2021). Artificial intelligence in the construction industry: Adoption, benefits and risks. In Proceedings of the CIB W78 Conference 2021. Luxembourg.

Bonanomi, M. M. (2019). A systematic methodology for change management: Proposal for a digital transformation support. In Digital transformation of multidisciplinary design firms (pp. 37–47). Springer.

Cavka, H. B., Staub-French, S., & Pottinger, R. (2015). Evaluating the alignment of organizational and project contexts for BIM adoption: A case study of a large owner organization. Buildings, 5(4), 1265–1300.

Chan, C. T. W. (2014). Barriers of implementing BIM in construction industry from the designers' perspective: A Hong Kong experience. Journal of System and Management Sciences, 4(2), 24–40.

Chen, K., Zhou, X., Bao, Z., Skibniewski, M. J., & Fang, W. (2024). Artificial intelligence in infrastructure construction: A critical review. Frontiers of Engineering Management. Advance online publication.

Davoudabadi, S., Pedo, B., Tezel, A., & Koskela, L. (2022). A cognitive review for improving the collaboration between BIM and Lean experts. In Proceedings of the 30th Annual Conference of the International Group for Lean Construction (IGLC30) (pp. 669–680).

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2008). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers, and contractors (1st ed.). John Wiley & Sons.

Edirisinghe, R., Pablo, Z., Anumba, C., & Tereno, S. (2021). An actor–network approach to developing a life cycle BIM maturity model (LCBMM). Sustainability, 13(23), 13273.

El Masry, M., & Chronéer, D. (2025). Obstacles to BIM adoption in construction production: A study of Swedish construction contractors' experiences. International Journal of Construction Management. Advance online publication.

Frank, E. W., Dahy, H., & Sánchez Vibæk, K. (2022). Challenges in creating a sustainable building certificate for single-family housing in Denmark through an Actor-Network Theory (ANT) lens. Current Research in Environmental Sustainability, 4, 100144.

Hamarashid, R. (2021). Challenges of implementing digital tools in a municipality: The case of BIM in the land allocation process (Master's thesis). Jönköping University, School of Engineering.

Hochscheid, E., & Halin, G. (2018). BIM implementation in architecture firms: Interviews, case studies and action research used to build a method that facilitates implementation of BIM processes and tools. In Proceedings of the 36th eCAADe Conference (pp. 231–240).

Hochscheid, E., & Halin, G. (2020). Generic and SME-specific factors that influence the BIM adoption process: An overview that highlights gaps in the literature. Frontiers of Engineering Management, 7(1), 119–130.

Jang, J., Kim, H., Lee, S., & Kim, J. (2025). Generative AI in architectural design: Application, data, and evaluation methods.

Latour, B. (2005). Reassembling the social: An introduction to actor-network-theory. Oxford University Press.

Lindblad, H., & Vass, S. (2015). BIM implementation and organisational change: A case study of a large Swedish public client. Procedia Economics and Finance, 21, 178–184.

Liu, Z., Wang, Y., Osmani, M., & Demian, P. (2020). Leveraging micro-level Building Information Modeling for managing sustainable design: United Kingdom experience. Advances in Civil Engineering, 2020, Article 3641950.

London, K., & Pablo, Z. (2017). An actor-network theory approach to developing an expanded conceptualization of collaboration in industrialized building housing construction. Construction Management and Economics, 35(8–9), 553–577.

Ma, L., Zhao, X., Jiang, R., Wu, C., Liao, L., Yang, Z., & Tan, J. (2025). Adopting large language models in the construction industry: Drivers, barriers, and strategic implications from China. Buildings, 15(23), 4296.

Pettigrew, A. M. (1987). Context and action in the transformation of the firm. Journal of Management Studies, 24(6), 649–670.

Proietti, S., & Magnani, R. (2025). Assessing AI adoption and digitalization in SMEs: A framework for implementation. arXiv.

Raj, K., Mastrolembo Ventura, S., Comai, S., & Ciribini, A. L. C. (2025). Toward a sustainable and efficient design process: A BIM-based organisational framework for public agencies—An Italian case study. Sustainability, 17(15), 6716.

Rydin, Y. (2013). Using Actor-Network Theory to understand planning practice: Exploring relationships between actants in regulating low-carbon commercial development. Planning Theory, 12(1), 23–45.

Sadeh, H., Mirarchi, C., & Pavan, A. (2021). BIM implementation for micro, small and medium-sized enterprises. In Proceedings of the 2021 European Conference on Computing in Construction (EC3) (pp. 1–8).

Succar, B., & Kassem, M. (2015). Macro-BIM adoption: Conceptual structures. Automation in Construction, 57, 64–79.

Tehami, M., & Seddiki, M. (2023). Investigation toward the adoption of Building Information Modelling in Algeria from architects' perspective. Journal of Construction in Developing Countries, 28(2), 329-352.

The American Institute of Architects. (2024). The architect's journey to specification: Artificial intelligence adoption in architecture firms-Opportunities & risks. AIA.

Tong, N., & Phung, Q. (2021). Developing an organizational readiness framework for BIM implementation in large design companies. International Journal of Sustainable Construction Engineering and Technology, 12(3), 57–67.

Troiani, E., Mahamadu, A.-M., Manu, P., Kissi, E., Aigbavboa, C., & Oti, A. (2020). Macro-maturity factors and their influence on micro-level BIM implementation within design firms in Italy. Architectural Engineering and Design Management, 16(3), 209–226.

Wang, Z., Liu, Z., & Liu, J. (2022). Innovation strategy or policy pressure? The motivations of BIM adoption in China's AEC enterprises. Journal of Asian Architecture and Building Engineering, 21(4), 1578–1589.

Wang, X., Zhao, Y., Zhang, W., Li, Y., Shi, X., Xia, R., Su, Y., Li, X., & Xu, X. (2025). Artificial Intelligence-Based Architectural Design (AIAD): An influence mechanism analysis for the new technology using the hybrid multi-criteria decision-making framework. Buildings, 15(21), 3898.