

A Systematic Review of Current Risk Assessment Practices in Construction Projects

Maureen Ambrose ¹, Nur Fadilah Darmansah ², Azilah Baddiri ²

¹ Postgraduate Student, Universiti Malaysia Sabah, 88400, Kota Kinabalu Sabah Malaysia

² Universiti Malaysia Sabah, 88400, Kota Kinabalu Malaysia

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ABSTRACT

Purpose: This systematic review examines current risk assessment practices in construction projects, analyzing methodological approaches, technological integration, and thematic priorities in literature published between 2020 and 2026. The study aims to identify prevailing risk assessment practices and research gaps while providing a comparative analysis of methodological evolution.

Methodology: Following PRISMA guidelines, a systematic literature review was conducted across Scopus, Web of Science, and Dimensions databases. The search targeted peer-reviewed articles on construction project risk assessment published from January 2020 to February 2026. From 847 initial records, 187 articles met inclusion criteria and were analyzed using bibliometric and content analysis methods with inter-reviewer agreement validation.

Findings: Analysis reveals quantitative methods dominate (47%), followed by qualitative (32%) and mixed-methods (21%). Current practices comprise traditional techniques (31%), advanced methods including AI and machine learning (37%), hybrid approaches (18%), and real-time assessment (14%). Advanced methods demonstrate 15–25% higher prediction accuracy but face implementation barriers including data requirements and interpretability challenges. Real-time assessment, despite 35–50% accident reduction potential in trials, remains limited due to cost and infrastructure constraints. Significantly, 65% of studies exclude post-construction variables, and developing economies remain underrepresented (24%).

Originality: This review provides the first comprehensive synthesis of risk assessment practices spanning 2020–2026, quantifying methodological trends and identifying that 65% of studies lack integration of post-construction variables. The findings establish a baseline for understanding the evolution toward technology-enabled, proactive risk assessment frameworks in construction projects.

Keywords: Risk assessment, risk estimation, hazard identification, construction projects, systematic review, quantitative methods, artificial intelligence, sustainable risk management

INTRODUCTION

The construction company operates in conditions marked by widespread uncertainty, where proficient risk management is essential for determining project success or failure. Risk assessment, fundamental to risk management, is the methodical identification, analysis, and evaluation of potential hazards that could affect project objectives (Almashhour et al., 2025). Despite extensive research and practice over several decades, building projects still encounter substantial cost overruns, schedule delays, and safety mishaps, indicating enduring discrepancies between theoretical frameworks and practical execution.

The scale of these challenges is significant. Research demonstrates that 55% of construction projects and 65% of public infrastructure projects in developing economies experience cost overruns (Yussif et al., 2025). Conventional construction generates approximately 35% of global waste, whereas sustainable techniques demonstrate potential to reduce waste by 50% during construction phases (Yussif et al., 2025). These statistics

underscore the critical need for robust risk assessment approaches adapted to contemporary construction environments.

Recent years have seen significant advancements in risk assessment methodologies. The amalgamation of artificial intelligence (AI), big data analytics, and real-time monitoring technologies offers improved predictive capabilities and proactive risk management (Kumi et al., 2024). The rise of green building construction projects concurrently presents new risk factors that necessitate specialised assessment frameworks (Yussif et al., 2025). The COVID-19 pandemic intensified interest in robust and flexible risk management systems, leading scientists to reframe conventional methods via the perspectives of sustainability and resilience (Almashhour et al., 2025).

Research Gap and Novelty

Despite increasing academic interest, the current literature lacks a systematic synthesis that compares the methodological evolution of traditional, advanced, hybrid, and real-time approaches. Previous reviews investigate individual strategies (Kumi et al., 2024; Almashhour et al., 2025) yet do not offer a comparative examination of their respective strengths, limitations, and contextual relevance. Moreover, no thorough assessment examines the trade-offs among accuracy, implementation cost, and scalability, which are essential factors for industry adoption. This review specifically addresses three significant gaps: (1) a systematic comparison of four methodological categories utilising quantifiable performance metrics, (2) a trade-off analysis evaluating implementation feasibility across diverse project contexts, and (3) the identification of technology integration pathways and barriers to adoption.

Current Risk Assessment Practices

Traditional Risk Assessment Methods

Traditional risk assessment approaches remain prevalent owing to their established framework, regulatory endorsement, and reduced implementation expenses. Fault Tree Analysis (FTA) delineates the root causes of accidents by depicting the interconnections between equipment failures and dangers (Kabir et al., 2020). Researchers have used Fault Tree Analysis to examine tower crane falls and scaffolding failures (Wang et al., 2022; Aljassmi et al., 2013). Failure Mode and Effects Analysis (FMEA) predicts likely failures prior to their occurrence. Hassan et al. (2022) utilised FMEA to discern risks in high-rise buildings that traditional checklists failed to recognise. Recent iterations integrate FMEA with fuzzy logic to more effectively address uncertainty (Chen & Lee, 2023), enabling a nuanced analysis of ambiguously defined or non-quantifiable risks.

The Analytic Hierarchy Process (AHP) aids decision-makers in assessing various risks via significance weighting. Darko et al. (2020) discovered that 42% of infrastructure projects utilise AHP for risk assessment. Researchers have employed AHP in public-private partnerships and sustainable construction projects (Li et al., 2018; Nguyen & Macchion, 2023). Risk matrices, fundamental diagrams depicting probability and outcomes, continue to be extensively utilised despite their constraints. Bao et al. (2023) improved traditional matrices by using fuzzy bounds to more accurately depict variable site conditions. Checklists and risk registers provide systematic risk documentation; Wuni and Shen (2022) created specialised checklists for modular building projects. Traditional methods provide numerous benefits, including governmental approval, fewer training demands, and accessibility for small- to medium-sized firms. Nonetheless, they exhibit considerable limitations: they see risks as static in spite of dynamic building settings, rely on subjective judgement prone to cognitive biases, and fail to reflect intricate risk interrelationships adequately (Aljassmi et al., 2013). These inadequacies illustrate academics' growing amalgamation of traditional approaches with modern technologies to improve decision-making and reduce evaluation biases.

Advanced Risk Assessment Methods

Advanced techniques employing artificial intelligence and machine learning provide improved accuracy and the ability to handle large data sets. Machine learning comprises 45% of advanced methodological research, forecasting risks with 15–25% greater accuracy than traditional methods (Kumi et al., 2024). Deep learning evaluates construction site images for safety infractions with an accuracy of 87% (Akinosho et al., 2020). Natural

language processing examines accident reports to discern emerging risk patterns (Resende et al., 2024). Predictive models anticipate project delays four weeks ahead utilising real-time data (Zhong et al., 2022).

Bayesian networks are present in 23% of advanced research publications. These models demonstrate causal links between dangers and revise predictions as new information becomes available, which is crucial for effectively managing risks in projects like tunnel construction and pipeline developments. Zhang et al. (2021) employed Bayesian networks to assess tunnel construction risks in the context of geological conditions and monitoring data. Kabir et al. (2022) examined 43 unique risks associated with pipeline developments, including environmental impacts, regulatory challenges, and technological failures that can affect project outcomes. Fuzzy logic tackles confusing terminology in risk assessment, demonstrating notable efficacy in multinational projects marked by increased uncertainty (Celik et al., 2023; Moheimani et al., 2024), particularly in clarifying risk factors and improving decision-making processes in complex environments. Big data analytics analyses previous project data to identify predictors of cost overruns (Adebayo et al., 2025). Although sophisticated approaches exhibit enhanced accuracy and predictive capacities, they encounter considerable implementation obstacles. These procedures necessitate significant amounts of high-quality data, which is sometimes inaccessible at standard construction sites. Numerous AI technologies operate as "black boxes", concealing their decision-making mechanisms and undermining industry confidence in their results. Furthermore, execution involves considerable setup expenses and necessitates specialised competence (Albasyouni et al., 2025), hence limiting their application to large enterprises and research projects rather than conventional construction practices.

Hybrid Risk Assessment Models

Hybrid models integrate many methodologies to optimise the advantages of each. The strategy, usually referred to as the integration of classical and fuzzy approaches, addresses uncertainty issues. Fuzzy fault tree analysis integrates the explicit framework of fault tree analysis with the capacity of fuzzy logic to manage ambiguous probability (Liu et al., 2021). Susanto et al. (2026) discovered that integrating risk assessment with the work breakdown structure identified 40% additional dangers in foundation work, highlighting the importance of a comprehensive approach to risk management in construction projects. Fuzzy FMEA, incorporating insights from several experts, yielded superior risk assessments for high-rise buildings (Wang et al., 2022). The integration of simulation and analysis yields superior outcomes compared to each method in isolation. Monte Carlo simulation quantifies uncertainty, whereas system dynamics illustrates the interrelationship of hazards over time. Nasirzadeh et al. (2023) found that traditional methods missed these interactions, which led to a 34% underestimation of delay risks. Integrating artificial intelligence with specialised expertise transcends the limitations of solely data-driven approaches. Choi et al. (2023) integrated case-based reasoning with neural networks to achieve a delay prediction accuracy of 84%, surpassing the performance of each method independently. Medaa et al. (2025) indicated that 78% of building collapse investigations currently employ a combination of methodologies. Incorporating risk assessment into BIM transforms building models into instruments for risk management. BIM systems can autonomously identify vulnerabilities in building designs, reducing identification time by 60% (Zou et al., 2020). Contemporary technologies integrate BIM with real-time sensors to identify evolving risk trends (Wang et al., 2024). Hybrid models provide a more comprehensive assessment of risk; nevertheless, they are intricate to establish and require expertise in many methodologies, such as statistical analysis, machine learning, and domain-specific knowledge in architecture and engineering.

Real-Time Risk Assessment Methods

Real-time risk assessment represents an emerging evaluation paradigm for construction projects. Given constantly evolving site conditions, monitoring risks in real-time is prudent, though obstacles including high costs and inconsistent site connectivity impede progress. Sensor systems constitute 55% of real-time research. Wearable devices monitor worker location and physiological indicators. Proximity alerts when workers approach machinery reduce incidents by 47% (Awolusi et al., 2020). Positioning systems detect hazardous worker-equipment proximity with 91% accuracy (Li et al., 2021). Environmental sensors monitor dust, noise, and temperature, reducing exposure incidents by 35% (Kang et al., 2021). Smart helmets identify worker fatigue before accidents occur (Hwang et al., 2023). Computer vision comprises 32% of real-time research. Camera systems with intelligent algorithms assess personal protective equipment compliance with 82% accuracy (Fang et al., 2020). Systems identify hazardous ladder use and excavation risks (Han & Lee, 2022). Integrating camera

views with architectural models detects personnel in restricted zones with 88% precision (Chen, H., 2024). IoT platforms integrate these components, with edge computing enabling on-site data processing for immediate alerts (Ojghaz et al., 2024). Digital twins provide virtual site replicas that continuously update risk assessments (Almatared et al., 2023). Preliminary trials indicate real-time systems could reduce accidents by 35–50% (Pereira et al., 2026). However, sensors malfunction in abrasive, dusty environments; workers express privacy concerns; and managers require training to manage continuous alerts. As costs decrease and evidence accumulates, real-time assessment is expected to proliferate.

METHODOLOGY

Review Protocol

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency. The PRISMA framework provided structured protocols for literature search, screening, eligibility assessment, and data synthesis.

Search Strategy

Comprehensive literature searches were conducted in three academic databases: Scopus, Web of Science, and Dimensions. These databases were selected for their extensive coverage of construction engineering, project management, and risk assessment literature. The search strategy combined keywords related to construction projects, risk assessment methodologies, and publication timeframe

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they met the following criteria: (a) specifically addressed risk assessment in construction project contexts; (b) presented original empirical research or systematic reviews with clear methodological descriptions; (c) were published in English; and (d) appeared in peer-reviewed journals or conference proceedings. Conversely, studies were excluded if they: (a) discussed risk management without a specific focus on assessment phases; (b) explored contexts beyond the construction sector; (c) comprised editorials, commentaries, or book reviews devoid of empirical or analytical content; or (d) had inaccessible full texts.

Screening and Selection Process

The screening process involved four stages. Database searches initially yielded 847 potentially relevant records. After removing 234 duplicates, 613 records proceeded to title and abstract screening, which excluded 356 records that did not meet inclusion criteria.

The remaining 257 articles underwent full-text eligibility assessment, with two independent reviewers conducting screening and achieving 89% inter-reviewer agreement. The 11% of disagreements were resolved through discussion with a third reviewer. To minimize selection bias, search results were systematically documented, and exclusion reasons were recorded for all full-text rejections. Detailed full-text evaluation resulted in exclusion of 70 articles due to insufficient methodological focus or peripheral relevance to risk assessment, yielding a final sample of 187 studies meeting all inclusion criteria.

Data Extraction and Analysis

A standardized data extraction form captured: publication details (authors, year, journal), research context (project type, geographic focus), risk assessment methodology (qualitative, quantitative, mixed), specific techniques employed (e.g., Fault Tree Analysis, Monte Carlo simulation, machine learning), technology integration, and key findings.

Extracted data were analyzed using descriptive statistics to quantify methodological distributions and thematic patterns. Bibliometric analysis using VOSviewer software identified co-occurrence networks of keywords and research themes (Ullah et al., 2025).

RESULTS AND DISCUSSION

Publication Trends and Geographic Distribution

Analysis of the 187 included studies revealed growing scholarly attention to construction risk assessment between 2020 and 2026. Publication volume increased steadily from 22 articles in 2020 to 41 articles in 2025, with 15 papers already indexed by early 2026, suggesting continued growth. This upward trajectory reflects increased recognition of risk assessment's critical role and the emergence of innovative methodological approaches. Geographically, research originated from 38 countries, with highest contributions from China (31%), the United States (18%), the United Kingdom (12%), and Australia (8%). Developing economies contributed 24% of studies. However, Yussif et al. (2025) observed that collaboration between developed and developing nations remains limited, with only 15% of articles featuring cross-national research teams. This gap constrains knowledge transfer and method adaptation across different regulatory, economic, and cultural contexts.

Distribution of Research Methodologies related Risk Assessments

Quantitative methods dominated the literature, employed in 47% (n=88) of reviewed studies. These approaches encompassed statistical analysis, mathematical modeling, simulation techniques, and AI applications. Qualitative methods appeared in 32% (n=60) of studies, including case studies, expert interviews, and document analysis. Mixed-methods approaches constituted 21% (n=39) of the sample. The predominance of quantitative methods reflects growing emphasis on objective, data-driven assessment. Kumi et al. (2024) noted that statistical methods appear in 38% of quantitative studies examining risk factor relationships. Mathematical modeling techniques feature in 27% of quantitative research, while simulation methods are employed in 22%. However, qualitative and mixed methods approaches maintain significance for exploring contextual factors and stakeholder perspectives that quantitative techniques may overlook.

Current Risk Assessment Practices in Construction Project

Analysis of 187 studies on current risk assessment methodologies in construction projects reveals the distribution of methodological approaches. Table 1, comparative analysis of risk assessment Methodologies. Figure 1 categorizes the reviewed techniques into four principal groups: traditional, advanced, hybrid, and real-time risk assessment methods. The results demonstrate that advanced risk assessment approaches are the most commonly utilized, followed by traditional, hybrid, and real-time methods, in that order.

Table 1. Comparative Analysis of Risk Assessment Methodologies

Method Category	Key Techniques	Advantages	Limitations	Adoption (%)	Maturity Level	Relative Cost	Scalability
Traditional	FTA, FMEA, AHP, Risk Matrices, Checklists	Regulatory acceptance; Low cost; Minimal training; Accessible to SMEs	Static representation; Subjective bias; Poor handling of interdependencies	31%	Mature	Low	Limited
Advanced (AI/ML)	Neural Networks, Bayesian Networks, NLP, Big Data	15–25% higher accuracy; Pattern recognition; Predictive capability	Data hunger; Black-box opacity; High setup costs; Expertise required	37%	Emerging-Mature	High	High

Hybrid	Fuzzy-FTA, Fuzzy-FMEA, BIM Integration, System Dynamics	Comprehensive coverage; Synergistic advantages; 40% better hazard detection	Complexity; Multiple expertise needed; Integration challenges	18%	Developing	Medium-High	Medium
Real-time	IoT Sensors, Computer Vision, Wearables, Digital Twins	35–50% accident reduction; Immediate alerts; Continuous monitoring	Infrastructure requirements; Privacy concerns; Data reliability issues	14%	Emerging	High	Medium

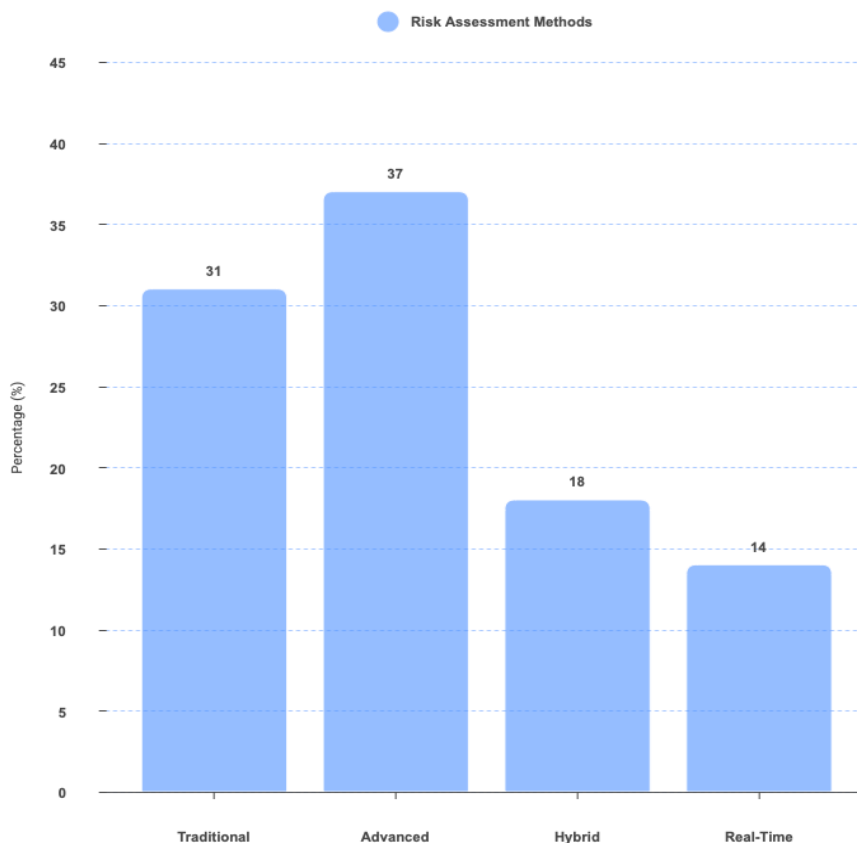


Figure 1. Percentage of current risk assessment methods

Advanced Risk Assessment Methods

Advanced techniques were present in 37% (n=69) of the analysed papers, surpassing traditional methods and signifying a shift towards technology-driven evaluations. Machine learning for risk prediction was the primary category, accounting for 45% of advanced method investigations. Neural networks attained 82% accuracy in predicting safety occurrences when trained on comprehensive datasets (Kumi et al., 2024). Such algorithms could revolutionise safety management from reactive investigation to proactive intervention. Bayesian network models (23% of advanced research) provide distinct advantages by integrating probabilistic reasoning with expert knowledge and refining predictions when new information becomes available (Kabir et al., 2022; Zhang et al., 2021). These characteristics are especially beneficial when historical data is scarce and expert knowledge is plentiful.

The transition to advanced methodologies is driven by three converging factors: exponential growth in computational capabilities facilitating complex analysis, enhanced accessibility of digital project data from BIM and IoT sources, and industry demand for more precise predictions in the face of increasing project complexity. The 37% acceptance rate in literature considerably exaggerates actual industry implementation, given the majority of research is experimental rather than operational. Despite evident potential, the industry's preparedness for AI implementation remains inadequate—Poh et al. (2024) found that merely 12% of construction businesses have the requisite data infrastructure and analytical competencies. The disparity between academic advancement and industry application, with 35% of studies proposing AI models yet just 18% incorporating real-world validation, constitutes a significant obstacle necessitating immediate focus from both

Traditional Risk Assessment Methods

Conventional methodologies appeared in 31% (n=59) of investigations. These strategies persist due to validated efficacy across decades of application (Liu et al., 2024), accessibility requiring neither specialized software nor technical expertise—particularly advantageous for small and medium enterprises (Fernández-Muñoz et al., 2024). Regulatory endorsement strengthens their position, as safety standards and insurance mandates explicitly recognize these procedures.

However, conventional approaches encounter well-documented constraints: static representations fail to capture evolving site dynamics (Liu et al., 2024); dependence on subjective expert evaluations includes cognitive biases potentially underestimating certain risk categories (Smith et al., 2022); and limited capacity to manage interdependencies may overlook cascade effects where minor hazards combine for significant repercussions (Kabir et al., 2020).

For standard evaluations of ordinary projects with proficient teams, customary procedures suffice. For complex or high-stakes projects, they should function as foundations upon which more advanced analyses are constructed by researchers and practitioners.

Hybrid Risk Assessment Methods

Hybrid models were present in 18% (n=33) of studies, reflecting an increasing acknowledgement that no singular approach sufficiently encompasses all risk factors. Susanto et al. (2026) demonstrated that the amalgamation of work breakdown structure with risk assessment frameworks improved hazard detection efficacy by 40% compared to isolated approaches, whereas Medaa et al. (2025) reported that 78% of structural collapse studies currently employ integrated computational, qualitative, and data-driven methodologies.

Hybrid approaches leverage synergistic advantages by combining the structured frameworks and stakeholder engagement of traditional methods (Darko et al., 2020), the predictive capabilities and extensive dataset analysis of advanced methodologies (Kumi et al., 2024), and the capacity of qualitative approaches to elucidate contextual subtleties and organisational dynamics (Almashhour et al., 2025).

Successful integration necessitates careful consideration of reconciliation methods to prevent inconsistent outcomes (Kiani et al., 2025). This optimal comprehensiveness incurs heightened complexity, necessitating expertise in several disciplines and extended implementation timescales. Susanto et al. (2026) report a 40% enhancement in hazard detection, which must be considered alongside a 25–30% increase in implementation costs relative to single-method approaches. This trade-off is advantageous for high-value, complex projects, while conventional methods may be adequate for routine applications.

Real-Time Risk Assessment Methods

Only 14% (n=26) of the analysed research concentrated on real-time or near-real-time methodologies, underscoring a significant gap in the literature that starkly contrasts with the swift technological advancements in other fields and suggests construction-specific challenges necessitating investigation (Pereira et al., 2026).

In real-time investigations, sensor-based monitoring constituted 55% of applications, encompassing wearable devices and environmental sensing (Awolusi et al., 2020), whereas computer vision techniques accounted for 32% of real-time research (Fang et al., 2020), and IoT platforms that integrate various data sources were present in 27% of studies (Ding et al., 2020).

According to Pereira et al. (2026), the potential impact is considerable, noting that trial implementations decreased occurrences by 35–50%, suggesting that transitioning from periodic to continuous monitoring could markedly improve safety outcomes. Notwithstanding this encouraging promise, significant obstacles impede widespread implementation.

Data quality challenges in harsh construction environments, such as dust, vibration, temperature fluctuations, and intermittent connectivity, undermine system reliability (Awolusi et al., 2020). Privacy issues related to ongoing employee monitoring present ethical challenges that demand thorough examination (Hwang et al., 2023), while management's ability to respond to real-time alerts requires substantial changes in supervisory practices, including training for supervisors on how to effectively interpret and act on these alerts.

Furthermore, real-time risk assessment technologies are still in the nascent stages of maturity: sensor durability in construction settings is at Technology Readiness Level 6-7, computer vision accuracy under varying conditions is at TRL 5-6, and integrated platform reliability is at TRL 4-5, all necessitating additional development prior to widespread implementation.

CONCLUSION

This systematic review of 187 studies published from 2020 to 2026 offers a thorough examination of contemporary risk assessment methodologies in construction projects. The findings indicate a research environment marked by methodological diversity, technological progress, and ongoing deficiencies that necessitate academic focus. Quantitative methods predominate in contemporary research (47%), indicating a focus on objective, data-driven evaluation.

Nevertheless, qualitative (32%) and mixed-methods (21%) approaches remain crucial for elucidating organisational and human factors. The transition from conventional procedures (31%) to advanced methods such as AI and machine learning (37%) indicates significant revolutionary potential; nevertheless, the use of hybrid (18%) and real-time (14%) assessments remains constrained.

A comparative analysis indicates clear trade-offs: traditional methods ensure accessibility and regulatory approval but lack predictive power; advanced methods deliver enhanced accuracy yet encounter implementation obstacles such as data demands and interpretability issues; hybrid approaches maximise comprehensiveness at the expense of heightened complexity; real-time techniques offer potential safety enhancements but necessitate significant infrastructure investment and raise privacy concerns.

Ongoing deficiencies encompass insufficient focus on post-construction variables (65% of research), inadequate processes for knowledge accumulation (22%), lack of empirical validation for sophisticated methodologies (18%), under-representation of situations in underdeveloped countries (24%), and disjointed technological integration. Addressing these deficiencies necessitates lifecycle assessment frameworks, the development of learning systems, collaborations for practitioner-researcher validation, context-sensitive technique adaptation, and integrated BIM-IoT-AI platforms.

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