

MODERN CONSTRUCTION TECHNOLOGIES AS DRIVERS OF EFFICIENT PROPERTY MANAGEMENT

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Received 20.10.2025; accepted 12.11.2025

Abstract. The construction industry is undergoing rapid technological transformation, creating new opportunities to improve the efficiency, sustainability, and cost-effectiveness of real estate management. This study examines the integration of modern construction methods like Building Information Modelling (BIM), modular construction, 3D printing, and smart building systems, into property management practices in Latvia. Using a mixed-methods approach that incorporates literature review, policy analysis, case studies, and an expert survey, the study evaluates current adoption levels, perceived benefits, and barriers to implementation. Results show that while BIM and smart building technologies are increasingly used and provide measurable improvements in documentation accuracy, maintenance planning, and energy performance, the uptake of industrialised construction methods remains limited. Key obstacles include high initial investment costs, shortages of qualified specialists, fragmented regulations, and low awareness among building owners. Comparative analysis with leading European countries highlights the importance of national digitalisation strategies, mandatory standards, and capacity-building initiatives. The study concludes that modern construction methods have strong potential to enhance life-cycle-based property management in Latvia, but broader adoption requires coordinated policy measures, financial incentives, and improved digital competence across the sector.

Keywords: *3D printing, BIM, modern construction methods, modular construction, property administration, real estate management, smart building systems.*

INTRODUCTION

The rapid transformation of the construction industry in recent decades has significantly influenced practices in real estate management and administration worldwide. With accelerating urbanisation, increasing energy-efficiency requirements, and growing societal demand for sustainable solutions, the management of buildings throughout their life cycle has become one of the key determinants of a high-quality built environment (de Brito & Silva, 2020; Gudac et al., 2025). Modern construction methods, such as Building Information Modelling (BIM), modular construction, 3D printing, and intelligent engineering systems, open new possibilities not only in design and construction but also in the optimisation of building operation and maintenance processes (Waqar et al., 2023;

Eid et al., 2025; Baranda Rodriguez et al., 2025). Their integration enables substantial reductions in operational costs, improved safety and efficiency, and extended building life cycles while providing enhanced user comfort.

In Latvia, the adoption of modern construction technologies is progressing gradually; however, their application in real estate management and administration remains relatively limited. This issue becomes particularly critical in the context of the European Green Deal and the Renovation Wave initiative, which imposes stricter requirements on building energy performance, emissions reduction, and the integration of digital tools in building management (Chaaya et al., 2025; Nowak-Michta, 2023; Rojas-Herrera et al., 2025). At the same time, several challenges persist within the Latvian real estate management sector: high upfront investment costs, shortages of qualified specialists, a fragmented regulatory environment, and a generally low level of digital readiness (Bokalders & Bloka, 2021).

Scientific literature increasingly emphasises that modern construction methods offer substantial benefits for property management, including more accurate monitoring of technical conditions, proactive maintenance planning, reduced operational expenses, and improved decision-making. However, in Latvia, the practical implementation of these approaches and their full impact on real estate management remains insufficiently studied.

The aim of the study is to analyse modern construction methods and their potential to improve real estate management and administration in Latvia, identifying key barriers to implementation and proposing solutions for more effective integration. The study is based on a combination of theoretical literature analysis, international practice review, case studies, and expert surveys, enabling a focused examination of factors that most significantly influence building operation efficiency and long-term sustainability.

This study assumes that the integration of modern construction methods into the real estate sector has the potential to significantly improve building operation, reduce long-term maintenance costs, and enhance sustainability.

Accordingly, the study advances the following hypothesis: the implementation of modern construction methods like BIM, modular construction, 3D printing, and smart building systems, significantly improves the efficiency, sustainability, and cost-effectiveness of real estate management in Latvia.

To examine this hypothesis, the study addresses a set of interconnected questions:

- How widely are modern construction methods currently adopted within Latvia's real estate management sector?
- What barriers (technical, regulatory, financial, and organisational) limit the implementation of modern construction methods in Latvian real estate management?
- How does Latvia's progress in adopting modern construction techniques compare with leading European countries, and what measures could support wider implementation?

The results demonstrate that modern methods can substantially enhance life-cycle-based property management, yet their broader use in Latvia is constrained by

both economic and institutional factors. The article offers practical recommendations for policymakers and industry professionals on how to support the integration of modern solutions to improve energy efficiency, reduce maintenance costs, and promote sustainable development of the built environment.

1. MATERIALS AND METHODS

The study employs a mixed-methods approach that integrates qualitative and quantitative techniques to examine the influence of modern construction methods on real estate management and administration in Latvia. The study is based on several categories of data sources, including scientific and professional literature, national and international policy documents, case studies of construction projects in Latvia, and expert survey responses. The combination of these materials provides a comprehensive basis for evaluating the current level of integration of modern construction technologies and their practical implications for building operation, maintenance, and overall management efficiency.

The theoretical foundation of the study was developed through an extensive review of scientific literature related to real estate management, construction innovation, sustainability, BIM technologies, modular construction, and building life-cycle approaches. The document analysis enabled the identification of conceptual definitions, methodological approaches, and regulatory trends relevant to the integration of modern construction methods in real estate management.

To understand the practical implementation of modern construction technologies, the study employs a comparative case study method. Several recent projects in Latvia that have incorporated advanced construction solutions, were selected for in-depth examination. Project documentation, publicly available technical reports, and developer-provided information were analysed to identify how these modern methods influence construction quality, the accuracy of technical documentation, maintenance needs, and the long-term operation of the buildings. The case studies also enabled the identification of patterns regarding the operational benefits and challenges associated with modern construction solutions in the Latvian context.

The study further incorporates qualitative data obtained through an expert survey conducted among professionals representing construction companies, architectural and engineering firms, real estate management organisations, and public-sector bodies involved in building regulation. The survey consisted of both structured and semi-structured questions, allowing experts to evaluate the applicability, advantages, and barriers associated with the implementation of modern construction methods in real estate management. Open-ended questions invited respondents to provide detailed comments based on their professional experience, helping to identify specific challenges such as high initial costs, insufficient digital competence, fragmented regulatory requirements, and limited awareness among building owners. The survey was distributed via electronic form, and responses were collected anonymously to ensure impartiality and reduce response bias.

Quantitative components of the study were included in the processing of survey results. Numerical responses were analysed using descriptive statistical methods to identify dominant trends, frequency distributions, and correlations between variables such as perceived benefits, barriers, and the level of technology adoption. Data visualisation tools, including charts and graphs generated with Microsoft Excel and the *VisiDati.lv* platform, were used to illustrate the most significant patterns emerging from the dataset. This allowed for a clearer interpretation of expert perceptions and contributed to the validity of the findings.

Analytical methods were applied to synthesize information from the literature review, document analysis, case studies, and survey results. Comparative analysis was used to contrast the Latvian situation with international best practices, particularly those from Scandinavian countries, Germany, and the United Kingdom, where the integration of modern construction technologies into building management is more advanced. This comparison helped identify transferable lessons and potential pathways for improving real estate management in Latvia through technological innovation.

The combination of qualitative and quantitative study techniques ensures methodological triangulation, enhancing the credibility and reliability of the study's conclusions. By relying on multiple types of data and analytical approaches, the study provides a holistic assessment of how modern construction methods influence the efficiency, cost-effectiveness, and sustainability of real estate management throughout the building life cycle. This methodological framework enables the identification of both systemic challenges and practical opportunities for integrating innovative construction solutions into property management processes in Latvia.

2. RESULTS

The results of this study provide a detailed and multi-dimensional understanding of how modern construction methods are currently adopted, perceived, and operationally applied within the Latvian real estate management sector. Drawing on expert survey data, case study findings, and comparative analysis, the results reveal the complex interplay between technological readiness, economic feasibility, regulatory frameworks, and organisational capacity. Together, these dimensions illustrate the potential of modern construction methods to contribute substantially to building lifecycle optimization, while simultaneously highlighting the structural challenges that impede broader implementation.

Survey responses indicate that the adoption landscape across Latvia is notably uneven, with some technologies advancing more rapidly than others. Building Information Modelling stands out as the most established modern construction method, with most experts reporting either high or moderate levels of implementation. This reflects its centrality in digital project planning and its increasingly widespread use in both public procurement and private-sector development. Smart building systems, primarily IoT-based monitoring tools and automated energy management systems, are also gaining traction, particularly in new commercial and mixed-use buildings.

By contrast, industrialised construction methods, such as modular construction and 3D printing, remain at an early stage of development in Latvia, constrained by high investment costs, a lack of specialised production facilities, and limited market demand. These findings are summarised in Table 1, which presents a detailed distribution of the reported adoption levels across the four main categories of modern construction methods provided by 52 experts.

Table 1. The Current Adoption Level of Modern Construction Methods in Latvia, % (created by the authors)

Construction Method	High	Moderate	Low/no
Building Information Modelling	58	34	8
Smart Building Systems (IoT)	42	39	19
Modular Construction	18	36	46
3D Printing Technologies	5	15	80

Beyond simple adoption rates, the results also shed light on the perceived benefits of modern construction technologies for improving real estate management practices. According to expert evaluations, modern methods significantly enhance predictive maintenance capabilities. BIM-driven documentation and digital twins allow facility managers to anticipate component degradation, schedule timely interventions, and minimise unexpected technical failures.

Survey data show that 78 % of respondents consider improved maintenance planning to be the most valuable contribution to modern construction methods. Reduced operating costs were identified by 71 % of experts, while 67 % emphasised improved energy performance. These findings correspond to international patterns observed in Northern Europe, where digitalisation and industrialised methods have long been central to construction sector innovation. A summarised visual distribution of perceived benefits is presented conceptually in Fig. 1, illustrating the prominence of maintenance, cost reduction, and energy efficiency among the reported advantages.

The case study results further substantiate the survey findings by providing quantitative evidence of operational improvements achieved through the implementation of modern construction solutions. In projects where BIM was used intensively, documentation accuracy increased by 45 %, reducing information gaps and discrepancies between design and construction phases. Similarly, buildings incorporating smart monitoring technologies achieved an average of 18 % savings in annual energy consumption and a 35 % reduction in unexpected maintenance events. Lifecycle cost predictability improved by 32 %, driven by more transparent long-term maintenance planning and clearer operational data. These improvements are consolidated in Table 2, which presents the quantified impacts observed across the case studies.

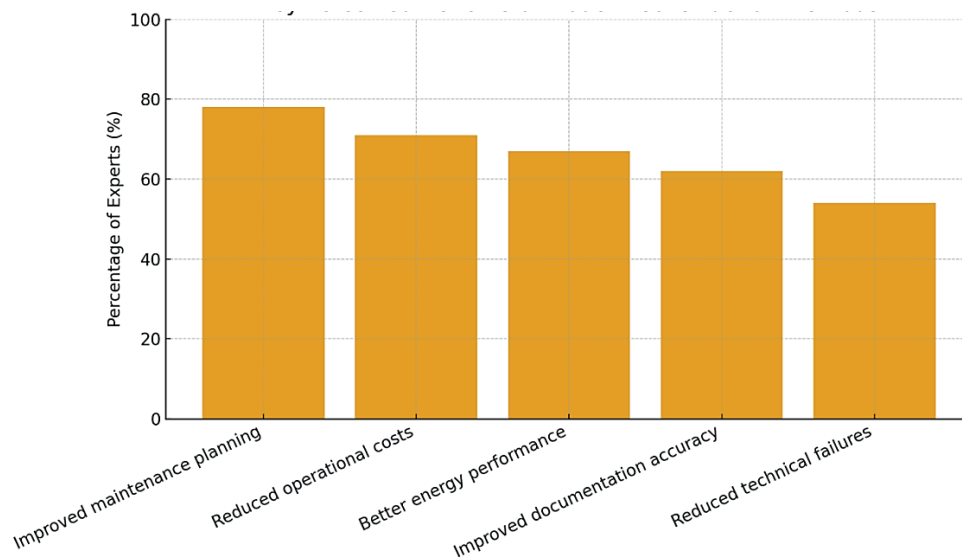


Fig. 1. Key perceived benefits of modern construction methods (created by the authors).

Table 2. Operational Improvements Observed in Case Study Projects (created by the authors)

Improvement Indicator	Average Improvement Observed, %
Reduction in unexpected maintenance events	– 35
Reduction in energy consumption	– 18
Increase in documentation accuracy	+ 45
Improvement in lifecycle cost predictability	+ 32

Despite these demonstrated benefits, experts consistently identified several barriers that hinder the widespread adoption of modern construction methods in Latvia. High initial costs constitute the most significant challenge, cited by 32 % of survey respondents. These costs include investment in specialised software, hardware, training, and, in the case of modular construction or 3D printing, factory infrastructure.

The shortage of qualified professionals represents the second significant barrier, particularly affecting smaller construction and property management firms that lack the resources to hire or train digital specialists. Regulatory fragmentation also emerged as a substantial challenge, with experts highlighting inconsistencies between national construction regulations, the EU-level directives, and practical implementation guidelines.

Limited awareness among property owners and integration issues between different digital platforms further impede adoption. The proportional distribution of these barriers is illustrated in Fig. 2, and their weighted severity is presented in Table 3.

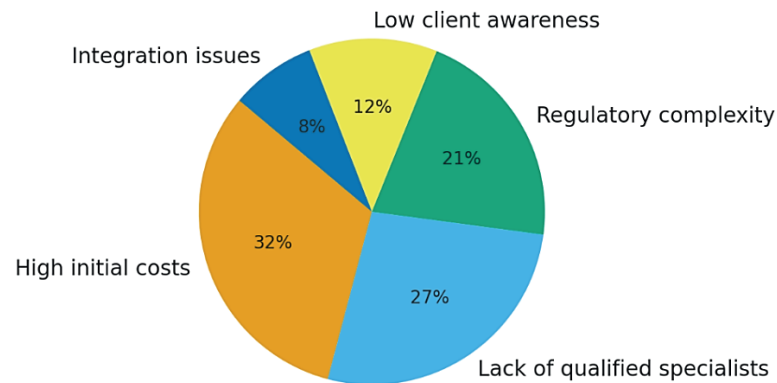


Fig. 2. The main barriers to implementation of modern construction methods (created by the authors).

Table 3. Severity of Identified Barriers (created by the authors)

Barrier Category	Severity Score (0–10)
High initial costs	8.4
Lack of qualified specialists	7.9
Regulatory and administrative complexity	7.2
Limited awareness among property owners	6.1
Technology integration challenges	5.4

The international benchmarking analysis reveals that Latvia's slower uptake of modern construction methods is not due to technological unavailability but rather structural differences in policy, regulation, and training systems. Countries such as Norway, Finland, and the United Kingdom have implemented mandatory BIM requirements in public-sector projects, accompanied by national-level digitalisation roadmaps, financial incentives, and large-scale professional training initiatives.

In contrast, Latvia relies primarily on voluntary adoption, resulting in fragmented practices and uneven capacity across the industry. Nevertheless, recent commercial developments in Riga, such as "Verde" and "Origo One", demonstrate that private-sector actors increasingly recognise the long-term operational benefits of modern methods, even in the absence of strict regulatory mandates. These examples suggest that as awareness grows and technological infrastructure improves, adoption rates are likely to accelerate.

Results clearly demonstrate that while modern construction methods have begun to reshape certain aspects of real estate management in Latvia, particularly through improved documentation accuracy, enhanced maintenance planning, and better energy performance, their full transformative potential remains unrealised. Broader sector-wide adoption is constrained by economic, institutional, and educational barriers, many of which could be mitigated through coordinated policy interventions, targeted incentives, and capacity-building initiatives. The findings underscore the need for a strategic national approach to digitalisation in the

construction and property management sectors, drawing on best practices from leading European countries.

CONCLUSIONS

- The findings show that modern construction methods, such as BIM and smart building technologies, deliver measurable improvements in building performance and real estate management. Digital tools enhance documentation accuracy, reduce information gaps, and support better coordination across project phases. Case studies confirm reductions in unexpected maintenance events, improved energy efficiency, and stronger lifecycle-based decision-making, demonstrating that these technologies are already viable and productive within the Latvian context.
- Although BIM has achieved relatively widespread adoption, the uptake of other modern methods remains limited. Smart building systems are gaining momentum primarily in commercial projects, while modular construction and 3D printing technologies remain in early development stages. The unevenness of adoption reflects differences in market readiness, investment capacity, available expertise, and the presence or absence of supportive infrastructure.
- Experts consistently report substantial operational and strategic benefits associated with modern construction methods. These include improved maintenance predictability, lower operational costs, enhanced energy performance, and more accurate digital documentation. The long-term financial and environmental advantages of these methods align with broader European sustainability objectives and reinforce their relevance for real estate lifecycle management.
- High initial investment costs represent the most significant obstacle to adoption, particularly for smaller companies with limited budgets. The shortage of trained specialists and the lack of a cohesive regulatory framework further complicated implementation. Limited awareness among building owners about the long-term financial advantages also restricts market demand, reinforcing the need for educational and informational initiatives.
- The comparative analysis shows that countries with structured digitalisation policies, such as mandatory BIM requirements, national training programs, and incentive mechanisms, achieve faster and more consistent adoption of modern methods. Latvia can draw valuable lessons from these examples by implementing policies that encourage standardisation, promote professional development, and reduce adoption barriers across the sector.
- The absence of unified national digitalisation policies results in fragmented practices across the Latvian construction and real estate sectors. A coordinated national strategy would significantly accelerate industry transformation by establishing consistent standards, improving interoperability among systems, and providing clearer incentives for

adopting innovative construction technologies. Public-sector leadership is essential to guide this transition effectively.

- Modern construction methods demonstrate strong potential to enhance real estate management efficiency, sustainability, and long-term performance in Latvia. While the benefits are clear and increasingly recognised, the pace of adoption is hindered by economic, institutional, and knowledge-related barriers.
- With targeted policy interventions, financial incentives, and systematic capacity-building efforts, Latvia can unlock the full value of modern construction technologies and strengthen its competitiveness within the broader European construction landscape.

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