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IMPROVING SCIENTIFIC AND METHODOLOGICAL FOUNDATIONS FOR ORGANIZATIONAL AND TECHNOLOGICAL SOLUTIONS IN CONSTRUCTION USING MODERN INFORMATION TECHNOLOGIES: BEST PRACTICES AND STRATEGIES

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Abstract. *The article addresses current issues in improving the scientific and methodological foundations for developing organizational and technological solutions in construction projects using modern information technologies. In the context of the dynamic development of the construction industry and increasing demands for quality, deadlines, and project costs, effective organizational and technological solutions are becoming a critical success factor. Traditional approaches to managing construction processes often fail to meet modern requirements and capabilities, limiting the potential of construction enterprises in achieving strategic goals. The use of modern information technologies, such as Building Information Modeling (BIM) systems, automated construction process management systems, and digital platforms, significantly enhances the efficiency of planning, monitoring, and implementing construction projects. The article focuses on developing scientific and methodological approaches to forming organizational and technological solutions in construction, based on integrating modern information technologies. The research involves developing effective models for managing construction processes, optimizing resource planning, and implementing innovative monitoring and control methods. Special attention is paid to applying virtual modeling technologies, real-time data analysis, and integrating various management systems into a unified digital ecosystem for construction projects. To achieve the stated objectives, methods of systems analysis, mathematical modeling of construction processes, and expert evaluation methods are employed. The study analyzes existing organizational and technological solutions utilizing modern information systems and examines their impact on construction efficiency. A significant part of the research focuses on studying real case studies of successful implementations of information technologies in construction projects. The research results demonstrate the significant potential for improving organizational and technological solutions through the adoption of modern information technologies. The proposed methods and approaches reduce resource costs, shorten construction timelines, and improve work quality. The article makes an important contribution to developing scientific approaches to managing construction processes and offers practical recommendations for implementation at both enterprise and project levels.*

***Keywords**: organizational and technological solutions; construction; information technologies; BIM; optimization; digital technologies.*

Introduction.

Enhancing the scientific and methodological foundations for the development of organizational and technological solutions in construction is a crucial task for ensuring effective project management, meeting deadlines, and optimizing resources. Traditional methods of organizing and planning construction work often fail to address modern challenges arising from project complexity, limited resources, and high quality requirements.

One of the key issues is the insufficient application of modern information technologies in the development of organizational and technological solutions. This leads to planning errors, misalignment among project participants, and productivity losses. The lack of scientifically grounded methodologies complicates the integration of innovative technologies, such as Building Information Modeling (BIM) systems, digital resource management platforms, and analytical tools for risk forecasting.

Another major challenge is the lack of coordination between different stages of the construction process, which causes delays, resource overruns, and inefficient material use. Unforeseen changes during construction, along with the absence of an integrated approach to data management, hinder timely decision-making and project execution control.

To address these issues, it is necessary to develop and implement scientifically based methodological approaches for the formation of organizational and technological solutions using modern information systems. This includes the integration of digital tools, optimization of communication processes among construction project participants, and the application of innovative technologies to enhance the efficiency of construction management.

Research objective.

The aim of this article is to analyze the current state of organizational and technological processes in construction, assess existing methods of logistics and resource management, and identify key problems and challenges. Particular attention is given to the implementation of innovative technologies such as IoT, automated inventory management, and artificial intelligence (AI) for forecasting material needs. The objective is to develop effective approaches that optimize planning processes, enhance efficiency, reduce costs and project timelines, and provide specific recommendations for the successful integration of modern information technologies in the construction industry.

Literature review. A study conducted by researchers from Germany focused on a systematic analysis of the integration of augmented reality (AR) and virtual reality (VR) technologies with Building Information Modeling (BIM) across different phases of the construction lifecycle: design, construction, and operation [1]. The research methodology included a systematic literature review using the Scopus database, where 32 relevant publications were selected from 447 records spanning the period 2017–2022 based on keywords related to BIM, AR, and VR. The classification was carried out according to construction lifecycle phases, device types, and specific use cases.

The authors identified five main categories of AR/VR applications in BIM: planning, inspection and quality assurance, task guidance, safety, and training [1]. The study found that VR is predominantly used in the design phase for architectural reviews and interior modeling, whereas AR is more prevalent in the construction and operation phases, where it facilitates quality control, task guidance, and maintenance.

The research also highlighted challenges related to AR tracking accuracy on construction sites and potential cybersecurity risks associated with VR solutions. The reviewed studies placed the greatest emphasis on the construction phase, where AR is actively used for verifying compliance with design requirements, monitoring construction progress, and supporting task execution [1]. In the operational phase, AR proves effective for navigation within buildings and maintenance processes, allowing for fault detection and step-by-step repair guidance.

The authors emphasize that future research should focus on an in-depth exploration of the operational phase, the integration of AR/VR with Internet of Things (IoT) technologies, improving AR tracking accuracy for construction site applications, and conducting direct comparisons of AR and VR effectiveness across different use cases [1].

In the article "Examining the Position of Building Information Modeling (BIM) Technology in Different Dimensions of Building Smartness," the authors explore the impact of Building Information Modeling (BIM) technology on various aspects of smart construction, risk management, safety enhancement, and energy consumption reduction in construction projects [2]. The primary goal of the study is to analyze BIM's role in improving construction efficiency through the integration of modern data management, visualization, and modeling technologies. The research is based on a combined approach that includes a systematic analysis, a review of existing BIM implementation methods, and scenario modeling to assess BIM's effectiveness in key construction areas [2].

The authors examine two primary BIM implementation methodologies: the central tank method, where all project data is stored in a single database, and the extended reservoir method, which integrates independent databases through interoperability mechanisms. The study focuses on BIM's impact during pre-construction, construction, and post-construction phases, covering design, material management, scheduling, and quality control. The findings demonstrate that BIM enables effective project analysis through 3D visualization, 4D scheduling, and 5D cost estimation, helping to identify potential conflicts early in the design phase and minimizing their impact on the construction process [2].

The researchers also highlight BIM's role in enhancing construction site safety. By leveraging visualization capabilities, BIM allows for the identification of potential hazards and risk zones before physical work begins. Integration with cloud technologies ensures efficient information exchange among all stakeholders, including architects, engineers, project managers, and contractors. The study further explores BIM's potential for reducing energy consumption by simulating building energy efficiency, analyzing lighting systems, and forecasting resource usage [2].

In the field of risk management, BIM enables the creation of a risk database that includes both internal and external risks associated with construction projects. The research shows that BIM facilitates early risk detection and the implementation of preventive measures to mitigate them. Additionally, the study demonstrates that BIM can be utilized to develop intelligent building management systems, allowing real-time integration of building condition data for improved resource control [2].

In the article "Do you need a blockchain in construction? Use case categories and decision framework for DLT design options," the authors explore the potential of Distributed Ledger Technology (DLT) and its applications in the construction industry. The study aims to bridge the gap between the theoretical possibilities of DLT and its practical implementation in construction. The authors analyze existing use cases of DLT in construction projects, classify them into categories, and propose a framework for selecting the appropriate type of DLT based on specific project requirements [3].

The research is based on a systematic literature review covering 24 potential use cases of DLT in construction, grouped into seven main categories: internal administrative use, transaction automation between stakeholders using smart contracts, immutable transaction records, immutable asset and ownership records, tokens as payment or incentive mechanisms, decentralized applications (DApps), and decentralized autonomous organizations (DAOs). Each category aligns with a particular value proposition of DLT, such as increased transparency, efficiency, or automation of business processes [3].

The study develops a three-stage decision-making model for DLT implementation. The first stage answers the question: “Is DLT needed for this use case?” It evaluates the necessity of data storage, the number of authors modifying the system, the possibility of using a third-party trust provider (TTP), and the level of trust among participants. The second stage determines the most suitable type of DLT (public, private, permissioned, or permissionless) based on factors such as data access, transparency requirements, and protocol-level control. The third stage considers additional technical constraints, including performance, data storage capacity, interoperability with other systems, privacy, smart contract support, and cost structure [3].

The study demonstrates that DLT can significantly enhance transparency and trust among construction project participants while automating administrative processes and workflow monitoring. In particular, smart contract capabilities allow for transaction automation, contract obligation enforcement, and real-time data integrity verification. However, the authors emphasize that in many cases, a third-party trust provider could be a viable alternative, making DLT implementation unnecessary. The use of DLT is justified when decentralization, high transparency, and complex process automation are essential [3].

The research findings highlight the substantial potential of DLT for optimizing supply chains, automating administrative tasks, and developing decentralized data management solutions in construction projects. However, the authors call for further studies, particularly in prototyping and real-world DLT implementation, to quantitatively measure its effectiveness [3].

Indian experts are exploring the potential of implementing an integrated information system for managing construction production processes. The primary focus is on developing an automated system based on SCADA (Supervisory Control and Data Acquisition), capable of integrating planning, monitoring, control, and task execution to ensure a full-cycle construction management process. The study aims to develop a toolkit that addresses key construction production issues, such as poor coordination, lack of transparency, low process standardization, and inefficient resource management [4].

The research methodology combines Lean Construction principles, SCADA technologies, machine learning, LiDAR, BIM, and the "Genchi Genbutsu" philosophy ("go to the source and get the facts") for effective management. The proposed system follows a two-stage approach: a top-down method for collecting environmental data from the construction site using sensors, drones, and LiDAR, and a bottom-up method for analyzing worker activity and productivity. These data sets are integrated into a machine learning module that compares actual data with BIM-planned models to identify deviations and determine necessary corrective actions [4].

Key success factors for integration include the implementation of flexible sensor systems, data centralization in a "Control Room", machine learning for performance analysis, and resource optimization [4]. The SCADA system enables real-time data collection and processing, allowing for rapid problem detection and corrective action. Specifically, automated monitoring helps prevent equipment overload (Muri), production irregularities (Mura), and resource waste (Muda) [4].

The study results demonstrate that implementing an integrated information system significantly enhances productivity, ensures transparency at all construction stages, improves coordination among project participants, and minimizes costs. Machine learning not only identifies deviations but also predicts potential issues based on historical data and real-time site conditions. Additionally, the research highlights the importance of cloud technologies for data storage and sharing, which enhances integration and coordination within construction projects [4].

An important aspect of construction management is change management. Researchers are exploring approaches to managing change when implementing new technologies in the architecture, engineering, and construction (AEC) industry. The main goal of the study is to identify the relationships between specific change management practices and the success of technology adoption in AEC organizations. The research is based on an analysis of 167 cases of organizational change, collected through an online survey of companies in the United States and Canada [5].

The methodology includes correlation analysis between change management practices and their implementation success, as well as data reliability testing using Cronbach's alpha and Principal Component Analysis (PCA). Researchers identified seven key change management practices: senior leadership engagement, provision of training resources, effective communication of benefits, realistic implementation timelines, effectiveness of change agents, establishing measurable benchmarks, adjusting workloads.

Each of these practices was analyzed in terms of its impact on achieving technology implementation goals, long-term sustainability of changes, and realizing tangible benefits [5].

The study found that change agents' effectiveness, measurable benchmarks, realistic timelines, and communication of benefits had the strongest positive impact on successful change adoption. These factors facilitated smooth transformation processes and helped overcome resistance at all organizational levels.

Other practices, such as senior leadership involvement and training resource availability, were also important but had a less significant impact compared to the first four. Workload adjustment was identified as the least influential factor [5].

The study also revealed that technology adoption success varies depending on the type of organization and employees' hierarchical positions. Senior executives generally reported higher satisfaction with change initiatives, whereas project team members faced more obstacles and workload stress. Additionally, subcontractors, who specialize in specific tasks, achieved higher success rates compared to general construction contractors [5].

A key conclusion was that the type of technology being implemented (business process software, project management tools, or hardware solutions) did not significantly impact change adoption success. Similarly, the difference between introducing new technologies and upgrading existing systems was statistically insignificant.

This finding underscores the critical role of organizational change management practices, rather than the specific technology being implemented [5].

The study emphasizes the importance of a systematic approach to change management, which includes: active involvement of senior leadership, clearly defined implementation stages, use of effective change agents, regular measurement of results based on established performance indicators.

Future research should focus on a more detailed analysis of the relationships between change management practices, technology characteristics, and the specifics of organizations in different construction sub-sectors [5].

Scientific novelty. This research focuses on the development and implementation of an innovative approach to the formation of organizational and technological solutions in construction. It is based on the integration of modern information technologies, such as Building Information Modeling (BIM), automated construction management systems, and digital platforms. This approach enables the creation of a unified digital ecosystem for construction projects, ensuring synchronization and coordination across all phases of construction.

A key role is played by virtual modeling methods, real-time data analysis, and management system integration, which enhance transparency, accuracy, and efficiency in construction operations.

The study provides a comprehensive analysis of the impact of information technologies on construction efficiency, covering aspects such as resource planning optimization, quality monitoring, and project timeline control. The proposed innovative methods contribute to reducing resource consumption, shortening construction timelines, and improving project execution quality.

The research offers specific recommendations and methodologies for the successful implementation of modern information technologies in construction processes. The proposed approaches facilitate the integration of various digital tools and the development of adaptive management systems that address the contemporary challenges of the construction industry.

Thus, the research findings make a significant contribution to the advancement of logistics theory and practice in construction.

General conclusion.

The integration of modern information technologies is a key factor in enhancing the efficiency of organizational and technological solutions in construction. The use of BIM systems, automated construction management systems, and digital platforms significantly improves project planning, control, and execution. These technologies ensure transparency, resource optimization, and improved work quality.

Virtual modeling, real-time data analysis, and the integration of various management systems into a unified digital ecosystem for construction projects play a particularly important role. This enables the timely identification of deviations, risk minimization, and continuity of work.

The study emphasizes the importance of implementing innovative monitoring methods, such as IoT technologies, artificial intelligence, and blockchain. These tools improve coordination between project phases, ensure data reliability, and automate administrative processes.

Optimizing organizational and technological solutions helps to reduce resource costs, shorten construction timelines, and ensure high-quality project execution. The practical recommendations presented in the study can be useful for construction companies seeking to increase operational efficiency and achieve strategic goals.

The general conclusions highlight the importance of an integrated approach to construction process management, which includes the use of modern technologies, workforce upskilling, and adaptation to changing market conditions. Ongoing research and the adoption of innovative methods are essential for the continued development of the construction industry.

Perspectives. A key direction for development is the implementation of Building Information Modeling (BIM) technologies, automated construction management systems, and digital platforms for real-time monitoring and data analysis. The use of IoT will significantly enhance the efficiency of material resource management, while AI-driven analytics will enable precise forecasting of resource needs and optimization of work processes.

Special attention should be given to environmental aspects, as the sustainability of construction projects and compliance with modern environmental standards are becoming strategically important. Integrated logistics systems, which combine planning, supply chain management, waste management, and transportation, should become the foundation for improving construction operations efficiency.

Further research should focus on the impact of logistics processes on construction quality, particularly in identifying the relationships between planning accuracy, timely deliveries, and final project outcomes. Cross-industry knowledge exchange, including adapting solutions from other sectors, will help identify innovative approaches to improving construction processes.

Future studies should cover the development of new methods for technology integration, optimization of interactions among project participants, and the creation of efficient digital ecosystems for construction management. This will not only reduce costs and project timelines but also increase transparency, reliability, and resilience to external challenges.

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