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Artificial Intelligence in Construction and Legal Challenges

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ABSTRACT

The article examines the legal challenges of using artificial intelligence in the field of construction in the context of the digital transformation of the construction industry and the spread of automated systems for design, risk management, quality control, safety monitoring and operation of facilities. It is substantiated that the introduction of AI in construction changes traditional approaches to determining legal responsibility, causation and distribution of risks between participants in the construction process, in particular customers, designers, contractors, software developers, digital platform operators, and insurance companies. The main models of legal regulation of artificial intelligence in the European Union, Ukraine, the USA and the United Kingdom are considered, which made it possible to identify differences between risk-based, sector-specific and innovation-oriented approaches to regulation. The key legal risks of using AI in construction have been identified, including: ensuring the safety of construction works and facilities, protection of personal data, the legal regime of results created or modified with the help of AI, intellectual property issues, transparency of algorithmic decisions, liability insurance and proving guilt in case of damage. Special attention is paid to the use of BIM technologies, digital twins and predictive analytics systems as tools that complicate the traditional causality model and form the network nature of responsibility. The expediency of moving from fragmentary regulation of individual technological solutions to the lifecycle governance model, which provides for legal support of AI systems at all stages of the life cycle of a construction facility – from design to operation, has been proven. Conclusions have been drawn on the need to integrate a risk-based approach into national construction legislation and the development of special mechanisms of legal control over the use of AI in construction.

KEYWORDS

artificial intelligence, construction, legal regulation, legal liability, causation, risk sharing, personal data protection, BIM, lifecycle governance, risk-based regulation.

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Штучний інтелект у будівництві та правові виклики

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СТАТТЯ

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АНОТАЦІЯ

У статті досліджено правові виклики застосування штучного інтелекту у сфері будівництва в умовах цифрової трансформації будівельної галузі та поширення автоматизованих систем проєктування, управління ризиками, контролю якості, моніторингу безпеки й експлуатації об'єктів. Обґрунтовано, що впровадження ШІ у будівництві змінює традиційні підходи до визначення юридичної відповідальності, причинного зв'язку та розподілу ризиків між учасниками будівельного процесу, зокрема замовниками, проєктувальниками, підрядниками, розробниками програмного забезпечення, операторами цифрових платформ і страховими компаніями. Розглянуто основні моделі правового регулювання штучного інтелекту в Європейському Союзі, Україні, США та Великій Британії, що дало змогу виявити відмінності між risk-based, sector-specific та інноваційно орієнтованими підходами до регулювання. Визначено ключові правові ризики використання ШІ у будівництві, серед яких: забезпечення безпеки будівельних робіт і об'єктів, захист персональних даних, правовий режим результатів, створених або модифікованих за допомогою ШІ, питання інтелектуальної власності, прозорість алгоритмічних рішень, страхування відповідальності та доказування вини у разі заподіяння шкоди. Окрему увагу приділено застосуванню BIM-технологій, цифрових двійників і систем прогнозної аналітики як інструментів, що ускладнюють традиційну модель причинності та формують мережевий характер відповідальності. Доведено доцільність переходу від фрагментарного регулювання окремих технологічних рішень до моделі lifecycle governance, яка передбачає правовий супровід ШІ-систем на всіх етапах життєвого циклу будівельного об'єкта – від проєктування до експлуатації. Сформовано висновки щодо необхідності інтеграції risk-based підходу в національне будівельне законодавство та розвитку спеціальних механізмів правового контролю за використанням ШІ у будівництві.

КЛЮЧОВІ СЛОВА

штучний інтелект, будівництво, правове регулювання, юридична відповідальність, причинний зв'язок, розподіл ризиків, захист персональних даних, BIM, lifecycle governance, risk-based regulation.

1. Introduction

The current stage of development of the construction industry is characterized by the institutionalization of the use of artificial intelligence technologies, which function as an integrated element of the digital environment for managing construction processes and are used to predict risks, model terms and costs, carry out automated control over safety and quality of work, manage resources, as well as ensure compliance verification of design and executive decisions within the BIM environment. In modern scientific research, it has been determined that the key areas of their implementation are the field of labor protection, risk management, resource optimization and quality control, which determines their system-forming role in the transformation of the industry [1].

At the same time, the multi-entity structure of construction activities, within which customers, developers, designers, software developers, suppliers of technical means, contractors, operators of digital platforms and insurance institutions interact, complicates traditional legal structures of liability. The functioning of artificial intelligence systems in the mode of human-machine interaction transforms approaches to establishing guilt as an element of tort composition, causality and risk distribution, which necessitates comprehensive intersectoral legal regulation with the involvement of institutions of tort, contractual, administrative, information, labor and insurance law [5].

The current stage of digital transformation of the construction industry, combined with the formation of national policy in the field of artificial intelligence and the processes of harmonization of legislation with the law of the European Union, causes the emergence of new legal conflicts in the field of regulation of human-machine interactions. In this regard, the issue of establishing a legally significant causal relationship and determining the subject of responsibility in multi-subject legal relations, in which the results of decision-making are formed with the involvement of algorithmic systems, is of particular importance. The lack of established approaches to the qualification of such situations, as well as the uncertainty of the boundaries of the application of traditional institutions of tort and contract law, indicates the presence of a systemic scientific and practical problem that requires conceptual understanding.

2. Literature Review

Modern foreign scientific discourse on the use of artificial intelligence in construction is structured in several relatively stable areas of research. The first of them includes the technical and organizational dimension, within which artificial intelligence is considered as a tool for improving productivity, safety and quality of construction processes; representative in this context are the generalized studies of S.O. Abioye and L.O. Oyedele [1]. The second direction is formed by socio-legal research, which focus on the issues of labor protection, supervision and responsibility in the context of the use of artificial intelligence [3]. The third direction is represented by works on general models of legal regulation of artificial intelligence, including the problems of the balance of innovations, ethics and mechanisms of public control [22]. The fourth direction covers liability studies, which analyze the issues of defectiveness of AI products, risk control, and the limits of tort law application [15].

Domestic scientific research, despite their quantitative limitations, demonstrates a tendency to institutionalize basic conceptual approaches to the analysis of the outlined problem.

In particular, the works of V.V. Boyko consider international models of legal regulation of artificial intelligence [3], V.Y. Pryamitsin and O.Y. Gracheva – the issues of civil liability [20], and R.Y. Butynska – labor and human rights aspects of the use of artificial intelligence [7]. At the same time, the studies of D.V. Bondarenko and K.Y. Kalashnikova [4], M.V. Vyshnevskyi [22], G.V. Haman [15] and S. Ivanov-Kostetskyi [16] indicate the active digitalization of the construction industry of Ukraine and the integration of artificial intelligence into construction management practices, which necessitates a combination of technical and legal analysis of the relevant processes.

Thus, the analysis of scientific sources allows us to state the existence of an imbalance between the level of technological integration of artificial intelligence in construction and the level of development of legal mechanisms for regulating the relevant relations. The current stage of development of scientific research is characterized by the transition from the analysis of technical

aspects of the functioning of artificial intelligence to the study of legal mechanisms to ensure its lawful, safe and responsible application, which leads to the formation of interdisciplinary approaches.

3. Problem Statement

The article is aimed at conceptualizing the legal challenges of using artificial intelligence in construction through the prism of the transformation of doctrinal approaches to responsibility, causality and risk distribution in multi-subject human-machine legal relations.

4. Methods and Materials

The methodological basis of the study is a complex interdisciplinary approach that combines the methods of theoretical law, comparative law and system analysis. The choice of tools is due to the purpose of the article – the conceptualization of the legal challenges of the use of artificial intelligence (AI) in construction and the transformation of the institution of responsibility.

The theoretical and empirical basis of the work consisted of:

- EU AI Act, USA, UK and Ukraine;
- Specialized publications in the Scopus and Web of Science databases on technical and organizational dimensions of AI in construction and liability studies;
- The works of domestic scientists (V. Boyko, V. Pryamitsin, O. Gracheva, R. Butynska, D. Bondarenko, etc.) are devoted to the digitalization of the construction industry and civil law regulation of AI.

To achieve the goal of the study, the following methods were used:

- Comparative legal – to compare global regulatory strategies (risk-based, sector-specific and innovative approaches) and determine ways to harmonize Ukrainian legislation with EU law;
- System-structural and functional – for the study of the multi-subject structure of construction relations, analysis of human-machine interaction and determination of the "network nature" of responsibility with the participation of customers, software developers and insurance companies;
- Formal legal – to analyze the norms of current tort, contractual, construction and insurance law to identify gaps in the regulation of BIM technologies and digital twins;
- Legal modeling – to substantiate and construct a promising model of legal support of AI at all stages of the construction site (lifecycle governance).

5. Results and Discussion

At the level of the European Union, the most institutionalized model of legal regulation of artificial intelligence has been formed, which is based on a risk-based approach enshrined in the AI Act, which establishes a unified classification system for AI systems with differentiation of requirements depending on the level of risk, including a special regime for high-risk systems, transparency requirements, AI literacy and market surveillance mechanisms. In addition, compensation for damage caused by defective AI products is regulated in conjunction with the provisions of Directive (EU) 2024/2853 on liability for defective products, which leads to the integration of the AI Act with the institutes of product liability, tort law, and proof [10]. At the same time, the withdrawal of the AI Liability Directive, recorded in the EUR-Lex database as withdrawn, objectifies the increase in the importance of the updated model of liability in the field of defective products as a key tool for legal response to damage caused by the use of artificial intelligence [2].

As of 2026, the national model of legal regulation of artificial intelligence in Ukraine is at the stage of institutional formation and is characterized by a transitional nature. The Concept for the Development of Artificial Intelligence, approved in 2020, enshrines the basic principles of transparency, responsibility, security and privacy protection, while stating the existence of gaps in regulatory support, in particular in the field of personal data protection. Public policy is implemented according to the bottom-up model, which involves the use of self-regulatory tools, experimental legal regimes (sandbox) and phased harmonization with European Union law, including the preparation of legislation compatible with Regulation (EU) 2024/1689 [8].

The American model of legal regulation of artificial intelligence is characterized by the absence of a single centralized regulation at the federal level and is based on a combination of voluntary standards, regulatory positions of supervisory authorities and the legislation of individual states. The institutional formation of approaches to risk management in the field of artificial intelligence is provided by the framework documents of the National Institute of Standards and Technology, primarily the AI Risk Management Framework, in combination with the law enforcement practice of the Federal Trade Commission in the field of consumer protection and anti-discrimination.

Regulations of individual states, in particular the state of Colorado, indicate the institutionalization of risk-based regulation of high-risk artificial intelligence systems and the introduction of mechanisms to counteract algorithmic discrimination, without the formation of a single mechanism for pre-certification [19].

In the UK, an alternative model of legal regulation is being implemented, based on the principle of "pro-innovation regulatory approach" and provides for decentralized regulation through a system of industry regulators, recommendation documents and standards for the transparency of algorithmic decisions. In this regard, algorithmic transparency mechanisms and requirements for the explainability of decisions ensured, in particular, by the activities of the Information Commissioner's Office and the implementation of the Algorithmic Transparency Recording Standard in the public sector, are of great importance. In the construction sector, such tools perform the function of providing a link between technological solutions and legal responsibility, forming the basis for the accountability of the use of artificial intelligence [21].

Table 1. Comparison of approaches to regulating the use of AI in construction

Criterion	Ukraine	European Union	USA	United Kingdom
Legal definition of AI	Fixed at the conceptual level; there is no specialized framework for law	Normatively defined in the AI Act, risk-based classification is applied	There is no unified definition; framework approaches are applied	There is no codified definition; a principled regulatory approach is applied
Safety and reliability requirements	Fragmentarily integrated into sectoral regulation (urban planning, labor protection, data protection), special AI requirements are formed	Complex requirements are established for high-risk AI: risk management, data governance, human oversight, accuracy, robustness, and cybersecurity	Predominantly voluntary risk management standards and industry safety regulations;	They are implemented through industry regulators using the principles of safety, accountability and data protection
Model of legal responsibility	The general institutes of civil, contractual, administrative and criminal law are applied; there is no specialized AI-liability mode	Integrated model: AI Act combined with product liability and national tort law	Complex model: tort law, product liability, contract law, consumer protection; Active role of state enforcement	Traditional institutions (negligence, product liability) are used in combination with regulatory mechanisms
Conformity assessment (certification)	There are no specialized conformity assessment procedures for AI systems	Established conformity assessment procedures for high-risk AI; registration and CE marking are provided	There is no unified federal certification mechanism	There is no mandatory pre-certification system
Transparency and explainability	They are implemented mainly within the framework of sectoral regulation; there is a focus on European standards	Standardized transparency requirements, instructions for use, information rights and explanations for high-risk systems	Secured through FTC mechanisms, disclosure requirements, and state-level impact assessment	Provided through ICO recommendations and implementation of algorithmic transparency standards (ATRS)
Sanctions mechanisms	Sectoral sanctions (civil, administrative, criminal); there is no specialized system of fines in the field of AI	Multi-level system of fines: up to 35 million euros or 7% of global turnover for the most serious violations	There is no unified system of fines; Sanctions are applied in the field of consumer protection and at the state level	Sanctions are implemented through the current sectoral regimes

Source: Formed based on [6; 18].

Taking into account that the introduction of tools of algorithmic transparency and explainability provides the possibility of establishing legally significant circumstances and the proper distribution of

responsibility in the process of using artificial intelligence in construction, there is a need for a systematic comparison of approaches to the legal regulation of such relations in different jurisdictions, which necessitates their generalization in Table. 1.

Based on the generalization of approaches to regulating the use of AI in construction, we can state that there is a significant variability of institutional approaches to regulating the use of artificial intelligence, which leads to the heterogeneity of mechanisms for ensuring safety, responsibility and accountability in the construction sector. The identified differences in regulatory designs, risk management mechanisms and enforcement tools necessitate the conceptual separation of systemic legal problems that arise in the process of integrating artificial intelligence into construction activities. Structuring of key legal challenges is a necessary prerequisite for determining the current state and directions of transformation of the relevant regulatory environment.

The problems of tort liability in the field of artificial intelligence in construction are systemic, which is due to the transformation of classical doctrinal approaches to establishing causation, guilt and defect as grounds for liability. The integration of algorithmic systems into the decision-making process with significant technical, economic and security consequences complicates the identification of the proper subject of responsibility in the context of multi-subject interaction. The traditional binary model of responsibility loses its explanatory capacity and is transformed into structures of distributed responsibility based on risk control criteria, predictability of error and the limits of proper human supervision [5].

Regulatory security of the use of artificial intelligence systems forms a separate dimension of legal challenges associated with the need to establish comprehensive requirements for conformity assessment, testing and certification of such systems. Construction activities as an area of increased risk involve the use of artificial intelligence systems in critical processes, which necessitate the introduction of enhanced requirements for risk management, ensuring the accuracy and reliability of their functioning and guaranteeing proper human control. In such conditions, the regulation of artificial intelligence is integrated with the standards of technical safety of machinery and equipment, as well as with international risk management standards [12].

The problems of personal data protection form an independent direction of legal challenges related to the use of artificial intelligence technologies. The functioning of such systems in construction involves the processing of significant amounts of information about employees, including biometric, behavioral and geolocation data, which necessitates compliance with the principles of privacy and proportionality. Ensuring transparency and explainability of algorithmic decisions, along with effective human control, is a key condition for harmonizing technological processes with human rights guarantees [14].

A specific block of problems includes the issue of the legal regime of the results of intellectual activity created using artificial intelligence, as well as the legitimacy of using data to train relevant models. In the construction sector, this is manifested in the formation of digital design objects, including BIM models and technical documentation, for which the application of classical authorship criteria is limited. The lack of established legal approaches to determining the legal status of such results necessitates their detailed contractual regulation [17].

The institutional dimension of the problem is complemented by the need to form effective insurance mechanisms and contractual distribution of risks. The traditional model of legal response, focused on post-factum compensation for damages, does not provide an adequate level of prevention in the context of complex contractual structures of construction activities. In this regard, the importance of ex-post risk management tools, including contractual guarantees, audit procedures, obligations to monitor the functioning of systems and insurance coverage, which ensures the integration of tort law, insurance and contract regulation, is growing [6].

The ethical component of the use of artificial intelligence is being transformed into a legally significant element of regulatory compliance. The use of algorithmic systems in the field of labor process management determines the risks of bias, non-transparency of decision-making and restriction of professional autonomy, which necessitates the normative consolidation of standards of transparency, non-discrimination and professional competence. The requirements for ensuring human control and an appropriate level of awareness of users form a component of the legal standard of due diligence [11].

In order to empirically verify the structure of legal risks associated with the use of artificial intelligence in construction, the study uses the method of quantitative content analysis of the source

base, which includes 32 sources, including 10 regulatory legal acts, 8 official documents and 14 scientific publications. Within the framework of the analytical procedure, thematic coding of the content of sources by predetermined categories of legal risks was carried out, which made it possible to identify their relative representation in the array under study. The generalized coding results are reflected in the form of a structured distribution of shares, which are interpreted as indicators of the priority of the relevant areas of legal regulation.

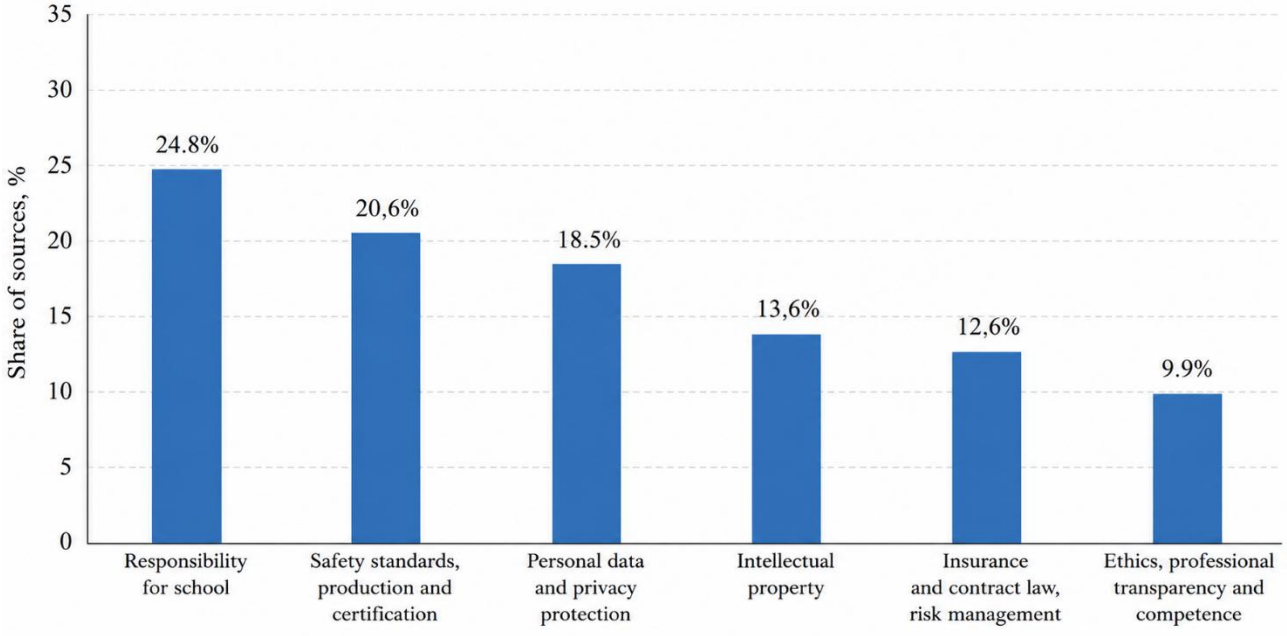

Figure 1. Distribution of key legal risks in the source sample

Source: Formed based on [1–10; 15; 20; 22].

The resulting distribution indicates the uneven representation of certain categories of risks, which reflects the varying degree of their regulatory and doctrinal development. In particular, the dominance of the issue of liability for damages, as well as a significant share of data security and protection issues, indicates the concentration of regulatory attention on priority segments of legal regulation related to risk management and prevention of negative consequences of the use of artificial intelligence.

In addition, the interpretation of the results obtained allows us to substantiate that legal responsibility in the field of artificial intelligence in construction is networked, not linear in nature. Damage can occur at different stages of the life cycle of a technological system, from design and development to integration, operation, monitoring, and updating of algorithmic models. Under such conditions, the identification of the appropriate subject of responsibility requires taking into account the functional role of each participant, the parameters of the use of the system, logs, operating instructions, the limits of human supervision and the specifics of the contractual architecture of the project.

In this regard, the conceptualization of legal risks in the field of construction AI cannot be limited to generalized categories, but requires a transition to a lifecycle governance model focused on specific scenarios of technology application. As a result, this ensures a more accurate identification of risks, their distribution between subjects and the formation of adequate mechanisms of legal regulation in accordance with the specifics of individual use cases.

The analytical generalization presented in Figure 2 reflects the structural complexity of legal relations arising in the process of applying artificial intelligence in construction and confirms their network nature. The formation of negative consequences is not limited to a separate stage, but can be determined by decisions made at the stages of design, integration of technological components, operation, monitoring, or updating of the algorithmic model. In this regard, the establishment of the appropriate subject of responsibility cannot be carried out in isolation from the functional role of each participant, the parameters of the use of the system, logging data, operating instructions, as well as the limits and quality of human supervision and the contractual architecture of the project.

This multifactorial nature leads to the transformation of approaches to legal regulation, within which liability acquires the characteristics of a distributed and context-dependent category, which is consistent with the principles of risk-based regulation and human oversight enshrined in modern European law [12].

Accordingly, the conceptualization of legal risks in the field of construction AI requires a transition from generalized categories to a lifecycle management model, which ensures the identification of risks at each stage of the system's operation and the formation of adequate mechanisms for their legal regulation depending on the specific use case.

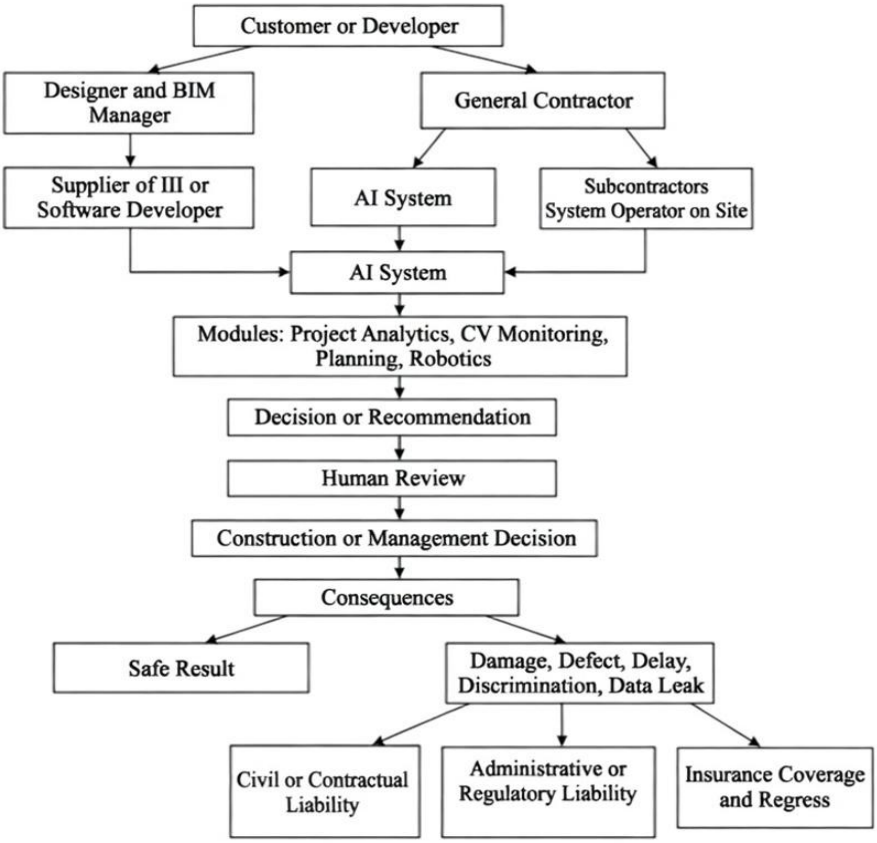

Figure 2. Structural and functional model of responsibility distribution in the system of artificial intelligence application in construction

Source: Formed based on [8–10].

Taking into account the identified patterns, there is a need to formalize applied mechanisms for managing legal risks, which determines the appeal to the system of practical recommendations.

Regulatory support for the use of artificial intelligence in construction requires a differentiated approach, within which this area should be defined as a regulatory-sensitive sector with an increased level of risks. In this regard, the identification of high-risk use cases, in particular systems used in safety-critical robotic processes, computer visual monitoring of employees, algorithmic admission and ranking of personnel, automated verification of compliance with project documentation, as well as decisions affecting the structural safety of facilities or evacuation planning, is of key importance. Such structuring corresponds to the risk-oriented methodology of European law and is consistent with the vector of harmonization of national legislation with the approaches enshrined in the law of the European Union.

The institutional integration of AI regulation with digital processes in construction involves its alignment with information modeling (BIM) technologies and electronic public administration systems. In this regard, the need for regulatory consolidation of the obligation to keep event logs (logs), the use of standardized documentation such as model cards or functionally equivalent tools for critical artificial intelligence systems, as well as ensuring their compatibility with digital construction services, BIM processes and labor protection requirements is substantiated. The lack of such integration creates a risk of excluding algorithmic decisions from formalized examination and control procedures [9].

The formation of a regulatory model in the field of artificial intelligence applications provides for the introduction of a multi-level system of liability and insurance provision.

For systems with an increased level of risk, it is advisable to establish minimum requirements for financial security of liability, disclosure of insurance conditions and the introduction of recourse mechanisms between the developer, integrator, user of the system and contractors. The European approach shows that the effectiveness of the protection of the rights of the injured party is ensured under the conditions of combining preventive safety requirements (ex-ante) with mechanisms for compensation for damage (ex post), which minimizes procedural and evidentiary asymmetry [13].

A separate area of improvement of regulation concerns the provision of an appropriate level of personal data protection in the context of the use of artificial intelligence systems on construction sites, which provides for the regulatory definition of the limits of permissible monitoring of employees, rules for processing video data, biometric and geolocation information, requirements for storing event logs, as well as the introduction of data protection impact assessment procedures similar to DPIA. Of particular importance is ensuring the employee's right to be informed about the use of algorithmic systems in the work environment.

At the level of practical activities of construction entities, a key tool for managing legal risks should be a preliminary AI impact assessment, which is carried out before the stages of procurement and implementation of relevant systems. Such an assessment should include the intended purpose of the system, the sources and quality of data, the risks of bias, the requirements for human oversight, the legal regime for processing personal data, incident response procedures, the procedure for updating models, as well as the limits of automated decision-making. The use of this tool allows you to prevent the use of artificial intelligence systems in high-risk scenarios without their proper legal qualification.

An important role in minimizing legal risks is played by the contractual regulation of relations between participants in the construction process. The inclusion of specialized provisions (AI annex) in the contract structure, defining the characteristics of the system, permissible scenarios for its use, the origin and mode of data, the legal status of the results, intellectual property guarantees, requirements for the storage of event logs, testing procedures, obligations for the explainability of decisions, audit rights, incident response mechanisms, as well as provisions for system updates and cybersecurity, is a necessary condition for due contractual regulation. The contractual architecture provides the most flexible mechanism for preventing regulatory gaps in the field of artificial intelligence.

The development of professional competence of participants in the construction process is an integral part of ensuring the proper use of artificial intelligence. The European approach considers the level of staff awareness as an element of regulatory compliance, which necessitates the formation of relevant knowledge among key project participants, including chief engineers, BIM managers, occupational health and safety specialists, project managers and persons responsible for personnel management. Professional training should include the functionality of the systems and their legal limitations, sources of error, human intervention procedures and requirements for documenting processes.

6. Conclusions

Based on the analysis, we can state that the use of artificial intelligence in construction is a factor in the transformation of existing legal risks and a source of new ones. The integration of algorithmic systems into construction processes makes it more difficult to establish cause-and-effect relationships in tort legal relations, increases the importance of verifiability, certification and safety audit procedures, actualizes the problems of personal data protection in the working environment, and transforms approaches to the legal regime of intellectual property objects, as well as reveals the limitations of traditional mechanisms of insurance coverage of risks. The combination of these factors indicates the systemic nature of the influence of artificial intelligence on the legal regulation of construction activities.

Comparative analysis confirms that the most institutionalized is the European model of regulation, based on a risk-based approach and a combination of preventive security requirements with mechanisms of legal responsibility. At the same time, even within this model, there are unresolved issues of effective compensation for damage and distribution of responsibility in complex multi-entity systems.

For the national legal system, the priority is not the formal reproduction of external regulatory structures, but their functional integration into the existing architecture of urban planning regulation, digital management tools, information modeling processes (BIM), occupational health and safety and e-governance systems. In this regard, the determining criterion for the effectiveness of legal regulation should be the formation of a coordinated and verifiable system that ensures the identification of liability entities, transparency of data use, control of the security of technologies, certainty of the limits of human intervention, proper documentation of decisions and the availability of effective insurance coverage mechanisms.

The implementation of these approaches creates prerequisites for the transition from a fragmented response to risks to their systematic management, within which artificial intelligence functions as a tool for improving the quality and safety of construction activities.

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