



RESEARCH ARTICLE

The Impact of Engineering Studies on the Construction Industry

Nataliia Arsenieva^{1*}, Vladyslav Lohvynenko², Dmytro Komyshev³, Kostiantyn Filchenko⁴, Denys Filchenko⁵

¹Faculty of Road-Building, Kharkiv National Automobile and Highway University, Kharkiv, Ukraine

² Interregional Academy of Personnel Management, Kyiv, Ukraine

³ Dmytro Komyshev Professor, Specially Appointed Expert from the School of Civil Engineering, North Minzu University, Academician of the Engineering Academy of Ukraine, Kharkiv, Ukraine

^{4,5}Faculty of Construction, Ukrainian State University of Science and Technologies, Research and Education Institute (REI) "Prydniprovsk State Academy of Civil Engineering and Architecture", Dnipro, Ukraine

ARTICLE INFO	ABSTRACT
Received: Jul 31, 2024	<p>Recently, engineering has been identified as a critical area for improving construction company operations in a globalised market. The study elucidates the definition of engineering and its functionality in construction. It is established that the category of engineering research in construction represents a convergence of engineering and consulting to achieve an optimal outcome in construction. The fundamental definitions of engineering have been elucidated, and the stages of advancement in engineering activity in construction have been delineated. A classification approach was formed based on theoretical and practical analysis of international experience. The functionalities of modern engineering activity in the construction sphere have been outlined, and their types and directions have been identified. The article examines engineering services in construction in the context of a comprehensive approach to the formation and refinement of the project idea, the means and approaches to its implementation, and the rational management of project resources. The efficacy of engineering in the construction industry has been examined in the context of international experience, with a particular focus on its capacity to enhance the efficiency of the construction business. The primary objective of engineering research in construction is to ensure the optimal effectiveness of project implementation by implementing contemporary scientific and technical solutions.</p>
Accepted: Sep 11, 2024	
Keywords	
Innovative business,	
Efficiency of enterprises	
Optimization	
Engineering	
Project	
Digitalisation	
*Corresponding Author: nataliarsen73@gmail.com	

INTRODUCTION

In prevailing instability and crises, economic entities engaged in the construction sector must operate within an unstable economic environment. It creates conditions conducive to decreased profitability, deteriorating project outcomes, the formation of related obstacles and difficulties, and the potential for unforeseen expenses.

The construction sector is distinguished by its unique features, which contribute to its uniqueness. In particular, the sector is distinguished by long project durations, complex production processes, high financial risks, an unfavourable regulatory environment, and significant industry competitiveness. Consequently, comprehensive engineering research is crucial to construction project management systems.

Engineering in the construction sector is implemented in several stages. A certain level of risk characterises the majority of construction projects. For effective managerial activity, it is necessary to carry out meticulous planning of the stages of the construction process. It should allow for the

prompt making of correct management decisions. The existing risks significantly influence the formation of project efficiency in terms of time, resources, cost, and quality of construction. Consequently, identifying the essence and vectors of priority optimisation of engineering research in the construction sector is a relevant direction for successfully implementing construction projects.

LITERATURE REVIEW

A series of scientific works and publications have been dedicated to various theoretical-methodological and practical aspects of the essence of engineering and its types of services. The theoretical aspects of engineering activity are reflected in the works of several contemporary scholars, including Borziak et al. (2022), Mikhno et al. (2022), and Koroviaka et al. (2021). Research on the development issues associated with the digitalisation of management processes is being conducted by Dudar and Brychanskyi (2023), Pashynskyi (2020), Shevchuk (2020), Sonko and Zelenchuk (2022).

As modern researchers assert (Sunak et al., 2022; Vovk, 2024), a priority necessity for the engineering research support of construction projects is the active application of modern innovative modelling technologies for construction objects within a unified specialised database. Researchers (Ihnatov et al., 2021) see the issue of constructing interactive models of buildings as the basis for an innovative approach to engineering research in construction as a priority for immediate resolution. Furthermore, Nguyen and Fayek (2022) are exploring the possibilities of applying fuzzy hybrid methods in construction engineering and management research, and Pan and Zhang (2021) are analysing the potential role of artificial intelligence in construction engineering and management.

While acknowledging the significance of the researchers' contributions, it is necessary to note that many issues related to the successful implementation of engineering activities in the national development context remain underexplored and require further refinement.

This study aims to reveal the essence of engineering and its functionality in construction and identify possible aspects of developing engineering services in Ukraine per international requirements.

MATERIALS AND METHODS

The study was conducted using the principles of scientific research, namely comprehensiveness and systematics, which permitted the analysis of the research object as an integral system with a series of interconnections and interdependencies. Several general scientific research methods, including abstraction, comparison, analysis, synthesis, induction, and deduction, were employed to achieve the research goals.

The research operated analysis and synthesis to identify the principal factors that underpin the essential functionality of engineering research in construction activities. The inductive method was used in the process of formulating prospective directions for the advancement of the subject matter under investigation. The deductive method was applied to identify the priority vectors of innovative engineering transformation in the construction sector within the national context. The abstraction method was utilised to elucidate theoretical generalisations, identify pivotal categories and concepts, and formulate conclusions regarding the priority vectors of innovative engineering development in the digital management and economic space. A comparison was employed to identify the specific characteristics of the contemporary innovative paradigm in the engineering research sector, in contrast to the traditional approaches to planning and implementation of construction projects.

RESULTS

The progressive advance of the architectural and construction industry in the global environment is characterised by a trend towards creating unconventional and unique construction projects. A primary concern is the effective implementation of novel methodologies for engineering research,

which must consider contemporary requirements. An innovative approach to construction combines effective research in engineering discovery, construction design, and building and assembly work, collectively ensuring the project's construction realisation.

The definition of engineering for construction projects characterises a specific activity that represents a synergy of scientific-technical and engineering approaches to project realisation, aiming to ensure the effective execution of construction activities. The accelerated growth of the integrated global engineering-technical services sector and its differentiation as a distinct type of activity is driven by the active advancement of scientific and technological progress, which has led to an increased reliance on complex equipment and, consequently, the necessity for the development of specific skills to address organisational and technological challenges from the design phase to the completion of the construction project.

Modern engineering research in construction is founded upon fundamental conceptual principles of a systematic, comprehensive, and interdisciplinary approach to the planning and implementation of construction projects. This approach frequently entails the execution of multiple technical, technological, and financial studies, which are then evaluated in order to identify the optimal option for the client. In this context, project development proceeds with consideration of the potential for incorporating innovative technologies, structures, materials, and equipment that optimally align with the specified conditions and unique requirements of the construction company. The concept of practical engineering in construction necessitates the utilisation of contemporary methodologies for the organisation and management of projects at all stages of their implementation.

In 1981, the American Society of Civil Engineers (ASCE) published the "Guide to the Use of Engineering Services." In this document, professionals analysed the practice of engineering consulting, developed a classification of engineering services, and highlighted related challenges.

Engineering effectively solves specific practical problems during construction, involving a synergy of creative analysis, synthesis, and modelling. The process is based on coordinating various concepts, strategies, and ideas to form a new, optimal solution. The range of problems addressed by engineering research varies by subject area, scale, and level of complexity. However, a systematic approach is envisaged for their resolution in all cases.

Under the current market conditions of the construction sector, engineering activities are focused on providing services related to preparing the production process and services that ensure the optimal production process. In this context, the comprehensive engineering approach is gaining significant weight in international practice in implementing construction projects. This encompasses technological engineering, consulting, and direct construction (Ibrahim et al., 2022).

Modern engineering consulting firms offer various engineering services for construction projects, which can be grouped into specific categories. These include preventive financial-economic comparisons and techno-economic studies, construction management, direct individual engineering research services, inspection and testing of equipment and materials, and operational services. Table 1 provides an overview of these categories.

Table 1: Construction Project Engineering Services

Service	Description
Direct individual services	Provided services to individual specialist consultants, including assisting in preparing legal procedures and engineering and technical issues.
Preliminary feasibility studies and financial and economic comparisons	Services precede project approval and include analysing conditions and comparing several possible options. The facility's environmental impact, operating costs, and financial aspects,

	including expected revenue, are assessed. The results serve as the basis for conclusions and recommendations on the feasibility of the facility.
Construction management	It involves applying management techniques and decision-making at different stages of construction.
Inspection and testing of equipment and materials	Accepting equipment at manufacturers' factories and testing materials the contractor uses to construct the facility (on-site).
Operational services	The service involves the engineering and consulting firm, upon completion of construction, assuming responsibility for the initial operation of the facility as the project author if the client requests it.

Source: compiled by the author based on (Borziak et al., 2022)

Modern engineering systems confer several advantages upon the industry. Firstly, they facilitate the intensification of investment activities, consolidating the necessary resources to implement investment projects. Secondly, they contribute to the enhancement of competitiveness among construction companies. It is also worth noting the minimisation of production losses, unplanned financial expenses, and the duration of work, as well as the formation of absolute prerequisites for transforming the management paradigm. The reduction of investment and other risks for a construction company that actively applies engineering potential is perceived as an additional benefit of the proposed concept.

In engineering research within the construction sector, a series of functions can be distinguished that assimilate into a specific logical-temporal sequence (Table 2).

Table 2: Functionality of Engineering Research for Construction Projects

Function type	Implementation specifics
Designing	Detailed design of the construction process, determination of optimal methods and materials, and formation of decisions on the form, structure, and technical characteristics necessary to ensure the successful implementation of construction activities.
Development	Creative use of scientific knowledge to develop new models and solutions in the construction industry.
Research	Study of methods, tools, concepts, and experimental and logical tools for thorough analyses of the problem.
Identifying project financial parameters	Develop project estimates and budgets, implement tenders and competitions, and create new financial and operational schemes.
Construction	Building the material infrastructure required for the construction project, developing the construction site, organising quality control, and preparing for operation.
Production	Controlling the functioning of construction and related processes, material and energy supply, and identification of procedures for implementing technological processes.
Production management	Planning the location of production processes, selecting the necessary equipment, raw materials and supplies, integrating all production processes, commissioning and inspection activities, and training personnel.

Source: compiled by the author based on (Akinosho et al., 2020)

The engineering sector in developed countries differs significantly from that offered by some enterprises in our country. The main difference lies in the availability of comprehensive information databases regarding licensors, suppliers, technology and equipment manufacturers, subcontractors,

and the ability to organise high-level project financing (Nguyen & Fayek, 2022). Furthermore, engineering practice in developed countries is characterised by a developed regulatory base, the availability of modern software, the implementation of digital solutions, adaptive project management, and continuous monitoring of each project implementation stage (Sunak et al., 2022).

Engineering research entails a comprehensive approach to forming, implementing, and developing a construction project idea. Furthermore, the researched definition encompasses ensuring its implementation based on rational resource management.

Engineering research is an effective tool in international practice to enhance the efficiency of business activities in the construction sector. At the core of the process are potential opportunities for optimising technological-organisational systems, equipment, and innovative technical solutions, as well as marketing research and ensuring the project's financial stability.

The subject area of engineering in construction is complex, encompassing the development, support, and control throughout the life cycle of architectural and construction projects. It also encompasses technological, organisational, and financial-economic concepts of construction objects by established goals (Sunak et al., 2022). Engineering company specialists collaborate with the construction object at its development's virtual and natural stages. In particular, engineers form a realistic virtual object representing a model or concept while implementing diverse scientific and technical research and technical-economic justifications. They then provide technical support for developing project documentation and construction to realise the virtual object in reality. Once the construction project is complete, adjustments are made to the virtual model or concept according to the parameters of interaction in the technological construction algorithm (Borziak et al., 2022). In the construction sector, the primary objective of engineering activity is developing and implementing a model of the object created based on innovative research and solutions. It is paramount to accurately model the technological processes during the object's operational phase, considering the real-world aspects. Consequently, all stages of engineering activity necessitate the continuous modelling of the construction process of the object, as well as the modelling of processes at the exploitation stage (Mikhno et al., 2022).

Engineering professionals engaged in preparing and supporting investment and construction projects are tasked with maintaining communication with external scientific, technical, and architectural environments. They are responsible for ensuring that the project plan is by the stipulated timelines, costs, and quality standards. Furthermore, they are tasked with developing pre-project and pre-investment technical proposals, concepts, and investment justifications. Additionally, they oversee the technical compliance of the approved project documentation and construction standards and regulations.

The system of engineering research is a directed activity (Ihnatov et al., 2021; Nguyen & Fayek, 2022) the principles above were manifested in the following areas: engineering design and consulting in the principles of engineering in construction, selection of materials and structures, tools, and processes; development of projects for air conditioning systems, cooling, engineering solutions for sanitary conditions and environmental pollution control, noise abatement; and geophysical, geological, and seismic studies.

The accelerated development of innovative solutions for the automation of production processes has made the synergy of innovative tools with management means based on programmable logic controllers, electronic computing machines, and intelligent measuring and control devices increasingly relevant (Delgado et al., 2020). The current priority is the maximum automation of engineering information acquisition processes, which is achieved through the use of digital levels, laser tape measures, GNSS, electronic total stations, laser scanners, uncrewed aerial vehicles, and other modern devices (Batygin et al., 2013; Pan & Zhang, 2021).

The automation of data collection, accumulation, and processing, as well as the development of digital design systems, including the use of artificial intelligence tools, have enabled the creation of digital models that simulate the anticipated effectiveness of actions (Nguyen & Fayek, 2022; Komyshev & Bieliatynskiy, 2023).

In the current context of the national construction industry, industry professionals on construction sites and offices frequently rely on paper-based documentation, plans, and diagrams. In order to optimise the situation and ensure maximum visibility and rapid access to information, the implementation of building and structure information modelling using cloud technologies is deemed appropriate. Using specialised software and robotic technology enables real-time information access and connection to the building's information model to be made available directly at the construction site through cloud connectivity (Vovk, 2024).

Further scientific development is required to determine the optimal conditions for implementing an engineering research support system for a construction project, the necessary precision of operations, and the technology for practical application of the results during construction (Dudnik et al., 2020). The intelligent combination of various innovative methods is a promising avenue for further investigation. For instance, integrating terrestrial laser scanning data with the capabilities of uncrewed aerial vehicles can facilitate the speed and cost-effectiveness of project execution.

The regulatory framework for conducting engineering research for construction needs in Ukraine is outdated and does not correspond to the capabilities of innovative engineering research tools. At present, the improvement of sectoral legislation to address the challenges of modern engineering in the national context, the introduction of a unified digital vector model of Ukraine's terrain, and the stimulation of the development of the construction industry are regarded as prerequisites for the sustainable development of the construction sector. One of the primary objectives in the development of the engineering research system in construction is the establishment of novel algorithms and communication channels between engineers and builders for the expeditious exchange of information, the practical analysis of measurement outcomes in real-time, and the implementation of necessary adjustments to the construction process, ensuring compliance with digital development.

DISCUSSION

Contemporary scholars (Delgado et al., 2020) are convinced that the traditional management paradigm in the field of engineering research in construction does not fully address the issues of the construction process dictated by modern demands for digitisation and integration of the socio-economic space. Pavlov et al. (2020) emphasise that an essential task in Ukraine today is the implementation of methodologies for calculating the accuracy of engineering works that could be used to model a comprehensive situation by synergising individual calculations.

Modern researchers (Fellows & Liu, 2021; Love et al., 2023) posit that a paramount necessity for engineering research support of construction projects is the active utilisation of technologies for archiving executive diagrams of construction objects in a specialised database. Researchers (BuHamdan et al., 2021; Noghabaei et al., 2020) consider the construction of interactive models of buildings to be a priority issue. Moreover, scholars (Akinosho et al., 2020) posit that the integration of diverse cutting-edge technologies, such as terrestrial laser scanning and uncrewed aerial vehicles, could enhance efficiency and reduce expenditure.

In turn, scholars (Abioye et al., 2021; Guerra & Leite, 2020) believe that the engineering system necessitates a systematic approach, irrespective of the differentiation of issues by scale, complexity, and subject area. Furthermore, scholars (Banerjee & Nayaka, 2022) emphasise the necessity for optimal enhancement of engineering models towards digitisation and their maximum integration into the global production environment.

According to several researchers (Knippers et al., 2021; Boton et al., 2021), the stimulation of effective development and improvement of the engineering research system in the construction sector, incorporating successful practices and innovative technological capabilities, is seen as a mutually beneficial project. This approach provides a comprehensive solution to the issues of improving the operations of construction companies and related organisational and management challenges.

It is recommended that further development of this research direction be pursued to implement and test innovative software for predicting and modelling the cumulative impact of factors requiring engineering research.

CONCLUSION

Engineering is a pivotal development area for construction companies seeking to enhance their operational efficiency. In defining the essence of engineering and its functionality in construction, it has been determined that the category of engineering research in construction represents a synergy of engineering and consulting aimed at achieving the desired result in construction.

The impact of effective engineering research on a construction company's performance, including financial and economic aspects, is considerable. The classification and functionality of engineering services, based on theory and international practice, highlight the issue of engineering research functioning in the national construction sector at this stage. Possible development aspects following international standards need to be identified.

The study focuses on engineering services in construction in the context of a comprehensive approach to creating and developing a project idea and its implementation based on practical management approaches to project resources. In the context of international experience, engineering is perceived as an effective means of enhancing the construction industry's productivity. The objective of engineering research in construction is to achieve maximum effectiveness in implementing construction projects by incorporating innovative scientific and technical achievements. Applying engineering principles allows for a significant reduction in the time and resources required for project implementation, a reduction in the volume of necessary investments, and an enhancement of the financial returns on investments. The practical role of engineering research in construction is to achieve substantial savings in financial resources, to increase the return on investment projects, and to intensify the competitiveness of construction companies.

Author Contributions

N. A.: Conceptualization, Methodology, Resources, Formal analysis, Writing – Original draft, Writing – Review & Editing.

V. L.: Conceptualization, Methodology, Resources, Data Curation, Writing – Original draft, Writing – Review & Editing.

D. K.: Conceptualization, Methodology, Resources, Formal analysis, Writing – Original draft, Writing – Review & Editing.

K. F.: Conceptualization, Methodology, Resources, Data Curation, Writing – Original draft, Writing – Review & Editing.

D. F.: Conceptualization, Resources, Formal analysis, Project administration, Writing – Original draft, Writing – Review & Editing.

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