Integration of innovations in the construction industry

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Abstract. The construction industry is one of the key sectors of the national economy, capable of determining social development vectors, solving social, economic and technical problems. In order to satisfy the growing needs of society, a higher level of development of the national economy and the construction sector in particular is required. This can be done only through the innovative development of the construction industry. The effective and dynamic development of the construction industry is linked with the formation of a modern innovation sector, which ensures its scientific and technical development on a commercial basis. The article deals with the integration of innovations in the construction industry aimed at the strategic development. The concept of innovation in construction is analyzed, the methodology for assessing the economic efficiency of the innovative process of the construction industry is described. The author’s definition of innovations in construction is offered. The features of innovative technologies used in the construction of new and reconstruction of existing buildings are described. Attention is paid to the economic effects of innovative technologies in the construction industry and further strategic planning.

The development of the construction economy, as well as the national economy as a whole is characterized by a shift towards scientific intensity of production. Such structural changes arise from the need to improve the quality of construction products, the economic efficiency of investment and construction projects and their competitiveness.

Taking into account the specifics of the world economy, the new technological order, further development of the construction industry is impossible without close relationships with science.

The theory of innovation and innovative technologies has become relevant in the scientific field. At the same time, the current stage of economic development is characterized by the innovative orientation of all economic sectors, including the construction one. The stage of development and implementation of scientific, technical and organizational innovations is the basis for the economic development of the construction industry [1].

The innovative activities in the construction sector are a resource for the economic development of the industry based on the theory of economic waves by N.D. Kondratyeva. J. Schumpeter developed the theory of overcoming crises in social production based on the use of innovative processes: creating a new product, using a new production technology, new sources of raw materials, creating new sales markets [23]. The Federal Law No. 127-FZ "On Science and State Scientific and Technical Policy" of 23.08.1996 defines innovation as " a new or improved product (service), a new way of sales, business practice, job, way of organization of external relations”. However, this definition does not reflect the
level of novelty, scientific and technical components and economic feasibility. This definition does not reflect the economic nature of innovation [7]. Some authors draw attention to the fact that the concept of innovation is focused on the production component (creation of a new or improvement of an old product, new or improved technology) [7]. Other researchers argue that innovation is a service for creating conditions for improving the production efficiency in order to satisfy the developing needs of man and society [15].

Innovation in the construction sector can be viewed as a sequence of certain elements: systems, changes, processes, results.

Let us analyze the model of "three qualities of innovation" (Figure 1). This model represents the process of creating and implementing innovations in the construction industry as a result of idea implementation, its subsequent formalization and materialization into a real development.

![Figure 1. The "three qualities of innovation" model.](image)

The trinitarian model which reflects the nature of innovation from a paradigmatic perspective differs from the dyadic model presented in Figure 2 in one additional component - control.

![Figure 2. Paradigm nature of innovation.](image)

The paradigm nature of innovation reflects only two relationships. The trinitarian model reflects three features of innovation and three relations. The third relation (control) makes the model stable, since it allows for the comparison of goals of innovations and results obtained, as well as for the assessment of their effectiveness. The trinitarian model allows us to identify the main features of innovation and main relationships in the innovation process.

The relationships arising from the implementation of innovation in the construction industry serve as the basis for a generalized innovation process, which includes more detailed innovation processes.

For a more detailed analysis of the innovation process in the construction industry, let us study the technological scheme of the innovation process presented in Figure 3.
Figure 3. The technological structure of the innovation and construction system.

The innovation process is presented in the form of blocks. The modern market economy builds the relationship of its subjects in such a way that the basis for the innovative development of the construction industry is an innovative need.

If there is a certain innovative need, a response in the form of an innovative idea is formed in accordance with the consumer's request [19,21]. The condition for the subsequent formalization of the generated idea is innovation and construction resources, for which they are analyzed and optimized. The analysis and verification of the innovative idea are followed by the next stage – transformation.

The transformation of an innovative idea, taking into account the available building resources and meeting the needs of a company is followed by the designing stage. The result of the design stage is an innovative construction development that must be implemented [11,20]. The process of implementing an innovative development is accompanied by diffusion, improvement and dissipation (deterioration). Dissipation implies the impact of the external environment at the stage of innovation planning on the innovation implementation process [6,12,22]. The stronger the impact of unaccounted factors, the stronger the dissipation, which negatively affects the results of the innovation process. The innovation process is accompanied by the improvement process. Additional solutions can be developed to improve the quality of innovative construction developments [3, 17, 21]. In addition, the exchange of experience between science and the construction industry can bring additional improvements.

The diagram of the innovation and construction system does not contain such significant stages as monitoring and management, but it is quite obvious that these processes are mandatory for any innovation process.

Most domestic enterprises invest in technological innovations. In 2011, 733,815.9 million rubles were spent for these purposes, and in 2017, the volume of investment increased twice and amounted to 1,404,985.3 million rubles [4]. To assess the economic efficiency of the innovation process in the construction industry, the following indicators can be used:

1. The effect of reducing the cost of production (CP) resulting from the use of innovations:

\[
E_{PC} = \frac{V_{ip}}{V_{pr}} \times (C_{in} - C_c)
\]  \hspace{1cm}(1)

where \(V_{ip}\), \(V_{pr}\) - the volume of products produced with and without innovative developments, rubles; 
\(C_{in}\), \(C_c\) - the initial cost of production and the cost of production after implementing the innovation product, rubles.
It should be emphasized that this indicator takes into account savings per unit of products or services provided and the economy of scale. Using this indicator, it is possible to calculate the economic effect for a certain period during the innovative development is used.

2. The effect of production cost saving can be calculated by assessing the indicator of reducing material costs per ruble of manufactured products (Emc), if the innovative development is aimed at increasing the efficiency of material resources:

\[ E_{\text{m.c.}} = \frac{V_{\text{mp}}}{V_{\text{spr}}} \times (M_{\text{mbe}} - M_{\text{cl}}) \]  

where Mbmc and Mei — basic material costs for the unit of production before and after the implementation of an innovative development, rub.

2. Increase in profit (\( \Delta P \)) as a result of the innovative development:

\[ \Delta P = (P_2 - P_1) \times (\frac{\sum_{i=tn}^k P_i \times dt - \sum_{i=tn}^k 3t \times dt}{k_p + \gamma}) \rightarrow \max \]  

where \( P_1 \) and \( P_2 \) — prices for one unit of production before and after the implementation of innovations, rub.;

\( C_1 \) and \( C_2 \) — production cost of one unit of production before and after the implementation of innovations, rub.;

\( VP_1 \) and \( VP_2 \) — production volume in natural measurement units before and after the implementation of innovations.

1. If the innovative development is aimed at improving the technological process, it is advisable to apply the technical and economic effect (Etc.):

\[ E_{\text{m.E.}} = [(C_{\text{bas}} + E \times K_{\text{bas}}) - (C_{\text{non}} + E \times K_{\text{non}})] \times N_{\text{non}} \]  

where \( N_n \) — annual sales of products manufactured as a result of technological process improvement, units;

\( C_{\text{bas}}, C_{\text{n}} \) — the cost of a product produced before and after the implementation of innovations, rub.

\( K_{\text{bas}}, K_{\text{n}} \) — capital investment per unit of production before and after improvement of the technological process, rubles;

\( E \) — the discount factor reducing the capital investments to one year and determined in accordance with the discount function method.

5. If the purpose of innovation implementation is to achieve some economic effect, it is possible to use the following methods for assessing the effectiveness of the innovation process:

Method 1: \( E_T = (\sum_{i=tn}^k P_i \times dt - \sum_{i=tn}^k 3t \times dt) \rightarrow \max \) (5)

Method 2: \( E_T = 3t \times \frac{\sum_{i=tn}^k P_i \times dt}{k_p + \gamma} \rightarrow \max \) (6)

Method 3: \( E_T = \left( \frac{(P_1 - P_2)(1+r)}{(k_p + \gamma)k_p + \gamma} \right) \rightarrow \max \) (7)

where \( E_T \) — the economic effect of an innovative project for its entire life cycle (from the beginning of the first financial investments (tn) to its completion (tk));

\( P_t \) — the cost estimate of the innovative results in the i-th year of the billing period;

\( C_t \) — the amount of costs for all types of resources required in the i-th year;

\( dt \) — the discount ratio;

\( k_p \) — the coefficient of renovation by service life is determined by formula \( k_p = \frac{r}{(1+r)^{t_c} - 1}, t_c \) — long-term innovation life span;

\( k_p^2 \) — the coefficient of renovation by production time is determined by formula \( k_p^2 = \frac{r}{(1+r)^{t_n} - 1}, t_n \) — innovation production time.

The conditions for applying the first method are: the possibility of assessment of costs after innovation implementation and costs of innovation implementation; instability of the main technical and economic indicators of production and operational activities.

The second method is also applicable if it is possible to assess the cost of the innovation construction project, stable technical and economic indicators for the billing period, and the innovation project financing is non-recurrent.
The conditions for applying the third method differ from the conditions for applying the second one: after the innovation implementation, the processes of funding and production can be carried out over a long period of time.

If it is not possible to assess the results in order to determine the economic effect of innovations, minimum costs can be used:

**Method 4**: 
\[ E_T = \sum_{t=tn}^{tk} 3t \cdot dt \rightarrow \min \] (8)

**Method 5**: 
\[ E_T = \frac{3t}{k_p+r} \rightarrow \min \] (9)

**Method 6**: 
\[ E_T = \frac{3c(1+r)}{(k_p+r)(k_p^2+r)} \rightarrow \max \] (10)

where \( C_t \) — costs for the development and implementation of innovations for the entire billing period, rubles.

The fourth method is used when there are data on costs and their instability over the billing period. The fifth method is used when costs are stable over the billing period and innovations are produced over several years. The sixth method is applied under the conditions of the fifth method, but taking into account the renovation coefficient by production time.

Innovations in the construction industry occupy a special place in the general classification, since they create positive synergistic effects at the stages of the life cycle of a building and in many related sectors of the economy [5,9,13]. An example is energy-saving innovations that are created in the construction industry; their effects are manifested in the energy sector, the environmental protection area, the housing and communal sector; they contribute to the scientific and technological progress in mechanical engineering, electrical, chemical and many other industries [14,16,19].

These approaches, indicators and methods make it possible to assess the effectiveness of the innovation process in construction at the production stage.

Construction innovation is the use of modern high-quality technologies when building new facilities and reconstructing the existing ones [2,8,10]. Reconstruction and modernization improve the architectural and engineering solutions of these buildings, technical reliability, comfort, environmental safety and economic efficiency of operation, while minimizing energy consumption and operation risks [3,5,20]. These factors are acute in the Siberian region due to the climatic conditions of Siberia: stricter housing requirements, seasonality, and higher construction costs in winter. Construction is complicated by peculiarities of the soil structure (e.g., taliks, solifluction, heaving mounds, frost cracks, thermal casts). In addition, expensive special equipment for housing construction is required in some areas [4].

Since the construction industry plays an important strategic role in the national economy due to its dynamism and prospects, providing almost 6% of Russia's GDP and about 2/3 of investments in fixed assets [23], it is advisable to present the main elements of the innovation and construction strategy (see Figure 4).
When developing a strategy for the innovative development of the construction industry, one should take into account such principles as:
1. correlation of the current state of the innovation sphere with the innovative development potential;
2. correlation of the enterprise development strategy with the development of innovative sectors;
3. long-term implementation of the goals of innovative development;
4. complexity, which involves the use of organizational, resource, innovative factors that ensure the project implementation in a timely manner;
5. multivariance which implies the possibility of changing the strategy under the influence of internal or external factors;
6. availability of scientific methods for the development and implementation of the strategy.
7. interconnection of all management functions;
8. optimality which implies the optimal composition and structure of resources for the development of innovative activities;
9. taking into account laws and trends in the development of innovative activities;
10. the progressive principle which implies the identification, analysis and use of the results of the analysis of factors affecting the development of innovative activities in the transition from one stage of development to another one.

The principles and directions of innovative development of the construction industry are determined by the concept of innovative development, which is one of the key elements of the methodology. The goals and objectives of innovative development are determined by the corresponding strategy.

The development of an efficient mechanism for investing in construction innovations is the most important condition for improving the competitiveness of the national economy.
The importance of solutions to the problem of efficiency of the innovation investment mechanism is due to the limited investment resources of companies in the post-crisis period, a decrease in the rate of return on capital invested at low rates of economic growth, and a decrease in consumer demand in certain sectors of the national economy. The limited investment resources necessitate the development of such theoretical-methodological and practical-methodological approaches that would make it possible to use them taking into account the need to solve long-term problems of economic and social development.

Intensification of innovative activities aimed at modernization and development of the diversified construction industry is a priority area for the Russian government.

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