Innovative materials in construction and their role in improving the organizations efficiency

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Abstract. The article discusses the results of the innovative concrete types application in the buildings and structures construction. A classification of effects types according to the recommended features is proposed. The methodological approaches to the cost-benefit analysis methods substantiating at the stage of assessment and implementation of a construction project by the organization using innovative constructional materials are investigated and proposed. The methodical approach of determining the profitability of the production and sale of construction products has been expanded through the approach of evaluating efficiency based on the resource and optimization methods use.

Introduction

The purpose of the article is to show that the basis for progressive economic growth of organizations engaged in the construction of buildings and structures is to increase their level of the competitive ability in terms of increasing the construction market share by means of the new design solutions implementation, the use of innovative constructional materials, technologies of construction projects design and erection. The problem of increasing the scale of innovative constructional materials in the buildings and structures construction is currently on-going. The research of scientists from different countries is devoted to the search for its solution [1]. However, no uniform methodological approach to the assessment of innovative construction projects and the substantiation of methods for assessing the impact of innovative constructional materials on the economic performance of the construction participants (owner/developers, contractors and other construction organizations) has been worked out yet.

The article presents a selective review of the applied innovative solutions for the use of the new constructional materials in the construction of modern buildings and structures. The use of innovative constructional materials provides potential opportunities for the construction time reducing, “green technologies” applying, construction costs reducing, quality improvement, durability of the production assets increasing and facilities being built. This actualizes the search for a solution to the problem, requiring the identification of effects and the substantiation of methods for evaluating the effectiveness of the innovative constructional materials application in construction, reflecting their impact on the economic performance of the construction organizations.

The authors propose a methodological approach to the indicated problem. This approach is to
develop a standard methodology for measuring, analyzing and evaluating the effectiveness of the innovative constructional materials application and the degree of their influence on the results of the construction participants effective performance.

The research results review in the field of the innovative constructional materials potential application in buildings and structures construction

The productive solution of this task is associated with the results of the innovative constructional materials development. This prompts to give a brief overview of the research results in the field of the potential building innovative materials use in buildings and structures construction. In particular, the recent studies by many scientists in the field of building materials have been reoriented to the research aimed at obtaining the new types of concrete with new qualitative characteristics. At the same time, a special place is given to the search for the opportunities in building up potential of applying the modern building material Nano-concrete in the construction.

The term “Nano-concrete” does not mean a brand of constructional material. This is a summary list or “family” of the constructional materials combined by a similar production technology or a composition of Nano-materials used in different proportions. By changing the proportion and combining Nano materials, the researchers get different characteristics and quality of the constructional material (different density, heat resistance and other properties). In particular, the results of the study [2, p. 131] revealed the positive role of the ultrasonic dispersion in obtaining Nano disperse additives and the potential effectiveness of the micro fillers use, which increases the fine-grained concrete density and strength. This greatly expands the potential application of the innovative constructional materials in the production of construction products (works, services), which have a direct influence on the results of the construction organizations effective performance.

The possibility of obtaining Nano concrete of different density (low, medium, high, ultra-high) provide new conditions for its use in the construction of buildings and structures. Thus, Nano concrete with low density has gained widespread currency in the separation partitions and walls in the construction of low-rise buildings and structures. The medium-density Nano concrete is used in the construction of bridges, other structures and roads. The Nano concrete with high and ultrahigh density gets an increasing scale of construction use, where the highest possible structural strength is required: the load-carrying units of buildings, structures, mines.

The results of the modified concrete properties studies for the manufacture of complex concrete structures for special purposes deserve a positive assessment [3, p.64]. The results of the study on the use of local natural and technogenic raw materials as an active mineral additive in the production of local constructional materials [4, p.76], which reduces the construction products costs, have important applied significance in the buildings and structures construction.

An advanced research direction [5, p.252] was the creation of large crack-resistant structures and products made of foam mortar using prestressed tendon, which is important in the construction of the high buildings. In this regard, the role of innovative solutions for the use of prestressed tendon and new technologies in the construction of the Lakhta Center high building in St. Petersburg in 2015 is significant. The box-shaped foundation was the basis of the high structure. When carrying out a unique operation on continuous simultaneous concreting of the subbase footing at the concrete casting (19,624 m³), a new world record in the construction of high structures was stated. In this process implementation, the thirteen factories of the Leningrad region were manufacturing concrete round-the-clock, and concrete mixer trucks drove up to the construction site almost every minute.

Methodological approaches to the methods substantiation for calculating the expected effects and effectiveness in the innovative materials application

The use of innovative constructional materials in industrial, civil, transport and other types of construction is associated with the manifestation of various types of effects. This actualizes the solution of the potential effects identification task and the classification and substantiation of methods for their calculation, reflecting the results of the innovative constructional materials’ use in
construction. As the conceptual basis for the identification and classification of various types of effects and associated types of effectiveness, due to the use of innovative constructional materials in construction at the stage of the investment projects evaluation and their implementation by the construction participants, we have proposed the classification according to the following criteria:

- the exhibited effect (economic, social, environmental, synergetic, technological, consumer, structural, innovative, local, integrated, integral, potential);
- the method of measuring, analyzing and evaluating the exhibited effect (quantitative, expert, local, complex, synergetic, integral, discounted, potential);
- the method of the effect corresponding type comparative evaluation (the type of effectiveness) of the analyzed innovative project with and without the use of innovative constructional materials;
- the method of comparative evaluation of the potential effect (type of effectiveness) obtained by construction participants, implementing innovative projects (in comparison with the main competitor, in general, by the type of economic activity “Construction”, regions and countries with developed market economies);
- the method of forming, measuring, analyzing, evaluating and monitoring potential types of effects (types of effectiveness) at the stage of evaluating the effectiveness of investment projects using innovative constructional materials;
- the method for measuring, analyzing, evaluating potential types of effects (types of effectiveness) manifested in the activities of the construction organizations using innovative constructional materials;
- the method for measuring, analyzing, evaluating and monitoring the influence of internal environment, micro- and macro-environment factors on the potential for nanotechnologies development in the production of constructional materials and the building organizations competitiveness change by increasing the scale of innovative constructional materials application and changing materials prices;
- the list of construction participants implementing innovative construction projects (investors, customers, owner/developers, design and survey providers and research organizations, contracting construction and installation organizations, main contractors, construction industry enterprises for the production of constructional materials, organizations for the supply and engineering and manufacturing scope of the construction supply with constructional materials, capital investment object users);
- the type of construction projects (projects of industrial and civil construction, transport construction, infrastructure facilities, special projects);
- the type of construction activity (new construction, reconstruction, expansion, technical re-equipment, overhaul of buildings and structures);
- the type of manifestation and methods of risk assessment at the stage of evaluation and implementation of a construction project using innovative constructional materials.

The proposed classification of potential effects is considered by the authors as a methodological prerequisite for identifying the methods of measuring the economic effect due to the use of innovative constructional materials at the stage of evaluation and the implementation of innovative construction projects by the construction participants. The potential conditions for the economic effect integral and local types formation are determined by the influence of many factors of the micro- and macro-environment. As the key factors are considered to be the institutional factors, the potential of scientific and technical progress, the factors of changes in the market environment, determined by the process of construction organizations transition to the innovative economy, the price-based competition increase in the construction market, the transition from the price-based competition to the non-price one, the change in innovative constructional materials prices and the scale of sales of construction products using innovative constructional materials.

The integral effect (IE) can be defined according to the expression due to the use of innovative constructional materials at the stage of evaluation and the innovative construction project implementation:
where \( I_{It} \) – is the generated integral income of a construction project using innovative constructional materials in the \( t \)-th billing period;

\( I_{Ct} \) – is the generated integral investments (costs) for the implementation of a construction project in the \( t \)-th billing period;

\( D_{Ct} \) – is the discount coefficient;

\( N \) – is the total number of potential local effects taken into account;

\( t \) – is the initial year of the billing period;

\( T \) – is the final year of the billing period.

One of the integral effect local components is the economic effect to be determined at the stage of evaluation of the innovative construction project and its implementation by the construction participants, including the construction company for the relevant period. At the same time, the economic effect estimated value determination objectively necessitates taking into account economic risk as a result of risk management, reflecting a different attitude to risk from the investors, owners and top managers of construction organizations.

Taking into account that the manifestation of economic risk can be aggravated by possible hazards and untapped opportunities, its quantitative assessment can be manifested in the form of damage or possible benefits [5, p. 67]. Therefore, the magnitude of the economic effect at the stage of evaluation and implementation of a construction project with the use of innovative building materials should be determined taking into account a quantitative measure of economic risk. In this regard, the potential baseline parameters for measuring the economic effect caused by the use of innovative building materials in the activities of construction organizations are considered:

- in the field of construction production: an increase in the volume of construction and installation work carried out in-house with the use of innovative building materials, a reduction of the unit costs (calculated in physical and cost measurement) and the consumption of materials for construction and installation work;

- in the field of sales of construction products (works, services): growth in sales of the construction products (works, services) with the use of innovative building materials, growth in gross profit and profits from sales, reduction in unit costs (calculated in physical and cost measurement) and the sold products material consumption.

In this regard, the evaluation of the economic effect in the form of gross profit \( (GP) \) of a construction organization based on the use of innovative constructional materials is recommended to be determined according to the expression:

\[
GP = \sum_{t=1}^{T} (TS_{Rt} - TC_{t} \pm I_{ERt}) \ast D_{Ct}
\]

where \( TS_{Rt} \) – is the total revenue (income) from the sale of the construction product (works, services) using innovative constructional materials in the \( t \)-th billing period;

\( TC_{t} \) – is the general expenses on the sale of construction product (works, services) using innovative constructional materials in the \( t \)-th billing period;

\( I_{ERt} \) – is the monetary value of the integral economic risk (the amount of profit or damage) caused by the use of innovative constructional materials in the \( t \)-th billing period.

The economic effect determining method is acceptable when evaluating an innovative construction project and evaluating the economic effect of the sale of construction products by the organization participating in the construction project implementation. However, the gross profit is a necessary but not sufficient condition for a qualitative comparative assessment of a construction project to be implemented with and without the use of innovative building materials. This objectively demands the calculation of an alternative parameter characterizing the economic efficiency level. Understanding
that “the general economic principle of evaluating the effectiveness of innovations is comparing the effect (result) and costs” [6, p.290] allows the authors to apply the costly method of determining the effectiveness of the innovative building materials use in relation to the analyzed object (investment project, construction organization, individual type of its activities, structural unit, construction site, a separate type of construction work).

This methodological approach, positioned as “cost”, allows to determine the estimated profitability of an innovative construction project, as well as the profitability (planned, actual) of a construction product (works, services) (PPt) of an organization implementing a construction project using innovative constructional materials, ratio of reduced economic effect to reduced costs (investment):

\[
P_{Pt} = \frac{\sum_{i=1}^{T} (TST_i - TC_i \pm \Delta E_{Rt}) \times D_{Ct}}{\sum_{i=1}^{T} (TC_i \pm \Delta E_{Rt}) \times D_{Ct}}
\]

This methodological approach, providing the evaluation and taking into account the risk and uncertainty due to the changes in the external and internal environment during the implementation of an innovative construction project by the construction organizations, does not contradict the Russian methodology for evaluation of the economic effectiveness of investment projects based on the foreign experience borrowing. However, the cost approach to the construction product profitability calculating is largely limited for the analysis purposes and evaluation in comparison with the estimate indicator of the construction product overall return on sales (RSt), determined according to the expression:

\[
R_{St} = \frac{\sum_{t=1}^{T} (TST_t - TCS_{St} - ME_t \pm \Delta E_{Rt}) \times D_{Ct}}{\sum_{t=1}^{T} TST_t \times D_{Ct}}
\]

where 

- \( SE_{t} \) – is the business expenses of the construction organization in the t-th billing period;
- \( ME_{t} \) – is the management expenses of the construction organization in the t-th billing period.

It is important to determine and compare the planned and actual local profitability of sales subtracting only commercial expenses. This allows to evaluate the business expenses effectiveness. If business expenses are growing at a faster pace, then it is not expedient to increase the volume of the construction products sales by using the innovative building materials.

The method of determining the estimated profitability, planned and actual profitability of the production and sale of construction products is recommended to be supplemented with a productive methodological approach based on the use of the resource and optimization methods for evaluating the effectiveness [1, p.17; 7], improving the quality of the assessment of the innovative building materials impact on changes in the construction organizations economic performance. The construction organization effectiveness determination of the innovative building materials in the construction of buildings and structures, it is recommended to add an indicator of the resource efficiency (RPr). The calculation of this indicator is recommended to be determined, following the principle of comparing the economic effect (reduced sales revenue) to the integral valuation of the resources used, resulting in its receipt, according to the formula:

\[
R_{Pt} = \frac{\sum_{t=1}^{T} TST_t \times D_{Ct}}{\sum_{t=1}^{T} (LR_t + MRT_t \times RC + FR_t) \times D_{Ct}}
\]

where 

- \( LR_t \) – is the cost estimate of the labor force costs of the construction organization in the t-th billing period, including the employees labor payment expenditures; salary accruals; the cost of training, retraining and personnel development;
- \( MRT_t \) – is the cost estimate of fixed assets at the initial (replacement) cost in the t-th billing period;
- \( RC \) – is the factor of lump-sum costs reduction to current costs;
- \( FR_t \) – is the average cost of current assets used in the t-th billing period. This is this indicator
value which is influenced by innovative constructional materials.

The value of the potential level of the innovative constructional materials effectiveness use by the construction organization (PET) is recommended to be determined according to the expression:

\[
PET = \frac{TSR_f(t)}{TSR_{opt}(t)} \leq 1
\]  (6)

where \(TSR_f(t)\) – is the actually achieved level of economic effect;
\(TSR_{opt}(t)\) – is the optimal value of the economic effect.

The design parameters of effectiveness, calculated according to the expressions (3,4,5,6), are recommended to be compared with the similar parameters calculated without the innovative constructional materials use in the construction of buildings and structures by the organization.

Summary

The recommended methodological approaches improve the quality of analysis and evaluation of the influence of the buildings and structures innovative constructional materials application level in construction on the economic performance of the construction organizations. Many scientists consider the questions of economic efficiency in conjunction with economic growth, business institutions [8]. In the proposed article, the authors note that in order to increase the efficient operation of the construction organizations implementing construction projects using innovative building materials, it is important to correctly determine the pricing method for innovative construction products with a focus on market demand or the competitors' offers and the sales profitability.

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