

# Innovative approaches and assessments of the efficiency of reconstruction of housing and communal infrastructure

Ariadna Kirillova<sup>1,\*</sup>

<sup>1</sup>Moscow State University of Civil Engineering, 26 Yaroslavskoye Shosse, Moscow, 109377, Russia

**Abstract.** The article discusses the general provisions for assessing the effectiveness of the implementation of reconstruction suggests the directions of SMART-reconstruction of real estate, creating conditions for saving resources, reducing time, improving the efficiency of reconstructive work, which ensures the sustainability of the urban environment, achieve development goals. It has been proven that an improved look is needed for approaches to restructuring organization that would meet modern requirements, as well as fundamental principles, such as: safety, environmental friendliness, energy efficiency and comfort. Research on the experience of reconstruction has shown that currently the following elements are not fully implemented: innovative mechanisms for carrying out a comprehensive reconstruction; a unified regulatory and legal framework, including for determining the costs of reconstruction, as well as a scheme of relations between the participants in the process, which would ensure the effective interaction of all participants in the reconstruction; managerial and organizational mechanisms that reduce costs during reconstruction, adapting to changes in the socio-economic situation; modern model of reconstruction, which would allow to achieve the goals for each specific project and include the latest developments in technology, the use of innovative materials, the improvement of the project mechanisms at the design stage, as well as the availability of a quality system for monitoring the timing and cost of reconstruction..

## 1 Introduction

Construction industry plays an important role in the country's economy. This is a large independent industry that provides reproduction of fixed assets. The construction industry is responsible for the construction of new properties, as well as for the reconstruction, major repairs and technical re-equipment of buildings. As a result of construction, new properties appear, which include industrial and non-industrial buildings, including residential and public buildings.

Investments in construction are an important element of economic policy for the effective development of each city and country.

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\* Corresponding author: kirillova\_an@mail.ru

One of the most important urban areas of urban development is the task of determining the best ways to build new and reconstruct existing areas. In recent years, the reconstruction of buildings has become a very important area in the field of capital construction. This is due to the "aging" of real estate, which is associated with physical and moral wear.

Reconstruction of residential real estate allows improving the quality and comfort of living, equipping buildings with modern technological and engineering equipment, extending the service life, increasing energy efficiency and application of "smart city" technologies, and also ensuring that buildings meet modern safety and environmental requirements. [1,2,3].

Organizational and technological solutions for reconstruction require individual methods and approaches, since existing buildings are very diverse. Buildings can be divided by type, capital, technical condition, space-planning characteristics, as well as by periods of construction. On this basis, consideration and improvement of the methods of renovation of residential buildings are an important and topical issue of the study. [7,10]

## 2 Materials and Methods

We need an improved look at approaches to restructuring of facilities, which would meet modern requirements, as well as fundamental principles such as: safety, environmental friendliness, energy efficiency and comfort. At the same time, we must not forget about achieving economic, social and budgetary effectiveness of the project. Such an approach to the reconstruction can be an article model "SMART - reconstruction", based on modern achievements in the construction industry, considered in the article. [11,12].

Methods of research are the introduction of organizational and technological solutions to reconstructions and the consideration of a new approach to existing methods for modern management of residential real estate reconstruction and the possibility of using the data obtained to apply in the reconstruction of objects in practice, which will allow to achieve the project goals as effectively as possible, for example, to reduce the duration reconstruction, reducing the cost of reconstruction, improving the quality of production. . [8].

The reconstruction of real estate, as opposed to capital repairs, is aimed not only at reducing physical wear, but also changing the parameters of the building itself, increasing living space, increasing the comfort of living, using innovative materials and structures, as well as extending the life cycle of the building. All this allows more efficient use of urban areas. The economic result of the reconstruction is a sharp increase in the value of real estate. [5].

In this regard, the reconstruction is the most important factor in the reproduction cycle of real estate, as well as a special kind of construction activity. [6].

The need for reconstruction is due to the following reasons:

- discrepancy between the existing planning structure of the city and the increasing functional and environmental pressures on the urban environment;
- insufficiently effective use of the housing stock;
- a deficit in the financing of the overhaul and reconstruction sphere, creating conditions for the constant accumulation of the volume of the fund of residential buildings and other facilities that have reached the economically optimal regulatory period for repairs and reconstruction (25-27 years), but due to lack of funding, they were not provided.
- increase in moral and physical deterioration of the existing building.

In accordance with the Russian Urban Planning Code, the term "reconstruction" is defined as a change in the parameters of an object, including the superstructure,

restructuring, expansion of a capital construction object, as well as the replacement and (or) restoration of supporting structures of a capital construction object.

Reconstruction of buildings is carried out in order to improve the quality and comfort of living, increase the usable area of the building, equip the building with modern engineering equipment, increase the service life of the property, improve energy efficiency, improve the architectural expressiveness of the object, bring the building into conformity with modern regulatory requirements, increase constructive and operational reliability of the object.

The increase in the additional total area of housing is 1.5 times cheaper than the construction in the new territory, the costs of material resources and the creation of engineering infrastructure are reduced by 25-40 percent. Costs for heating and hot water are reduced by 40-50 percent. The reconstruction does not require the allocation of new lands, but due to the superstructure and expansion of buildings, the completion of individual unfinished housing units, the intensity of use of urban areas increases. [2].

From a social point of view, the task of reconstruction is a more efficient use of urban space, the renewal of the planning structure of cities, and the equalization of living conditions in various urban areas.

From a technical point of view, the effectiveness of reconstruction is the use of modern building materials, structures and technologies. [ 13].

The economic efficiency of the reconstruction is achieved by careful development of economic justifications, determining the scale and order of demolition and modernization of the existing buildings, taking into account the improved use of the urban area and proportionality in the order and volume of reconstruction of the housing stock and public buildings. [8,9]. .

Based on the above, the reconstruction is an important type of construction, and also plays a significant role in the reproduction cycle of real estate in connection with its technical, economic and socially significant tasks.

In connection with the integration of modern trends and technologies, an important part of the study is the consideration of foreign experience in the reconstruction of objects. [4,14,15].

The first city reconstruction project was created in the middle of the nineteenth century in Paris. Nevertheless, the USA became the first state to develop comprehensive national programs for the reconstruction of cities, since a large number of cities needed to be updated due to their urbanization. The experience of the United States, was used to modernize the ancient cities of Europe. To date, the main direction of the urban planning policy of Europe is a comprehensive restoration of territories using reconstruction methods to abandon the elimination of the old buildings.

If we consider the foreign experience of reconstruction of objects in more detail, then considerable knowledge in the field of reconstruction of residential buildings has been accumulated in Germany, Finland, Sweden, France and Poland.

One of the methods of reconstruction in Germany is the decompression of buildings, that is, the dismantling of some sections of the building in order to transform them into something new, for example, one large section or terrace. This method of reconstruction was proclaimed by architect Stefan Forster, and the houses were called "urban villas". The architect believed that panel buildings have a future, if they are transformed into something else. The main idea is to give a new image to the areas of panel construction by increasing the comfort and architectural expressiveness of housing, creating in their place a traditional German city-garden

Due to the cold climate in Finland, the reconstruction is aimed primarily at improving the energy efficiency of buildings. The reconstruction is based on the use of modern engineering technologies that help reduce the costs of water consumption, heating and

electricity by creating controlled indoor climate systems, optimizing lighting modes and heat and humidity condition [ 8].

Taking into account climatic and geotechnical features, foreign experience in the reconstruction and modernization of the housing stock can also be used in domestic practice.

The development of the industry and the emergence of innovative technologies in construction require new methods of management and organization of the reconstruction of facilities and the creation of an intellectual model of reconstruction.

In accordance with the foregoing, it can be said that reconstruction is an increasingly important part of the reproductive cycle due to the increasing moral and physical deterioration of buildings. This is a separate type of construction, which has several features, as well as some problems.

Research in the field of experience in reconstruction has shown that today the following elements need improvements:

- mechanisms for complex reconstruction;
- a unified regulatory and legal framework, including for determining the costs of reconstruction, as well as the scheme of relations between the participants in the process, which would ensure effective interaction of all participants in the reconstruction;
- managerial and organizational mechanisms that reduce costs during reconstruction, adapting to changes in the socio-economic situation;
- a modern model of reconstruction, which would allow to achieve the goals for each specific project and include the latest developments in technology, the use of innovative materials, improvement of the project mechanisms at the design stage, as well as the integrated assessment of project performance and the availability of a quality control system for the timing and cost of reconstruction [16].

The important tasks of the digital technology era include meeting the needs of the population and business in the innovatively efficient operational quality of facilities and making a profit for investors. Advanced technologies make it possible to extract additional efficiency and profitability in all spheres of urban life, increase the level of sustainable development, and open up prospects for new ways of building and renovating and arranging living space.

The existing system of organizational and technological methods of reconstruction in modern realities requires modernization and new approaches to this activity, both at the design stage and at the stage of reconstruction work.

Such improvements can be expressed in the form of the “SMART-reconstruction” model. This model allows you to achieve maximum project efficiency, taking into account environmental friendliness, energy efficiency, safety and comfort.

The most difficult question in the reconstruction of the housing stock remains the question of the extent to which the boundaries of its feasibility are determined, due to the high residual value of buildings requiring reconstruction. Analysis of the comparison of unit costs for repair and reconstruction work from the cost of building 1 sq.m. housing showed that overhaul is 30-35%, modernization -50-55%, reconstruction -60-70%, respectively.

However, reconstruction methods are not always acceptable: the choice of the conversion method for each type of object should be based on a preliminary estimate of the cost of work. As a rule, reconstruction works are considered profitable if the costs of their implementation do not exceed 70% of the cost of constructing a new building. . [17, 18].

From the point of view of the authorities - the municipality, the reconstruction of buildings and structures should ensure the quality of the urban environment. For the population it is comfort and improvement of living conditions. For the investor-customer, the main thing is to make a profit. There is a conflict of interests of the parties involved in

the reconstruction and there is a need for a comprehensive assessment of the effectiveness of the reconstruction of real estate, taking into account the resolution of the conflict of interests of the main participants. The effectiveness of the reconstruction is also influenced by the time limits of its implementation: so the reconstruction of prefabricated buildings is advisable to be carried out during the period of 40-70 years from the beginning of operation. Outside the specified period, its effectiveness is significantly reduced, since more resources are consumed to overcome physical and moral depreciation.

In order to evaluate the economic efficiency of complex reconstruction, it is necessary to determine the factors that increase the efficiency of capital investments in reconstruction, such as: the use of more efficient technology and mechanization; greater scale of implementation of scientific and technological achievements; reduction of labor costs as a result of the introduction of complex mechanization, etc.

The decision to reconstruct and update the existing housing development and evaluate its effectiveness is influenced by internal and external factors. Internal ones include: constructive solution of buildings, existing object-planning solutions of buildings, their number of stores, physical and moral deterioration of buildings and engineering equipment, level of provision of housing, demographic composition of the population, provision of sanitary, hygienic, ergonomic requirements, etc.

External factors should include urban planning and technical, availability of development areas and condition of engineering infrastructure, Roads, possibility of repair and construction base, capacity and physical deterioration of the infrastructure of the area, Possibility of using innovative technologies and modern materials, ratio of budgetary to extrabudgetary financing, Share of credit financing, social activity of the population, improvement of the territory, general trends of development of the city district sources and financing schemes, housing allocation mechanism, income and expenditure structure of the population, land-use tax policy, forms of ownership and real estate market, urban planning standards and requirements, possibilities of targeted financing.

The following indicators of efficiency of implementation of investment and construction projects are currently being applied:

- Commercial (financial) efficiency, taking into account the results of the project implementation for its participants (for the organization);
- Budgetary efficiency, reflecting the financial implications of the project implementation for all types of budget: federal, regional, local;
- People 's economic efficiency, reflecting the final indicators of the project for the national economy as a whole.

Depending on whether the customer of the project is a public organization or a private company, the criteria (indicators) for assessing the effectiveness of the project will also differ. Thus, if macroeconomic and social indicators are priority for the state customer, microeconomic indicators for his business come first for the private customer (investor).

However, there are a number of economic indicators that are universal for all investors: income (profit), amount of investment and its payback period, return on investment. In addition, there is an indicator that generalizes, integrates all types of effect: competitiveness of the object in the market.

In general, the main purpose of reconstruction is to maximize the obtained increase in the value of liquid assets owned by natural and legal persons by 1 ruble of investments and increase tax payments and non-tax revenues to regional and local budgets.

In view of the difficulties of increasing the share of budgetary funds for financing projects of reconstruction of real estate objects aimed at eliminating physical and moral wear, the main priority should be the formation of long-term development of mechanisms of state support, public-municipal-private partnership, use of own funds of enterprises-

owners of commercial objects, co-financing of projects of reconstruction of housing stock at the expense of owners of housing and private investments.

The profitability of reconstruction projects to eliminate accumulated wear or change the functional purpose of the building at objects of commercial, office, entertainment and sports purpose is provided by renting premises, selling the object. Also, the profitability of projects of reconstruction of commercial real estate due to the construction of attic floors, superstructure, annex, completion is provided due to the receipt of additional space and on this basis the sale, rental of premises.

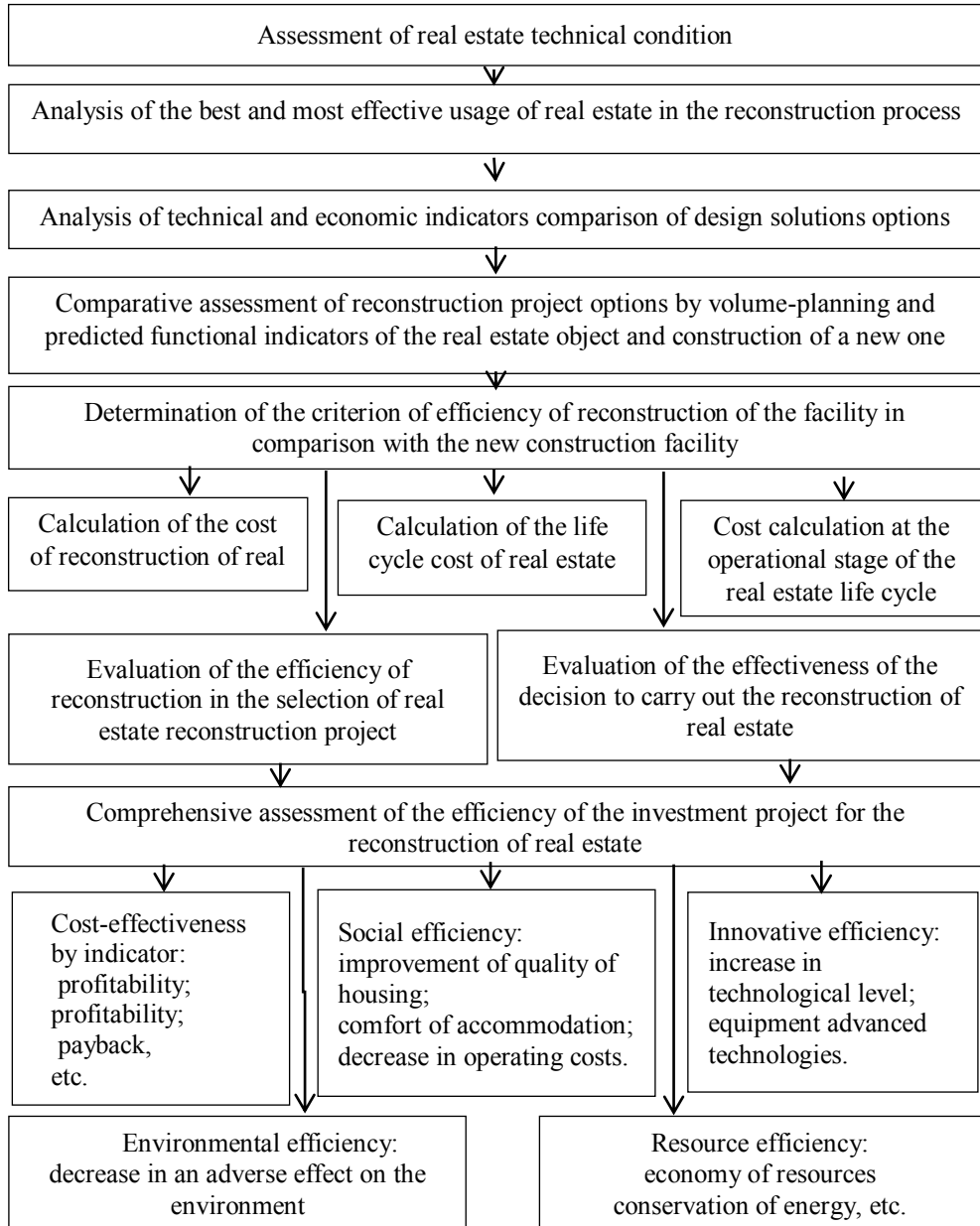
Profitability of projects for reconstruction of housing stock development due to elimination of accumulated wear and construction of attic floors is ensured by obtaining additional space and on this basis rental of premises or sale.

According to the sources of financing, the following models of investment of reconstruction projects are identified:

- For residential buildings, financing can be provided from the funds of owners of premises accumulated for major repairs in the form of monthly contributions, as well as with the involvement of private investments;
- For commercial real estate financing is carried out at the expense of resources of enterprises-owners of objects. Private investment and borrowing;
- For public infrastructure facilities, financing is provided within the framework of the implementation of investment programs of resource-supplying organizations and urban (municipal) programs at the expense of budgetary funds;
- For large infrastructure facilities, financing is provided under concession agreements through private investment and budgetary funds;
- For projects of reconstruction of urban environment facilities ensuring comfort and safety of life environment, financing is provided at the expense of budgets.

The synthesis of existing methods of assessment has led to the proposal of an algorithm for the integrated evaluation of the efficiency of object reconstruction, which includes the following sequential procedures:

- 1) carrying out a survey and assessment of the technical condition of buildings and structures with selection of design variants of types and works at reconstructed real estate objects, as well as analysis of technical and economic indicators of comparable variants of reconstruction objects;
- 2) comparison of volume-planning and functional-operational parameters of the existing object under investigation with versions of design solutions for reconstruction, as well as with predicted versions of new construction of a similar object;
- 3) realization of economic, social, innovative, energy-saving and operational objectives to assess the optimality of the reconstructed object and determine the cost of reconstruction options taking into account operational costs and the period of reconstruction of the object;
- 4) Selection of an effective option for reconstruction of objects, including: the cost of reconstruction of the object, calculation of the total cost of the life cycle of the building, evaluation of reconstruction options by indicators of costs at the operational stage of the life cycle of buildings, selection of an effective option for reconstruction of the object according to the criterion of the sum of the given costs for reconstruction, corresponding to not more than 70% of the given costs for the new construction project;
- 5) Comprehensive evaluation of the efficiency of the innovative project on indicators of commercial efficiency, taking into account the results of the project implementation for its participants and budgetary efficiency, reflecting the financial consequences of the project implementation for the federal, regional and local budgets Figure 1.



**Fig. 1.** Structural block scheme of evaluation of efficiency of real estate reconstruction projects implementation.

It is important to consider, when assessing efficiency, the application of innovative techniques of smart reconstruction, which uses various modern technologies in order to improve the quality of life, improve its competitiveness, while ensuring that the economic, social, environmental and technical needs of present and future generations are met.

The concept of smart reconstruction differs from other concepts in that it does not focus only on information and communication innovations, but it is also focused on achieving a new level of quality in the management, organization and control of reconstruction.

The tasks of the SMART-reconstruction can be described by a mathematical model of the following form:

$$\max \sum_{i=1}^n c_i x_i, \tag{1}$$

where  $c_i$  - the estimate of the  $i$ -th reconstructive component of the innovation technology, rubles per sq.m. of the useful area of the building;  
 $i$  - list of reconstructive components (types) of innovative technology;  
 $x_i$  - number of the area of the building reconstructed by the  $i$ -th list of components (types) of the innovative technology, sq.m. of usable area,  $x_i > 0$ .

Solving the problem of reconstruction with the help of model (1) provides recommendations on the composition of reconstructive innovative operations.

The concept of SMART is associated with innovation, high-tech clusters, information and communication technologies.

Since “smart” economic and technological changes in the development of cities are largely associated with increasing the efficiency of using all types of natural resources, environmental friendliness is becoming a key element of SMART-reconstruction.

The concept of smart reconstruction cannot be implemented without the smart management of all components of the model, which in turn cannot be implemented without human participation. This is all created to ensure the quality and comfort of living, which are also key elements of the concept. . [ 8].

Table 1 discusses the opportunities and threats to the implementation of the SMART model for the reconstruction of real estate.

**Table 1.** Opportunities and threats for the implementation of SMART-reconstruction.

Opportunities	Threats
Improving the quality of life and living comfort	High cost of innovative technology
Improving the quality of the management process of reconstruction	High project risks
Solving pressing economic and social problems through innovation	Lack of demand from the unprepared population
Increase of resource efficiency	High dependence on component supplies from abroad
Reduced time spent on project implementation	
Reduced financial costs in the field of resource saving	

Components of the model can be implemented separately or in certain combinations, depending on the objectives of the project.

This model is characterized by the following components: application of information modeling (BIM technology) at all stages of the building life cycle, modern automated technological audit system (monitoring the timing, cost and quality of the project), energy and resource saving technologies cogeneration systems, local and autonomous systems production of electricity and heat, elements of green construction (introduction of the BIPV technology), thermal insulation of enclosing structures and window blocks with modern materials and including the "transparent" insulation, vacuum insulation, the use of "smart" building systems, modern solid waste management system, the introduction of modern technologies for the production of works and innovative materials.

### 3 Results

For approbation of the provisions developed in the article on a specific example, a reconstructed four-storey dormitory building was selected as an object. in the city of Novosibirsk. After reconstruction, the functional purpose of the building is expanded in connection with the conversion of the first floor into commercial premises. Reconstruction involves the addition of the attic floor, redevelopment of dormitory rooms into apartments with business class rooms, the replacement of flat roofs with sloping roofs, the replacement of wooden windows with plastic windows, and the replacement of water supply, sewerage and heat supply networks.

For the project of reconstruction of the hostel, the following components of the SMART-technology are considered:

1. Application of information modelling technologies, including the method of visual planning;
2. Use of modern automated technological audit system: control over the timing and cost of the project;
3. Introduction of energy and resource saving technologies - heat insulation of enclosing structures;
4. Application of "intelligent" building systems:
  - 4.1 Automation system;
  - 4.2 Dispatching system;
  - 4.3 Modern MSW disposal system;
5. Introduction of modern production technology works - an innovative technology superstructure attic floor.

The effectiveness of the implementation of this project is understood as a category that reflects the compliance of costs and results of innovative reconstruction with the interests and goals of the project participants. Economic efficiency is determined by the main indicators of efficiency.

To assess the effectiveness of introducing optimized reconstruction methods, it was expedient to analyze and compare the project's expenses and revenues before applying improved methods and after reconstructing, respectively, based on the calculation of project costs, financing the renovation of the building, revenues from the dormitory renovation project, and cash flow.

The main calculated indicators for determining the economic efficiency of various options for the reconstruction of the object: the "traditional" reconstruction, SMART-reconstruction and a selective model of reconstruction (including some of the activities of innovative reconstruction) are shown in Table 2.

**Table 2.** Indicators of the economic efficiency of various reconstruction options.

Indicator	Indicators of "traditional" reconstruction	SMART-reconstruction indicators	Indicators of the "selective model" reconstruction
Internal rate of return (IRR),%	34.57%	43.52%	65.52%
Net income (NV), thousand rubles	73078.18	80740.65	85324.13
Investment Return Index (PI)	1.17	1.21	1.23
Payback period (PBP), months	20	19	17

The calculation of economic indicators suggests that all reconstruction projects are effective. Each project has pros, cons and risks, so the developer should choose a project

concept, as well as a set of components of the “Smart Reconstruction” model, based on the goals and possibilities of customers. Carrying out “Smart reconstruction” is more profitable in comparison with SMART-construction due to the fact that the building already has a prepared constructive-planning basis, which allows reducing the cost of expenses.

## 4 Conclusions

The modern approach to the organization of reconstruction and efficiency assessment creates the conditions for saving resources, reducing the time of work production, improving efficiency. SMART-technologies provide sustainability, a degree of security, additional characteristics to preserve the value of assets for the owner, as well as to maximize the achievement of development goals.

The following innovative measures will contribute to improving the efficiency of reconstruction of housing and communal infrastructure facilities: development of new instrumental methods for diagnostics of the state of structures and automated transmission of information for making decisions on the choice of repair and reconstruction works; usage of personal computers to calculate designs and implement effective design solutions using the latest materials; development of new methods of reinforcement as well as reconstruction of structures; development and implementation in the practice of reconstruction of BIM-projects, digital technologies based on a single information and communication platform of the life cycle of objects.

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