Строительные материалы и изделия
Construction Materials and Products

journal homepage: https://bstu-journals.ru

ISSN
2618-7183

DOI: 10.58224/2618-7183-2025-8-1-8

Factors of territorial resource use in the reconstruction of multi-purpose healthcare facilities

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Abstract: Medicine is one of the most important directions for the country development and has a fundamental position in the socio-economic policy of the state, ensuring the human health and well-being. With the development of medical technologies, the standards of medical care are also growing, and the requirements to healthcare facilities are becoming more stringent. In the conditions of dense urban development, the construction of a multi-purpose medical center that fully meets the standards may be problematic, and therefore the possibility of reconstruction of existing healthcare facilities to meet up-to-date requirements is being considered. The purpose of this article is to determine the possibility of reconstruction of multi-purpose healthcare facilities through densification of development; to analyze the methods of densification in relation to the territories of multi-purpose healthcare facilities; and to detect the architectural principles in the densification of development of multi-purpose healthcare facilities. The article authors also show the architectural techniques used in reconstruction with an increase in the technical and economic indices of the facility. The methodology of this research represents the analysis of academic papers, as well as the analysis and generalization of practical experience in the architectural design and reconstruction of multi-purpose healthcare facilities, including the personal experience of the article authors. The result of the research is the determination of the basic principles of the reconstruction of multi-purpose healthcare facilities, which make it possible to create the up-to-date typology of a healthcare facility, and have an impact on the formation of the architecture of multi-purpose healthcare facilities. The research is aimed at forming the up-to-date typology and architecture of multi-purpose healthcare facilities during reconstruction.

Keywords: typology of multi-purpose healthcare facilities, densification of development, modular scheme, architectural principles of multi-purpose healthcare facilities, reconstruction of the territory, territorial resource

Please cite this article as: Tesler N.D., Balakina A.E. Factors of territorial resource use in the reconstruction of multi-purpose healthcare facilities. Construction Materials and Products. 2025. 8 (1). 8. DOI: 10.58224/2618-7183-2025-8-1-8

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Received September 25, 2024; Received in revised form November 13, 2024; Accepted January 27, 2025

1. INTRODUCTION

Reconstruction of multi-purpose healthcare facilities (MHFs) is one of the most urgent tasks of modern medicine. The design of buildings for medical institutions is characterized by a number of peculiarities. Thus, along with a design assignment, the customer issues a medical and technological assignment (MTA) in accordance with SP 158.13330.2014 Buildings and premises of medical organizations, which is the basis for the design of healthcare facilities. It describes the functional subdivisions of the MHF being designed, the technological scheme of a medical institution, provides a list of required areas of rooms, determines the useful and total area of the facility. The combination of medical-technological and architectural-planning solutions represents the main peculiarity of the design of multi-purpose healthcare facilities and runs through all stages of development.

The MHF design experience described in the papers of Gayduk A.R. [13], Ledeneva N. [15], Kozhevnikova Y. [16] and other authors [20, 21, 22] show that the basis of the planning solution is not only the architectural composition, but also the functional and technological scheme of the medical complex. Therefore, the collaborative work of an architect and a technologist or an architect with a good knowledge of medical technologies is envisaged at the initial stage. At the initial stage of design, the functional and planning zoning of the departments is clarified, functional links are established between the treatment and diagnostic and auxiliary units, and the sanitary and epidemiological independence of patient flows is ensured. The floor plans of the building are developed on the basis of functional schemes. The role of the architect should not be underestimated at the initial stage. Already here, the space planning for the comfort and relaxation of patients and the convenience of the staff should be provided.

Further, in the course of collaborative work of the architect and technologist, technological assignments are drawn up for the layout of medical gas pipelines, power supply, water supply, sewerage, ventilation, air conditioning, security and fire alarm systems, and other low current systems. In turn, specialists in utilities systems develop construction assignments for architects and structural designers [23, 28, 29].

In the architectural part of the project, heat engineering, light engineering and acoustic calculations are also performed, and the energy performance of the building is determined.

2. METHODS AND MATERIALS

The methodology of this research represents the generalization of materials of academic papers devoted to the reconstruction of medicine facilities, as well as the analysis of scholarly publications devoted to urban planning analysis of the territory development of healthcare facilities, the generalization of practical experience in architectural design and reconstruction of MHFs, the application of the experience of the article authors in the reconstruction of MHFs.

Studies in the area of reconstruction of buildings and structures are devoted to the solution of construction engineering, construction technological and architectural problems. Papers [1, 2] consider the issues of the basic methods of reconstruction (superstructure, extension, insertion, remodeling), the peculiarities of elaboration of design documentation and choice of a rational scheme of construction and installation works, the issues of preservation and strengthening of structures when carrying out reconstruction, as well as performance of works in specific conditions of the existing development.

Papers [3, 4] describe the methods and ways of demolition of buildings, comparative characteristics of these methods, their advantages and disadvantages, connection of technical operation and reconstruction of buildings.

Article [5] considers the methodology of concurrent design, which makes it possible to combine the stages of design, approvals, reconstruction and operation, the issues of reconstruction for public buildings in Moscow without their shutdown: prerequisites, justifications, selection of optimal methods. The classification of the methods and ways of reconstruction of public buildings is provided in Fig. 1.

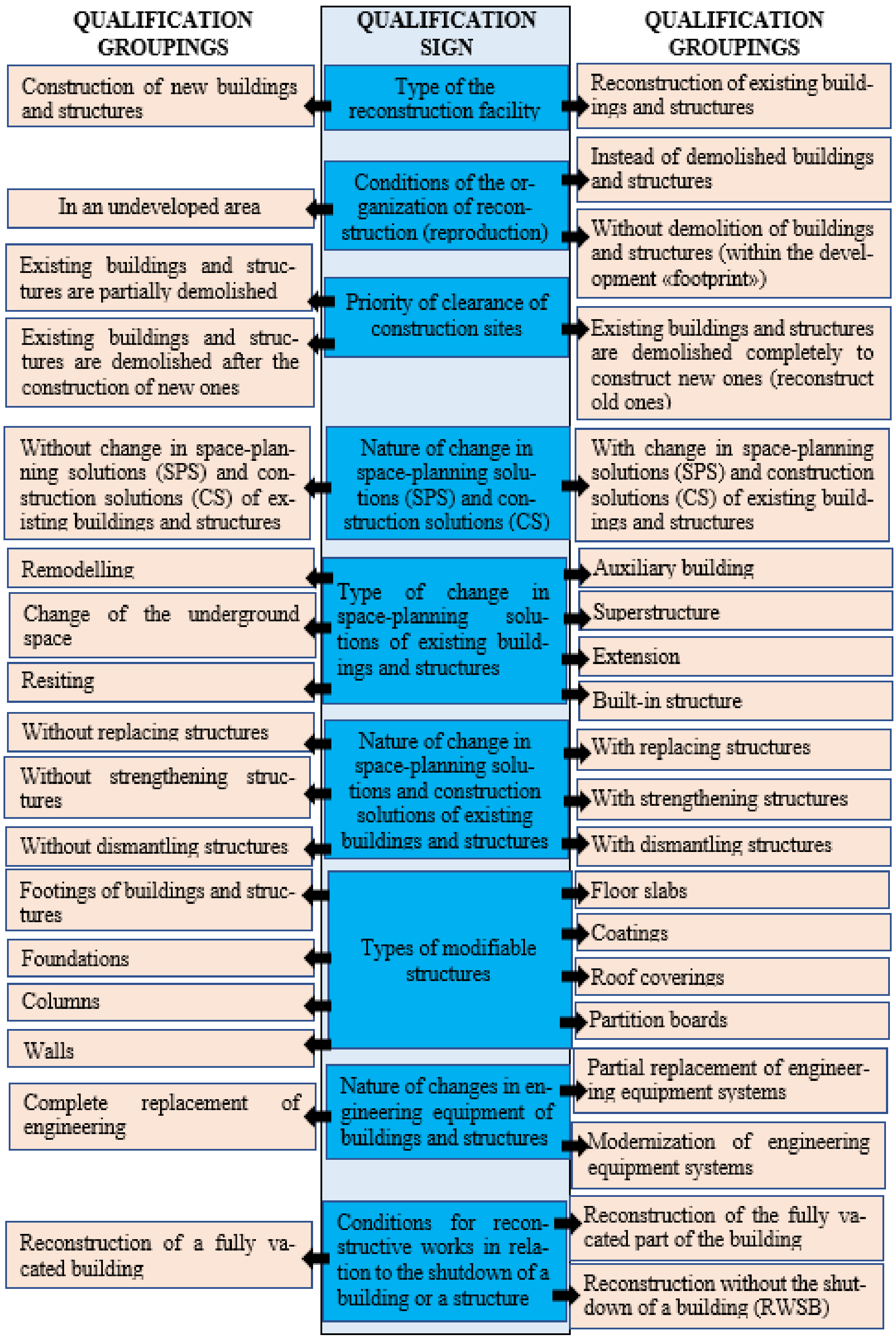

Fig. 1. Classification of the methods for reconstruction of public buildings.

The issues of integrated reconstruction of the historical urban environment have been considered in paper [6]. It is established that restoration facilities are always a monument of cultural and architectural heritage, which has historical, urban planning, architectural-artistic, scientific-restoration and functional value.

In general, the issues of reconstruction, renovation and other forms of renovation of both individual buildings and entire blocks of cities and inhabited localities are a very important area of scientific activity of many higher educational establishments of the country. These problems are also dealt with in the leading construction higher educational establishment of Russia - Federal State Budget Educational Institution of Higher Education “National Research University Moscow State University of Civil Engineering” (NIU MGSU) [7, 8], in other institutes [9, 10, 11]. Architectural issues in such studies are mostly considered in the aspect of the reconstruction of architectural monuments; the peculiarities of functioning of medical organizations during the reconstruction period are practically not investigated.

3. RESULTS AND DISCUSSION

Let us consider the peculiarities that are identified when designing the reconstruction of MHFs.

At the initial design stage, not only engineering surveys, structural condition surveys of buildings, measurement works, but also medical and technological survey of the complex of medical buildings and structures located in the territory of the institution are carried out. The scope of this survey includes the development of plans for the functional location of subdivisions at the time of reconstruction, the construction of a general functional scheme of the institution, a description of the growth areas of the institution, the calculation of space shortages to bring the needs of the center into compliance with the modern regulatory framework [18, 19]. As a result of this survey, the scope of reconstruction is determined, the technical and economic indices of the reconstruction, the planned capacity of the center after reconstruction are specified, and the medical and technological assignment and the program of premises are formed.

No effective reconstruction of MHFs is possible without an increase in the technical and economic indices of the facility. Only in this case it is possible to maintain or increase the number of beds of MHFs, other power indicators, and to bring MHFs in line with present-day standards and technological requirements.

For reconstruction with an increase in technical and economic indices, various architectural techniques are used, such as extension, built-in structure, insertion, and superstructure. At the same time, the territory of the medical center is being densified, which must be confirmed by the land plot development plan (LPDP).

Many medical institutions operate in narrow buildings built in the 1950s-70s or earlier, or in the buildings adapted for medicine. Let us consider the peculiarities of the reconstruction of MHFs using specific examples.

The clinical building of the Federal State Budgetary Institution “National Medical Research Center for Endocrinology” of the Ministry of Health of the Russian Federation at the address: 11, Dmitry Ulyanov Street, Moscow was erected in 1969-1970 as a school building, but later it was remodelled as a healthcare institution.

After 2000, the six-storey building was heightened with two floors (Fig. 2). The area of the building was approximately 9,000 sq. m. Fig. 2 shows the plan of the typical floor of the clinical building of the FSBI “National Medical Research Center for Endocrinology” of the Ministry of Health of the Russian Federation at the address: 11, Dmitry Ulyanov Street, Moscow, before reconstruction. As can be seen in Fig. 2, 3, before the reconstruction, the healthcare facility was a narrow building with one-corridor typology. Due to the limited width of the building, not all wards were provided with water closets. The wards themselves did not meet the modern requirements of the rules and regulations for medical premises by their area.

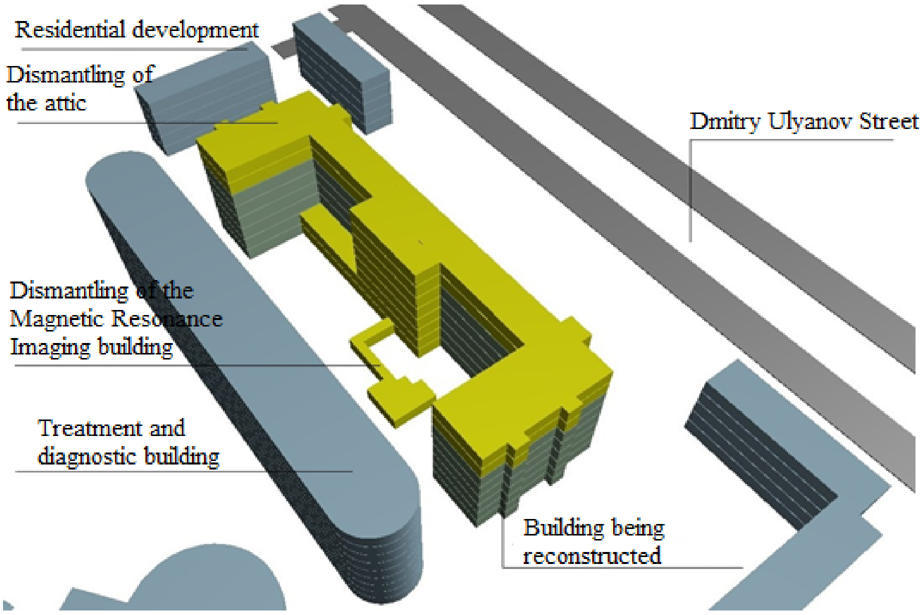

Fig. 2. Initial layout of the Endocrinology Center.

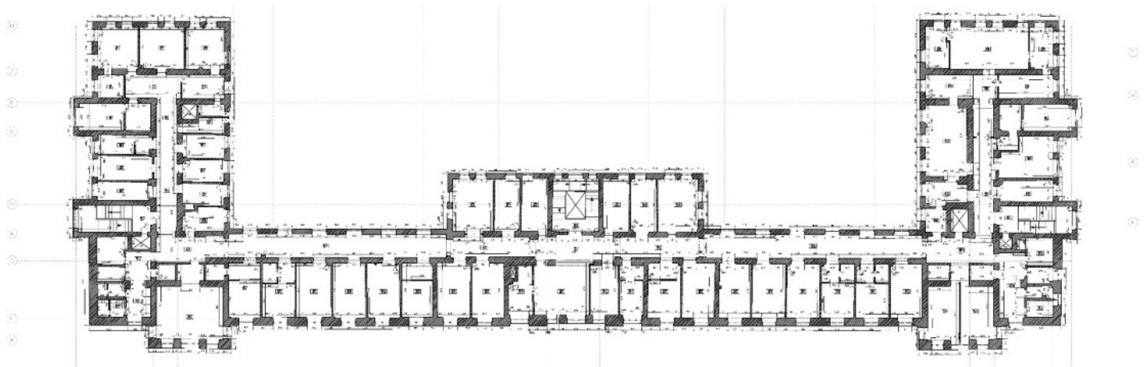

Fig. 3. Typological scheme of FSBI National Medical Research Center for Endocrinology of the Ministry of Health of Russia at the address: 11, Dmitry Ulyanov Street, Moscow before reconstruction.

Reconstruction of FSBI National Medical Research Center for Endocrinology was carried out by insertion, extension and superstructure. The new building received a two-corridor space planning, which made it more functional. More than 70% of the wards are oriented to the south side. In addition, a new passage connected a reconstructed building with the treatment and diagnostic building constructed in 2015 (Fig. 4). As a result of the reconstruction, the total area of the building was 27,000 m^2, including the underground area of 3,315 m^2, the construction volume is 97,373 m^3. Thus, the capacity of the facility has been tripled.

A monolithic insertion was built into the structural scheme of the existing building for the connection of old and new structural elements, an extension and a superstructure were erected (Fig. 4, 5). All this made it possible to change the typology of the clinical building (Fig. 6). At the same time, the load-bearing structures of the existing building were mostly preserved.

Fig. 4. Plan for the reconstruction of the MHF building by insertion and extension.

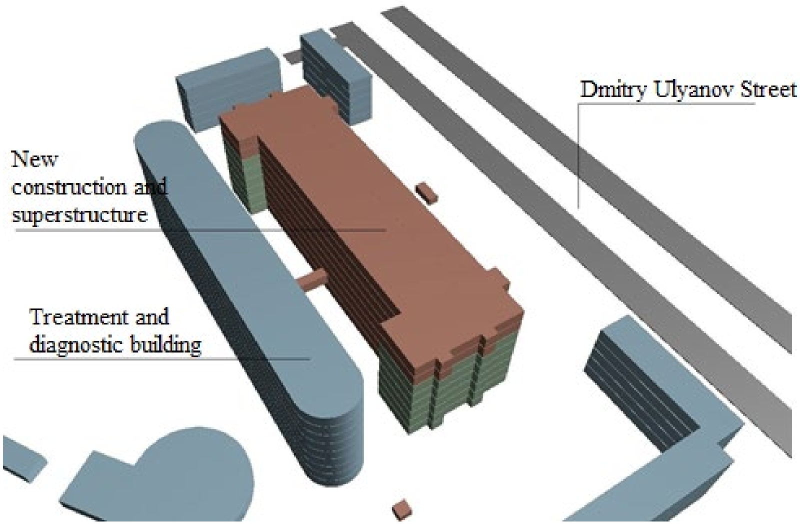

Fig. 5. Scheme of FSBI National Medical Research Center for Endocrinology of the Ministry of Health of Russia at the address: 11, Dmitry Ulyanov Street, Moscow after reconstruction.

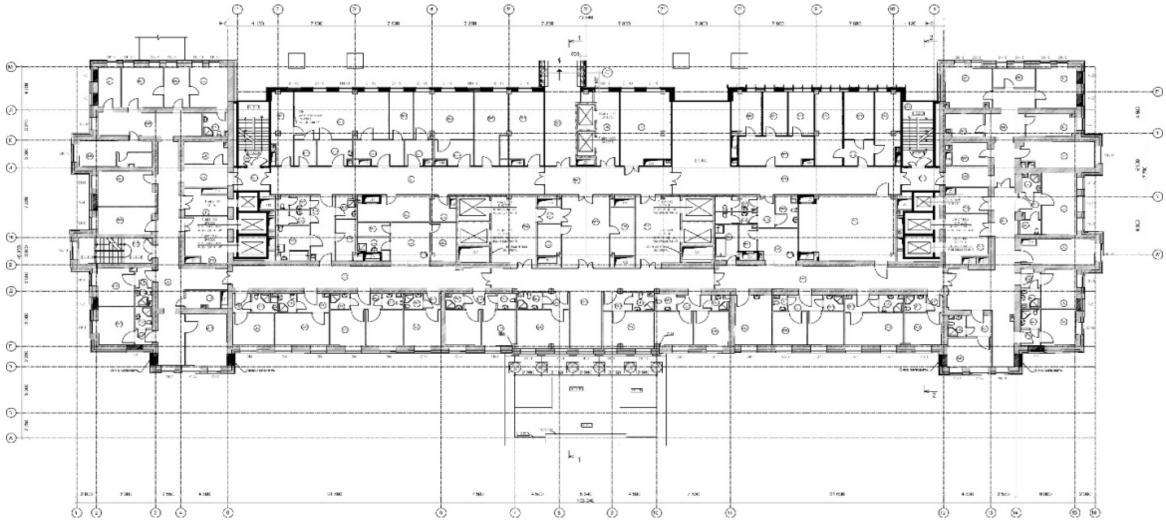

Fig. 6. Typological scheme of the National Medical Research Center for Endocrinology of the Ministry of Health of Russia at the address: 11, Dmitry Ulyanov Street, Moscow before reconstruction.

In the event that the structures of the existing building or buildings are in a limited operable or unsatisfactory condition, then the reconstruction is carried out with a phased dismantling of individual buildings and the construction of buildings with a new typological scheme in their place. At the same time, at each stage, the facility operates and continues to provide medical services.

Fig. 7 shows a modular scheme for the development of the territory of the hospital of the Federal Customs Service at the address: Otkrytoye Highway, Moscow, before reconstruction. The existing buildings of the medical treatment facility erected in 1960-1966 were located on the site: three four-storey medical treatment buildings, a one-storey catering unit and a medical admission unit, buildings of the morgue, archive, an oxygen and gas station, a transformer substation, and a checkpoint (Fig. 6). During the reconstruction, it was necessary to increase the capacity of the medical treatment facility, in fact, to create a multifunctional healthcare organization with the expansion and attraction of new areas of medical activity.

The facility had to operate continuously and at the same time be under reconstruction, which provided for doubling the capacity of the facility and the construction of two new corridor medical treatment buildings. To ensure the continuous operation of the facility, the MHF was conditionally divided into modules.

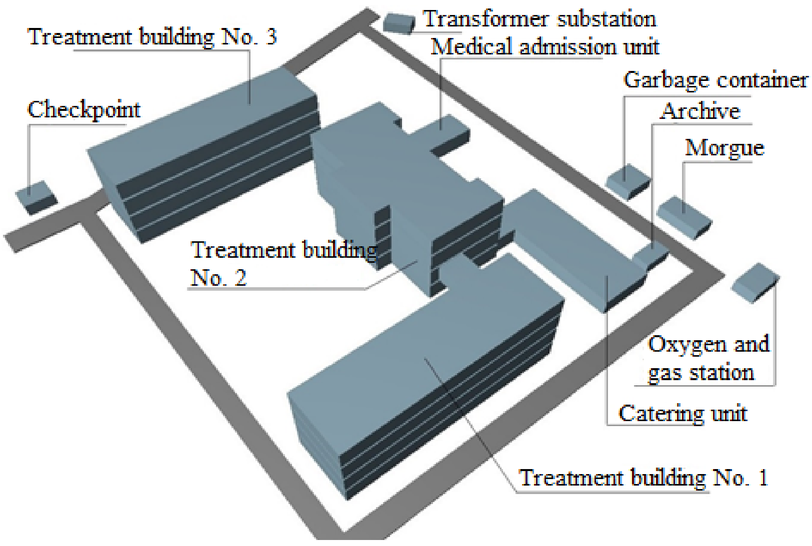

Fig. 7. Modular scheme of the reconstructed MHF.

The main problems during the reconstruction were the limitation of the site area, the impossibility of its extension and the provision of the continuous operation of the hospital for the entire period of construction. Reconstruction was carried out in four stages, with a phased replacement of modules.

During the implementation of the first stage of reconstruction, the module of treatment building No. 3, located on the western side of the site, was demolished. On the vacated site, a six-storey building of ward department No. 1 with the medical admission unit on the first floor was erected (Fig. 8).

The second stage of reconstruction included the demolition of a one-storey building of the medical admission unit and a transformer substation (TS). A new transformer substation and a stand-alone diesel power plant were built approximately on this spot (Fig. 9). On the site of the demolished medical admission unit, a catering unit and a nine-storey vertical communications unit (elevators, stairs) were erected. Patients in all buildings received meals from a new catering unit.

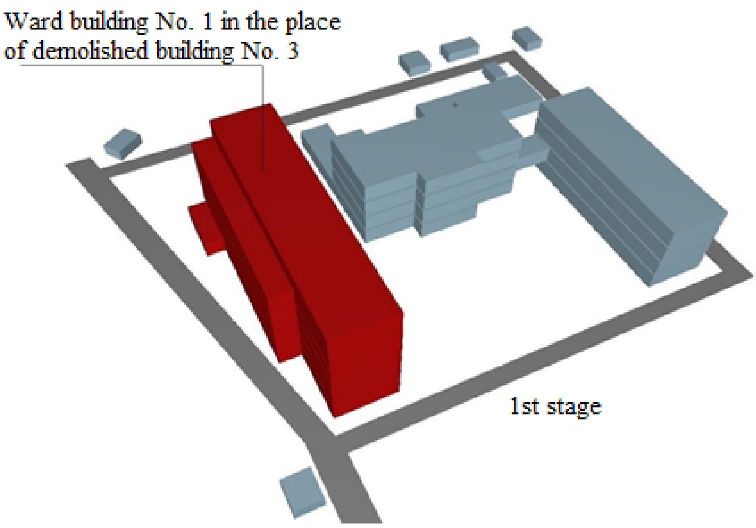

Fig. 8. First stage of hospital reconstruction (rotated).

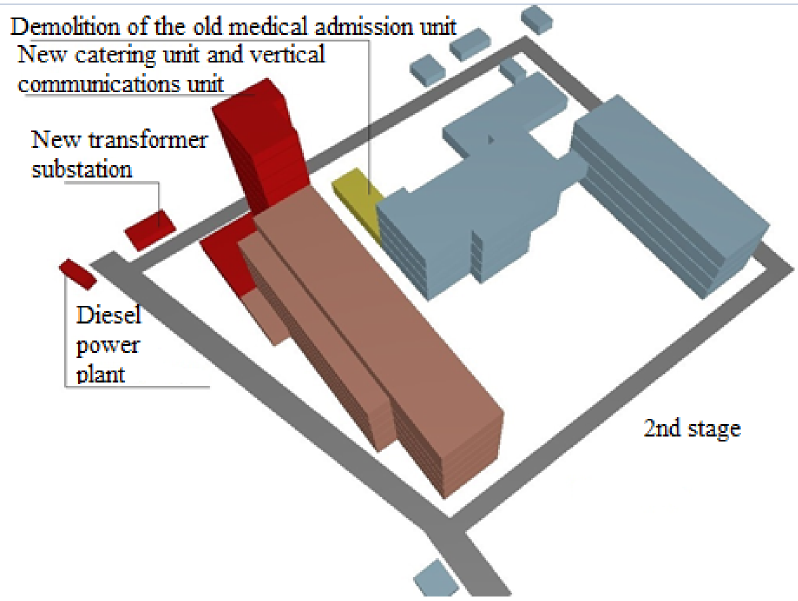

Fig. 9. Second stage of hospital reconstruction.

During the implementation of the third stage of reconstruction, the old catering unit, one-storey buildings of the archive, morgue, garbage container and other small facilities were demolished. A nine-storey treatment and diagnostic building was erected on the vacated site, a stand-alone oxygen and gas station and a garbage container were built (Fig. 10).

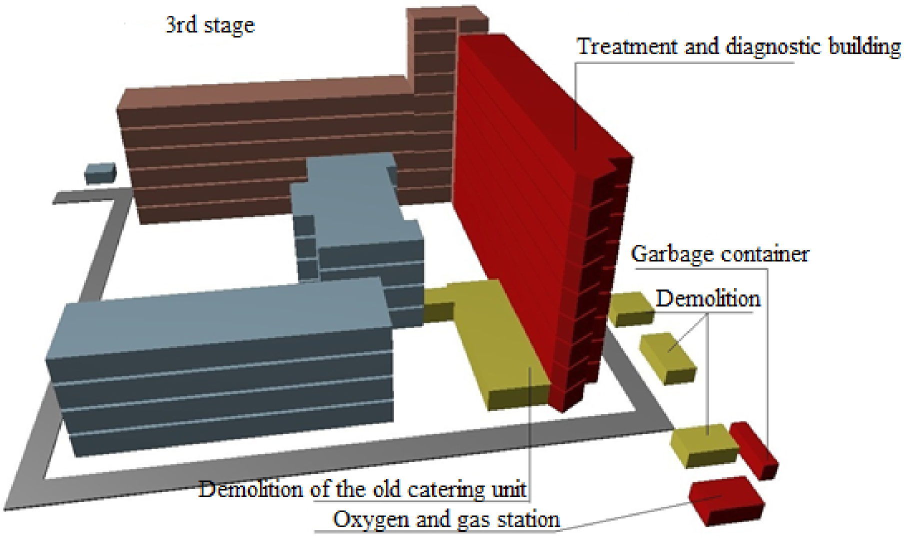

Fig. 10. Third stage of hospital reconstruction (rotated).

A new treatment and diagnostic building erected at the third stage was subsequently completed at the fourth stage. Thus, the construction of the building was divided into two start-up facilities. Moreover, during the construction of the third stage, all utility systems of the hospital were generally reconstructed.

The fourth stage of reconstruction included demolition of old treatment blocks No. 1 and No. 2. Underground garages were erected on the vacated sites, and then nine-storey ward department No. 2 was constructed. From the northern side, the building is closely adjacent to the treatment and diagnostic building erected at the third stage. At the same time, they were combined into a single two-corridor building with increased width (Fig. 11). At the fourth stage, a block of administrative premises, and a checkpoint were also erected; and land improvement of the site was carried out.

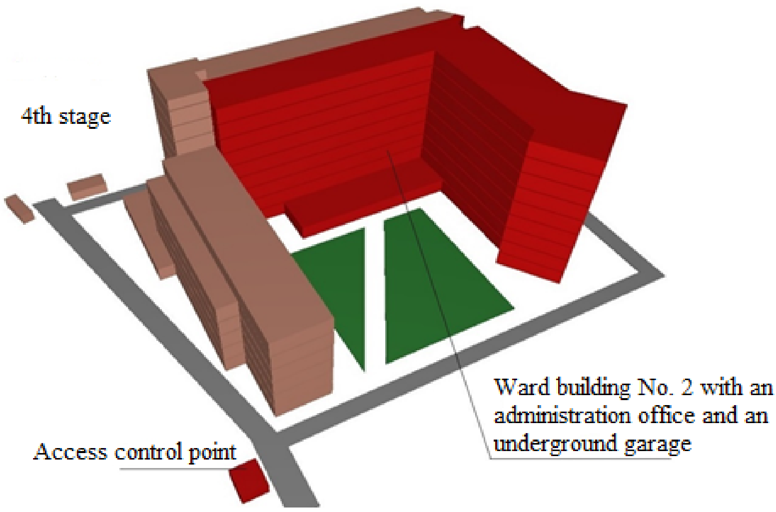

Fig. 11. Fourth stage of hospital reconstruction.

After the reconstruction work, the new buildings had the same U-shaped layout as before the reconstruction. At the same time, the number of floors and the productivity of the medical complex as a whole were increased, the typology of the buildings was changed.

If the site allows, the reconstruction can be accomplished by **inserting, building in and adding** a new building between two existing ones. Fig. 12 shows a modular scheme of the healthcare facility Medincentre in the city of Moscow after reconstruction. Previously, a two-storey building, which was demolished, had been adjacent to the building of the outpatient clinic constructed in 1980. A number of small facilities and house No. 6 were also demolished on the site. A new clinicodiagnostic building of variable number of floors (5-9 floors) with three underground floors was erected on the vacated area.

As a result of the reconstruction, a new wide in-patient building was inserted in the existing territory. The institution has significantly expanded its capabilities in providing medical care, is designed for all age groups, and in-patient treatment sections have appeared (Fig. 12). Patient wards have a western orientation.

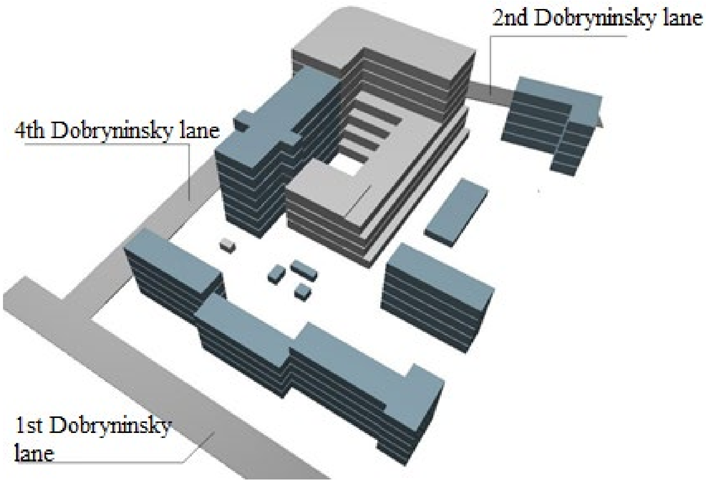

Fig. 12 Reconstruction of the MHF by insertion and extension.

The total area of buildings amounted to 22,563 m^2, including the area of underground floors - 7,868 m^2, which exceeds almost twice the area of the facility before the reconstruction.

Thus, the analysis of the development of space planning solutions showed that daring innovations can be applied in the reconstruction of the MHF: insertion of new volumes directly into the existing part of the building, insertion of vertical and horizontal transport links, and reorganization of underground and attic space. At the same time, the plastic capabilities of monolithic reinforced concrete, the thermophysical and acoustic properties of modern insulation materials, and new organizational and technological solutions should be used.

The development density factor for the reviewed facilities was 14,485 m^2/ha for the hospital of the Federal Customs Service, 33,108 m^2/ha for the Medincentre, and 25,641 m^2/ha for the Endocrinology Center. The average value of the development density factor was 21,680 m^2/ha, which is typical for most morphotypes of traditional Moscow development described in MGSN 1.01-99, and also does not exceed the maximum permissible values in accordance with SP 42.13330.2011 Urban Development.

Based on the conducted research, the principles affecting the effectiveness of MHF reconstruction have been identified, namely:

– P1. Increase in technical and economic indices of MHF, including capacity, which can be the total area of MHF or bed capacity for the inpatient unit;

– P2. Change in the typology of MHF, creation of wide buildings that provide the possibility of applying new medical technologies;

– P3. Bringing MHF into compliance with present-day standards. These are sanitation, fire safety standards, design standards of public buildings and internal utility systems, regulations;

– P4. Ensuring all types of MHF safety, including design safety;
– P5. Densification of development, ensuring urban planning regulations in the reconstruction of MHFs;
– P6. Ensuring the possibility for MHF being reconstructed to create new functional and technological subdivisions, taking into account the development and extension of the material and technical base;
– P7. Renewal of the entire engineering infrastructure of MHF, taking into account the increase in resource loads and reconstruction of all input nodes and resource
– -supplying facilities.

The summarized indicator PS=P1+P2+P3+P4+P5+P6+P7, thus PS is the summarized principle of territorial resource in the reconstruction of MHF. At the same time, it is not possible to apply the summarized principle of territorial resource to every reconstruction. The possibility of application and implementation of MHF principles in operation depends on the applied method of densification of development. The article illustrates the methods of densification of development, such as:
– M1. superstructure;
– M2. extension;
– M3. insertion;
– M4. superstructure + extension;
– M5. superstructure + extension + insertion;

Table 1 shows the dependence of the applicability of territorial resource principles on the method of densification of development.

Table 1. Dependence of the applicability of territorial resource use principles on the selected method of densification of development.

Principles affecting the effectiveness of MHF reconstruction	Applied method of densification of development				
	M1 Superstructure	M2 Extension	M3 Insertion	M4 Superstructure + extension	M5 Superstructure + extension + insertion
P1. Increase in technical and economic indices of MHF	✓	✓	✓	✓	✓
P2. Increase in the typology of MHF	×	✓	×	✓	✓
P1. Bringing MHF into compliance with present-day standards	✓	✓	✓	✓	✓
P4. Ensuring all types of MHF safety	✓	✓	✓	✓	✓
P5. Densification of development, ensuring urban planning regulations	✓	×	×	✓	✓
P6. Creation of new functional and technological subdivisions	×	✓	×	✓	✓
P7. Renewal of the entire engineering infrastructure of MHF	×	✓	×	✓	✓
PS Summarized indicator	**4**	**6**	**3**	**7**	**7**

As the table shows, the most effective method of densification of development is M5 method. Fig. 13 shows the model of efficient use of territorial resource in the reconstruction of MHF.

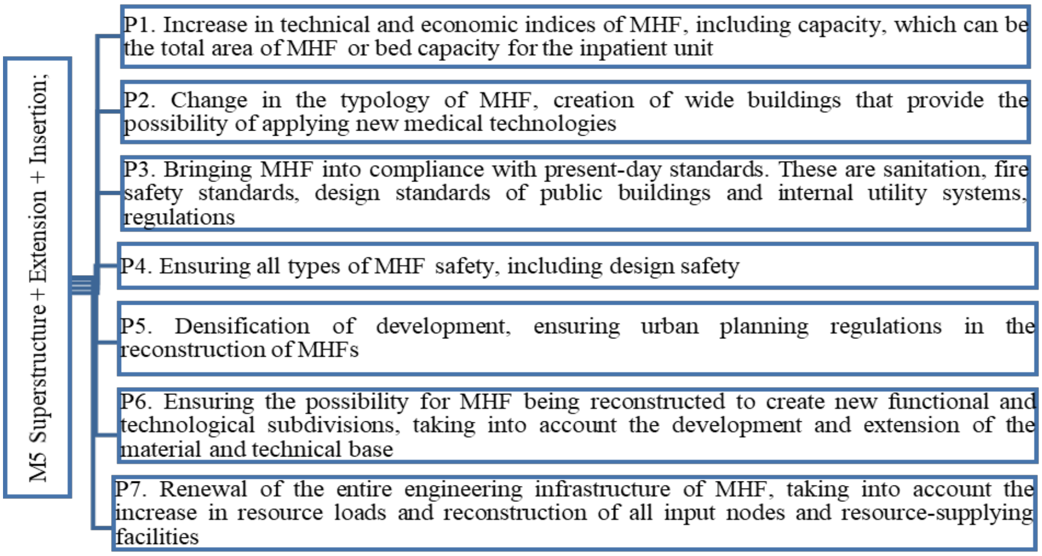

Fig. 13. Model of efficient use of territorial resource in the reconstruction of MHF.

4. CONCLUSIONS

Based on the conducted research, the technology of MHF reconstruction has been determined, based on which architectural solutions are implemented, namely:

- mandatory conduct of medical and technological survey (MTS), based on which the deficit of areas and fields of prospective development are detected, and the area required as a result of the facility reconstruction is determined,
- based on the MTS, elaboration of a medical and technical assignment (MTA) and an assignment for designing the reconstruction of the MHF,
- study of the possibilities of MHF reconstruction based on the land plot development plan (LPDP), in case of lack of density and height parameters for the facility development - determination of the procedure of making changes to the land use and development rules,
- creation of architectural and planning solutions for the MHF taking into account the described technology.

An important result of the research is the determination of the main principles of reconstruction. These are the principles presented in Table 1 and in Figure 13. Table 13 shows that there are principles without which no reconstruction method is effective. These principles are as follows:

- increase in technical and economic indices of MHF, capacity of the facility expressed as the total area and/or bed capacity of the inpatient unit;
- bringing MHFs in line with present-day standards, application of the agreed medical and technical assignment (MTA) in the development of architectural solutions;
- ensuring all types of MHF safety.

The specified principles make it possible to take into account the main requirements of modern trends in the development of medicine, improvement of the regulatory framework and ensure the development of MHFs.

The model of efficient use of territorial resource in the reconstruction of MHF has also been proposed. The specified model grants the opportunity to the architect, taking into account all the principles of reconstruction, to create the most attractive architectural and planning solutions for users. This means the application of modern typology of MHF, the possibility of using new architectural forms, new modern finishing materials for exteriors and interiors, as well as the creation of the most comfortable conditions for patients and staff. The said model provides for a complete upgrade of engineering solutions for all types of safety and efficient operation.

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