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High-rise construction in the Russian economy: modeling of management decisions

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Abstract: The growth in the building industry, particularly in residential high-rise construction, is having considerable influence on the country's economic development. The scientific hypothesis of the research is that the execution of town-planning programs of high-rise construction depends to a large extent on the management of the provision of material resources for the construction of a millionth city, while the balance model is the most important tool for establishing and determining the ratio between supply and demand for material resources. In order to improve the efficiency of high-rise building management, it is proposed to develop a methodology for managing the provision of construction of large cities with material resources.

1 Introduction

At the present time in Russia there is a sharp change in the priorities of the practice of town planning towards the construction of high-rise public buildings and residential complexes, which can be regarded as a positive trend. As the world practice shows, in large cities the construction of high-rise buildings is getting more and more developed, which is due to the high cost of land, limited urban areas, intensive population growth and other reasons. The accumulated experience abroad shows that, taking into account the cost of land, 30-50-storey building objects are optimal for economic indicators. High-rise buildings form the modern urban landscape of the cities of the USA, Canada, China, and Europe. As the world practice shows, the large number of storeys of buildings with a high population density leads to an improvement in the quality of life. Residential objects and objects of social sphere, located not far from each other, make it possible to eliminate the difficulties associated with overcoming unnecessarily large land areas by residents. Construction is unique in stimulating the growth of other sectors (Hillebrandt 1985) and this contribution varies according to the nature of the society in which construction takes place (Okpala and Aniekwu 1988) [1].

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According to the scientist Didenko V.G. the statistics of developed countries indicate a direct relationship between the density of the urban population and the cost of energy conservation. In cities with higher density, achieved due to high-rise construction, energy saving costs are significantly lower, due to the smaller length of thermal and electric networks [2].

The great age of high-rise buildings began after the end of World War II, when the world economy and population again expanded. It was an optimistic time with declining energy costs, and architects embraced the concept of the tall building as a glass prism. This idea had been put forward by the architects Le Corbusier and Ludwig Mies van der Rohe in their visionary projects of the 1920s.

As environmental control systems increased in cost, economic pressures worked to produce more efficient structures. In 1961 the 60-story Chase Manhattan Bank Building, designed by Skidmore, Owings & Merrill, had a standard steel frame with rigid portal wind bracing, which required 275 kilograms of steel per square metre, nearly the same as the Empire State Building of 30 years earlier. The same firm demonstrated economy of structure in tall buildings only nine years later in the John Hancock Building in Chicago

Building construction has settled into a period of relative calm after the explosive innovations of the 19th century. Steel, concrete, and timber have become mature technologies, but there are other materials—such as fibre composites—that may yet play a major role in building [3].

2 Methodological approaches and analysis

The Russian practice of high-rise construction boils down to construction, which in most cases refers to the compacting of existing buildings, which does not correspond to world practice. This in turn leads to poor ventilation of the space between the buildings, weakening of the bearing capacity of the soil, the removal of gardening, the lack of places for recreation and the creation of a visually aggressive environment.

High-rise buildings, especially mixed use, are rational because they can accommodate a large number of people in a small piece of land. This avoids the development of agricultural land and reduces energy consumption, as well as carbon emissions to the environment associated with pendulum migration (people moving from suburbs to work and vice versa). These facilities offer effective systems of vertical and horizontal movement, contributing to the creation of cities for walking.

High-rise buildings allow saving the city space and the municipality's expenses for infrastructure: pulling the network to a skyscraper per square meter of area is much more expedient than to a low-rise building or a cottage. The second aspect is environmental: the inhabitants of the upper floors, are not affected by the pollution and noise of the metropolis. Another positive moment is the image: unique high-rise buildings attract world attention (examples of the Empire State Building (449 m) in New York and the Burj Khalifa building (828 m) in Dubai are very indicative in this respect). Investigating the problems of high-rise construction should take into account such factors as the state of the air environment; the need for mechanical ventilation systems; the characteristic of aerodynamics; quality of the air environment and the need for engineering and environmental training.

With all the obvious economic feasibility, high-rise construction in large Russian cities is not carried out in sufficient volume. There are several objective reasons for this. Among the first, one should mention the absence at the federal level of technical regulations for the design and construction of high-rise complexes and the lack of experience in their construction. The issues of construction supervision over high-rise facilities and the interaction of federal and city structures in this area remain open.

Issues related to the placement and erection of high-rise apartment buildings and complexes in large cities of Russia should be the subject of the closest attention of city planners, architects, designers, engineers, ecologists, sociologists, demographers. It is obvious that high-rise housing construction is at the forefront of the construction sector today. The presence of skyscrapers is distinguished by any modern city, testifies to the high development of construction technologies, the intellectual capabilities of designers, the readiness of the corresponding material and technical base. The annual conference of the Council on High-Rise Buildings and Urban Environment CTBUH collects all the necessary information and statistics on skyscrapers and compiles the altitude ratings. According to NEDO (1988), timely completion of projects is the most important indicator of an efficient construction industry. Time overrun is the main cause of cost overrun and it affects both clients and contractors.

Even though government spending is increasing, it is not nearly enough to solve the housing problems and, therefore, over the last 10–12 years, private companies have stepped in to initiate real estate business through the construction and sale of middle to high-rise apartment buildings. The main reasons for high-rise rather than low-rise construction are scarcity of land and land prices (Figure 1).

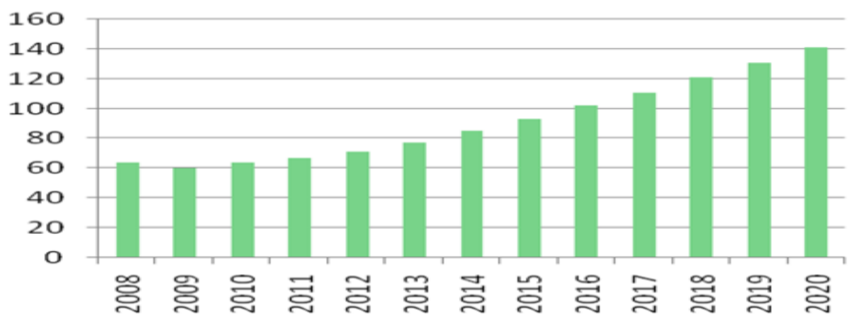

Fig. 1. Forecast of housing construction in the Russian Federation until 2020, million square meters [4]

In 2016, the volume of housing construction in Russia decreased, as compared to 2015, by 6.5%. A total of 1156,500 apartments with a total area of 79.8 million square meters were put into operation in the country in a year. meters - by 5.5 million square meters. meters less than in 2015 [5].

Leaders in terms of the commissioned housing in addition to the Moscow region and the Krasnodar Territory were Moscow (3361.8 thousand square meters), St. Petersburg (3116.3 thousand square meters), the Republic of Bashkortostan (2698.5 thousand square meters. m) and Tatarstan (2406.5 thousand square meters).

In the first quarter of 2017, 13.1 million square meters were commissioned. meters of residential (Figure 2).

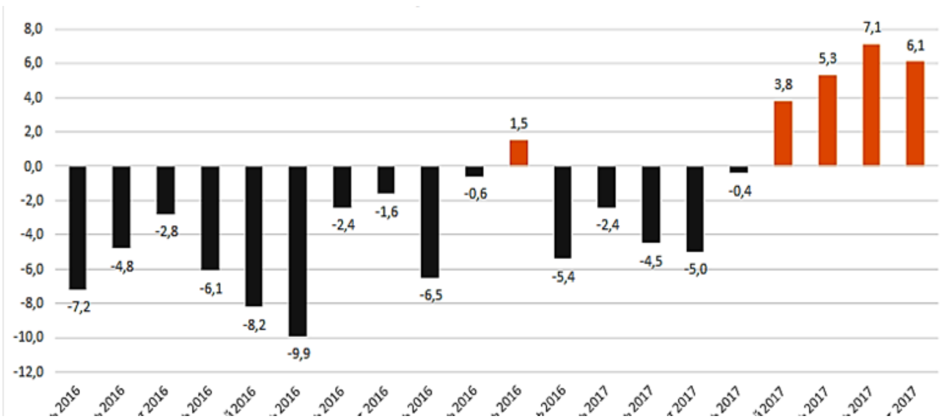

Fig. 2. The dynamics of the volume of work performed by type of activity construction in percent [6]

3 Results

Because of the relatively small experience of building high-rise complexes in Russia, not all of the above factors of high-rise construction have been thoroughly studied to date. The most acute issue in the construction of high-rise buildings and complexes is the provision of their power capacities. In view of the current electricity deficit in the city, it is necessary to consider the possibility of using alternative sources of heat and power supply. The following additional questions require further study: questions of engineering support; emergency situations; analysis of geoecological assessment; preliminary check of visual-landscape perception of high-altitude objects; Enlarged evaluation of the possibilities of transport services for high-rise facilities [7].

Among the problems arising in the design and construction of high-rise residential buildings in a big city and requiring mandatory accounting, review and decision, include the following [8]:

- the justified town-planning and functional-typological necessity of erection;

-limitable permissible height (height);

- the correct choice of the structural system, scheme and design solutions, taking into account the prevention of loss of stability of the base and the structure itself, leading to the destruction and collapse of structures;

- inadmissibility of deviation from the approved design decisions and changes in the number of storeys of structures in the process of construction;

- Optimum capacity of residential and non-residential, public premises;

- the necessary functional interaction of residential and non-residential buildings and structures with the transport and service infrastructure of the city;

- Required capacity of underground, land and aboveground parking lots of personal transport and their rational location;

- effective minimization of the threat of external and internal danger of building destruction by creating a special service for safe operation;

- the required fire and evacuation safety of people in high-rise buildings;

- rational efficiency of modern engineering solutions for the life-support and equipment of the building, energy saving and comfort of service.

In order to improve the efficiency of high-rise building management, it is proposed to develop a methodology for managing the provision of construction of large cities with material resources .[9]. It should be aimed at ensuring the possibility of identifying an imbalance between supply and demand by groups of material resources, as well as the formation on this basis of management decisions related to the increase in the capacity of existing enterprises or the construction of new enterprises for the production of building materials, products and structures, with a shortage of material resources for purposes of high-rise construction.

4 Discussion

In general, the history of management is among the most elaborate. The primary basis of classical administrative theory was laid by A. Fayol in the beginning of the 20th century. To create a scientific theory of management, scientists such as F. Taylor and G. Ford worked with him. Theoretical questions of the structural organization of various control systems were developed in the works of M. Weber [10].

Socio-economic and managerial aspects of urban development were investigated and described in the works of foreign and domestic researchers, to which, in the first place, include J. Vickery, V.E. Volkova, V.L. Glazychev, G. Simmel, A.N. Kabatskova, OL Leibovich, V.A. Lefevre, S.V. Pirogova, N.E. Pushkov, J. Forrester, N.V. Shushkov.

Modern economic processes are characterized by uncertainty and high risk. This makes it necessary to make managerial decisions based on variation calculations of the comparison of demand and supply of material resources for the construction of a metropolis in the implementation of urban development programs. The balance model allows making well-founded management decisions aimed at increasing the level of provision of high-rise construction with material resources.

The scientific hypothesis of the research is that the execution of town-planning programs of high-rise construction depends to a large extent on the management of the provision of material resources for the construction of a millionth city, while the balance model is the most important tool for establishing and determining the ratio between supply and demand for material resources [11].

The effectiveness of any actions to provide the building complex with material resources, including balanced balancing, depends on the availability of a single methodological toolkit. In this case, such a toolkit is understood as a rational composition of interrelated tasks of determining the balance, the result of which is a comprehensively grounded conclusion on the adoption of a concrete version of the balanced provision of high-rise construction with material resources for practical implementation.

The magnitude of the need for material resources (MRreq.) Is presented in the form of a uniquely defined relationship and is understood as the existence of a balance:

$$\sum \text{MRreq.} = \text{H MR (уд.)} \times \sum Q, \tag{1}$$

where H MR (ud.) - specific standards for the consumption of material resources;

ΣQ - the total volume of construction and installation works (the same as the total number of units of construction objects).

The following systematization of indicators of the material balance of high-rise construction is associated with the definition of the proposed amount of material resources of the construction complex of a large city. It can be determined on the basis of the total capacity of the construction enterprises, which should be divided into specific groups of material resources. Such an approach will allow developing managerial decisions on the rational distribution of orders for the production of building materials, taking into account the focus and capabilities of specific construction enterprises.

With reference to the balance of material resources, the main and obvious objective restriction of the supply of material resources by the construction complex of a metropolis can be the aggregate production capacity of enterprises that are part of the construction complex of a metropolis. If the relationship takes the form:

$$\sum \text{Buld.enterpr.} < \sum \text{VMR}, \tag{2}$$

This situation means that the enterprises belonging to the construction complex of a megacity of the enterprise are not able to provide the production of the necessary amount of material resources for all the nomenclature used. The balanced provision of the construction complex of the metropolis with material resources for the four groups of the enlarged nomenclature should be based on the following ratio:

$$\sum_{Z=1}^{Z} \mathrm{MR}_{\mathrm{kz(Buld.enterpr.)}} \geq \sum_{d=1}^{D} \mathrm{MR}_{\mathrm{dk(resours)}}, \tag{3}$$

where $\mathrm{MP}_{\mathrm{kz(Buld.enterpr.)}}$ – material resources of the **k**-th type produced by the **z**-th enterprise;

$\mathrm{MR}_{\mathrm{dk(resours)}}$ - material resources of the **k**-th type, consumed in the production of resources at the **d**-th building site;

k – the specific nomenclature group of products of construction enterprises (the total number of nomenclature groups k = 1, .., 4);

z - the enterprise of a building complex (the total number of enterprises z = 1, .., Z);

d – construction objects, where material resources are consumed (d = 1, ..., D).

The balanced provision of the construction complex of the metropolis with material resources for the four groups of the enlarged nomenclature should be based on the following ratio:

$$\sum_{z=1}^{Z} \mathrm{MR}_{\mathrm{kz(Buld.enterpr)}} \geq \sum_{d=1}^{D} \mathrm{MR}_{\mathrm{dk(resours)}}, \tag{4}$$

where $\mathrm{MP}_{\mathrm{kz(Buld.enterpr)}}$ – material resources of the **k**-th type produced by the **z**-th enterprise of the construction complex;

$\mathrm{MR}_{\mathrm{dk(resours)}}$ - material resources of the **k**-th type, consumed in the production of construction and installation work on the **d**-th building site;

k – the specific nomenclature group of products of construction enterprises (the total number of nomenclature groups k = 1, .., 4);

z - enterprise of the construction industry (total number of enterprises Buld.enterpr z = 1, .., Z);

d – construction objects where material resources are consumed (d = 1, ..., D).

The excess of the values $\sum_{z=1}^{Z} MR_{\mathrm{kz(Buld.enterpr)}}$ над $\sum_{d=1}^{D} \mathrm{MR}_{\mathrm{kd(resours)}}$ is explained by the objective necessity of having certain stocks (at least in the size of the insurance stock), which is an indispensable condition for rational management of the movement and use of material resources and should be taken into account in the balance sheet being formed. Quantitatively, this excess is determined by:

$$\mathrm{M}R_{\mathrm{k}} = \sum_{z=1}^{Z} \mathrm{MR}_{\mathrm{kz(Buld.enterpr)}} - \sum_{d=1}^{D} \mathrm{MR}_{\mathrm{kd(resours)}} \tag{5}$$

When forming a balance model, the fact that the consumption of material resources is carried out in the context of specific types of objects under construction is also taken into account. This means that the following ratio should be observed:

$$V_{MR\,(k)} \geq \sum_{d=1}^{D} V_{MR\,(kd)} \qquad (6)$$

This ratio means that the total demand for material resources included in the k-th nomenclature group should slightly exceed (not less than the amount of the insurance stock) the amount of consumption of material resources included in this nomenclature group for all created objects, where this type material resources are used.
The balance sheet model of the material resources of the construction complex must be based on ensuring the balance of material resources in the context of specific enterprises that are part of the construction complex. This condition of balance has the form:

$$\sum_{z=1}^{Z} \Pi_{\text{Buld.enterprK}_{(z)}} \geq \sum_{k=1}^{K} MR_{k(\text{Buld.enterpr}),} \qquad (7)$$

where $\sum_{z=1}^{Z} \Pi_{\text{Buld.enterprK}_{(z)}}$ – total volume of production of building materials and structures for all enterprises;

Z– the total number of enterprises in the construction sector (z = 1, .Z).

At that, in the composition of each share of the total volume of production $(\text{Buld. enterprK}_{(z)}$ includes a proportional part of the insurance stock.

5 Conclusion

The adopted managerial decision entails the need to form a new material balance of the construction complex of high-rise construction of a large city. It should take into account the changes envisaged by management decisions, and, accordingly, the adjustment of all indicators of the material balance. There must be defined a new result that characterizes the presence or absence of a balance of supply and demand for the material resources of the construction complex of high-rise construction, and the basis for adopting a new management decision is created.

In general, the balance sheet model of material resources of the construction complex of high-rise construction should provide for the possibility of adjusting the indicators as when changing the standards for the consumption of material resources, the volume of construction and production capacity of enterprises in different periods of time, and when adjusting the planned indicators of the high-rise building complex.

Thus, the developed conceptual model of the material balance of the construction complex of high-altitude construction covers all stages of the development of a methodology for managing the provision of material resources for the construction of a metropolis from the stage of setting management objectives to the stage of practical implementation.

The main results include the following developments:

1. The conceptual model of the material balance of the building complex of high-rise construction, covering all stages of developing methodological tools for providing the building complex of large cities with material resources from the stage of setting management objectives to the stage of practical implementation.
2. The system of indicators that determine the balance of supply and demand for the material resources of the construction complex and take into account the change in the price index for them.
3. Model of material balance in high-altitude construction, allowing to detect the magnitude of imbalance in various groups of building materials, products and structures in the enlarged nomenclature.

4. Methodological provisions for the justification of management decisions to ensure the construction of material resources on the basis of the material balance of the construction complex, decisions that differ in their variability and are adopted depending on the presence or absence of a balance of material resources and the possibility of eliminating imbalances.

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