

# Complex approach to organizations' capital assets reproduction

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**Abstract.** Effective production activities of organizations is impossible without the concept implementation of the constant reproduction of capital assets, a significant part of which is represented by buildings and structures for various functional purposes. Increased deterioration of industrial buildings does not allow to solve such important tasks as improvement and automation of production processes in their entirety, and has a negative impact on the working conditions and safety of personnel. The analysis of scientific and normative literature is showed that the issue under consideration requires further research. Author's approach to the reproduction of capital assets, the use of which allows to increase the management decisions efficiency on the basis of a complex of tasks for the joint estimation of damage and deterioration, planning of works under the given constraints with the use of mathematical apparatus and technological solutions for monitoring the technical condition of buildings is presented in the article.

## 1 Introduction

Scientists whose interests include the study of production capacity in the Russian Federation agree that capital assets are the dominant component of the Russian Federation national wealth. [1, 2, 3, 5, 8, 9]. It is well known, that the fixed assets largest share of Russian Federation commercial organizations is their passive part (buildings and structures) equals to two-thirds (66.1 %) [2], therefore, in this article, the authors consider a set of buildings that represent the production and non-production organization capacity of various ownership forms with a characteristic functional purpose, constructive and space-planning solutions as capital assets. At the same time, due to the lack of conventional approaches to the buildings classification as organization capital assets elements, the authors of the article adopted the approach where buildings classified in accordance with the function: the buildings ensuring a production process, the buildings ensuring the production process continuity, the buildings ensuring the management process continuity.

There are several reasons for the relevance of the author's study. Thus, at a present time many authors develop scientific approach to the risk assessment of construction projects due to construction objects life cycle is full of various risks. Risks come from many sources: temporary project team that is collected from different companies, construction

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site, etc. [3, 4, 5, 6, 7]. Moreover, in 2011, the Federal state statistics service (Rosstat) gave a quantitative assessment of the depreciation high level of capital assets belonging to the Russian Federation organizations (45-65 %) [8]. In particular, according to the indicator "the fixed assets depreciation degree by economic activities at the end of 2016 (in percent)" construction is included in the group of four economic activity types with the most worn-out capital assets (51.8 %) along with such economic activities as "mining" (56.1 %), "manufacturing" (49.5 %), "electricity, gas and water production and distribution" (46.1 %) [9]. At the same time, there is often another problem: a significant fixed assets part accounted in the organizations assets is not used in the production process at all [2], which does not allow to assess the capital investments amount correctly that needs to be directed to the organization buildings restoration.

As a result of the statistical data analysis carried out by the authors, it is determined that capital assets of a number of organizations represent up to 45% of organization capital assets for certain activity types in value terms, and the private organizations product volume exceeds the state and municipal organizations production indicators significantly due to the private organizations share excess in the Russian economy segment. Moreover, in the state economic indicators dependence conditions on the organizations production activities it is necessary to maintain the normative capital assets technical condition through constant reproduction.

## 2 Materials and Methods

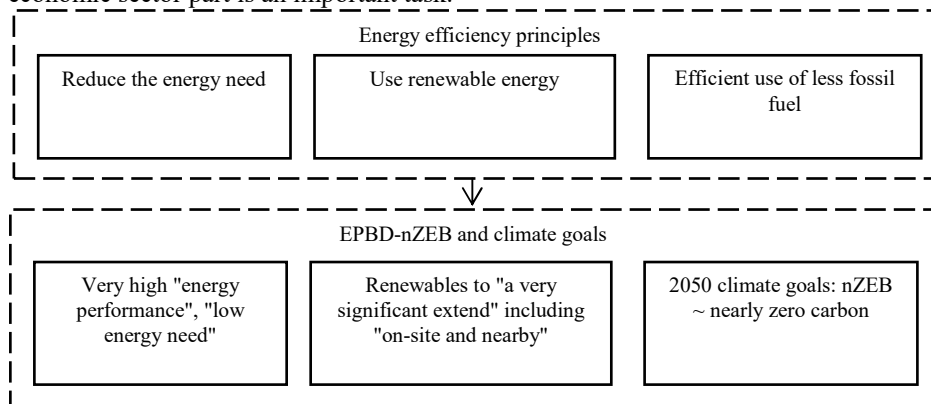
It should be noted that there is no unambiguous interpretation of the «reproduction» concept in the technical literature [5, 6, 7, 8, 9]. The study of the capital assets reproduction experience in the Russian Federation shows that the unified approach implementation to the assets reproduction process as elements of organization capital assets is possible only with a set of measures for the current or capital repairs, modernization, reconstruction and new construction depending on the building technical condition. At the same time, the presence of significant buildings physical deterioration and the lack of economic repairs appropriateness are the starting points for the building demolition, followed by new construction at the site of demolition.

The building restoration effectiveness study has shown that the effective repair and reconstruction building criterion is the maximum reduction of the physical deterioration level with minimum of capital investments. A particular task of the issue under consideration is the building energy efficiency increase in order to optimize the fuel and energy resources consumption, to reduce heat loss and operating costs. It should be noted that the solution of this problem is also being worked at outside the Russian Federation. Thus, according to Buildings Performance Institute Europe [10], buildings account for about 40% of the consumed energy in Europe and about 36% of the carbon dioxide entering the atmosphere. To reduce energy consumption and carbon emissions, the European Union (EU) established the Energy Performance of Building Directive (EPBD) (figure 1).

This initiative of the EU member states (MSs) and the European Commission was launched in 2005, it promotes the improvement of the energy performance (EP) of buildings within the Union, taking into account climatic and local conditions, as well as indoor climate requirements and cost-effectiveness (EPBD 2010). The EPBD requires all newly-built buildings to be nearly zero energy buildings (nZEBs) in 2020. Existing buildings will also have to comply with this regulation toward 2050.

The study conducted by the authors allows to conclude that it is not possible to improve building qualitative state without the use of scientific and methodological apparatus. The development of such tools, based on a scientific research, would make it possible to effectively plan the capital assets reproduction in the long term. Organization buildings

represent the basis of production processes implementation at the present stage of the Russian economy development. That's why the efficiency increase in this Russian economic sector part is an important task.



**Fig. 1.** Nearly zero energy buildings concept in the EU

### 3 Results

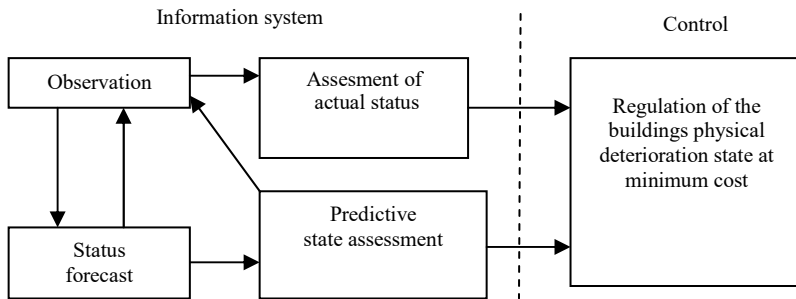
It is well known, that main problems of the buildings technical condition category decrease, which are inherent for many organizations, are: insufficient funding, operation regulations and non-compliance rules, as well as low-level control over the technical condition of the operated building [11]. Therefore, it is obvious that the technical condition control of building structures should be systematic and allow the changes assessment on the basis of quantitative criteria, which are determined though procedures of the structural elements actual strength, stiffness and stability calculation with regulatory requirements compliance. It should be noted, that performing control of technical condition is important for buildings technical maintenance in consequence of Russian Federation location, as far as significant number of buildings are exposed to adverse climatic factors, which is the cause of building structure technical condition gradual deterioration, the first minor and then major defects emergence. A durability reduction and structure bearing capacity is the result of this effect. In case of such critical damage occurrence, the building becomes incompatible with further exploitation, researchers should limit building operation activity and determine technical state as limited operational state; the building is assigned emergency condition in the absence of repair works.

The technical condition monitoring is one of the ways to control the technical building condition, this approach is fixed in the Russian normative documentation. Monitoring is a control system which is carried out under a specific program approved by the customer to identify buildings where there have been significant changes in the stress-strain state of the load-bearing structures that's why it is necessary to survey their technical condition.

The technical condition monitoring general scheme of buildings and structures is presented in figure 2.

Actually, the building structures monitoring system is a system of sensors, that are distributed over the object evenly, the information is constantly transmitted from the sensors to the self-contained data collection blocks. The self-contained data collection blocks are installed on the site or a special control station, the connection between the self-contained data collection blocks and the sensors is carried out by means of a wired or wireless data transmission system. The control station is served for generalization of the

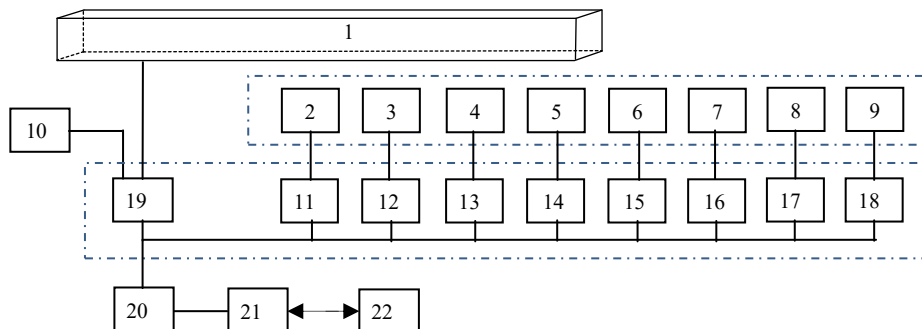
information coming from blocks, and also for results registration on stationary or removable data medium. The information is transmitted from the control station to the reception and processing center, stored and presented after signal processing.



**Fig. 2.** Scheme of building technical condition monitoring

The described remote control concept of over the structures technical condition was implemented on the basis of scientific Russian scientists' developments [11, 12, 13, 14, 15]. The authors of the article developed a remote monitoring and diagnosis system of the structures and engineering structures state. During the analysis of the nearest prototype technical characteristics, the authors found that the duplex radio communication between the modem and the structure technical condition control point is constructed in such a way that all transmitters and receivers are operated at the same carrier frequency. Therefore, transmitters have a negative impact on their own receivers, reducing their noise immunity and reliability of received information about the building technical condition. The main advantage of the proposed system in comparison with prototypes and other similar purpose technical solutions is that researchers can increase noise immunity and discrete information exchange reliability between the control point and the modem through the use of two frequencies and complex signals with phase manipulation.

The implementing of the operation principle of the remote control and diagnostics system of the engineering structure state is feasible through the authors' device use; the developed device scheme is shown in figure 3.



**Fig. 3.** The remote monitoring and diagnosis device scheme of the engineering structure state 1 – controlled construction part; 2 – strain block; 3 –mechanical stress block; 4 – vibration block; 5 – pressure block; 6 – discharge block; 7 – temperature block; 8 – bottom block; 9 - electric current block; 10 - electric potential block; 11 – 19 – information interpreters; 20 – controller; 21 – modem; 22 – wireless link

Thus, the developed system application is allowed to increase the remote monitoring

and diagnostics efficiency of the structures state (for example, the building subsidence monitoring, and changes in geometric parameters) and engineering structures during the entire period of their operation.

## 4 Discussion

In accordance with the Russian State Standard 31937-2011, the observation of buildings subsidence should be done to timely identify and stop the vertical deformations development during the operation. Visual observation is a periodic inspection of the object state. Visual observation is carried out generally 2 times a year: at the beginning and at the end of the heating season. Often, it is necessary to provide geodetic monitoring to buildings (i.e. monitoring of objects subsidence with high-precision trigonometric leveling) due to the appearance of significant cracks, joint opening, as well as an abrupt change in the operating conditions of the object. The technical condition of the organization administrative building in the Leningrad region was examined as the part of the research conducted by the authors (figure 4), the building is assigned the category of limited-working technical condition.

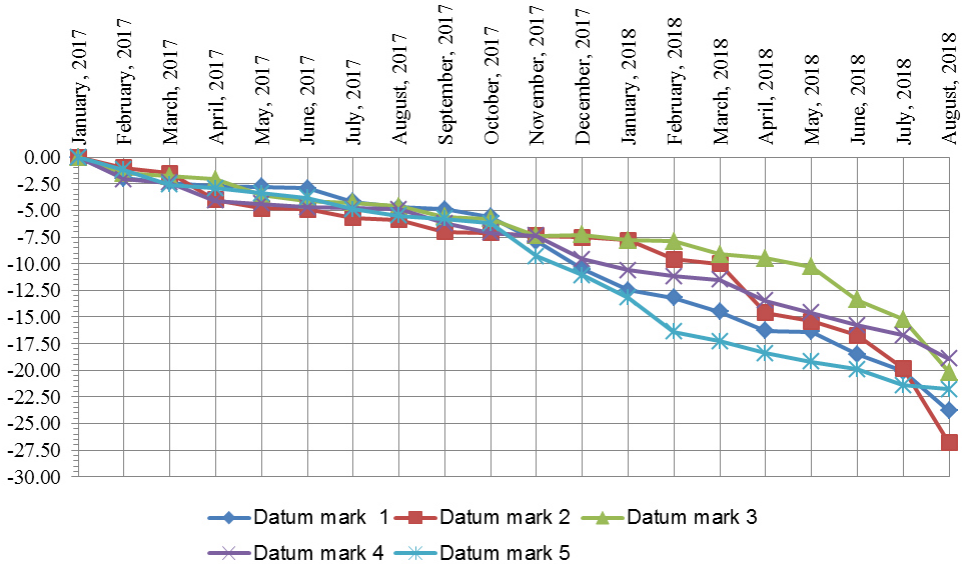
After the inspection the authors carried out the high-rise provisions measurement of the leveling marks, and then authors have done the comparison of measurement results for different time relative to the datum level. The observation graph of the building subsidence is shown in figure 5.



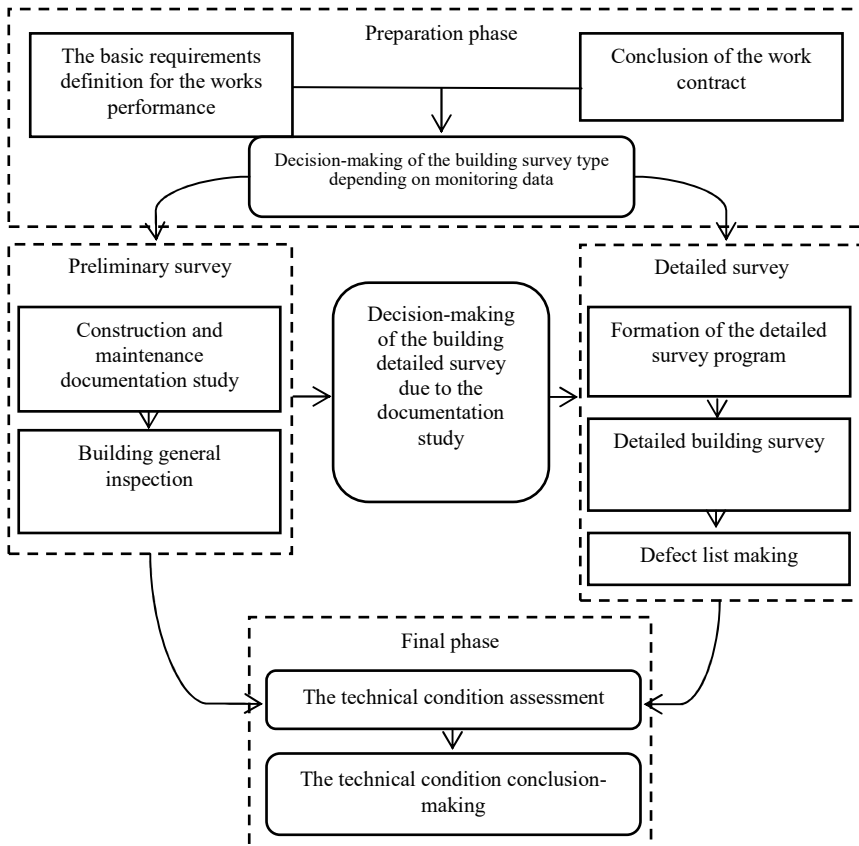
**Fig. 4.** The significant cracks appearance in the surveyed administrative building

The analysis of the observation results was dissected as the part of the research. The deflection of foundations was determined by the values and rate of leveling marks subsidence development. The organization's management was provided with information containing a joint assessment of the base and foundation spatial stiffness. The authors of the article interpreted the obtained results using the ratio of the maximum differential subsidence value to its mean value in accordance with Russian construction rules 126.13330.2012 Geodetic works in construction.

Presented geodetic monitoring results were the proposition basis to conduct a survey of the building technical condition in accordance with the authors' developed algorithm (figure 5). As the buildings are parts of the organization capital assets, it is important to perform the building technical condition assessment on a constant basis. The authors concluded that the reproduction strategy of buildings should be based on the regulatory, scientific and methodological basis of the buildings technical condition monitoring and survey. This approach allows to ensure optimal planning of works depending on the building technical condition and to prevent the reduction of performance indicators in case of defects appearance and further development over time.



**Fig. 5.** The subsidence graph of the administrative building for the observed period, mm



**Fig. 6.** The building technical condition survey algorithm

The multivariate criterion in the selection of technological solutions and used

construction materials determines the feasibility of the use of mathematical apparatus. This approach can provide balance formation between the capital investments presence (for the reproduction strategy implementation of the capital assets) and the costs that the company will incur as a result of the work performance.

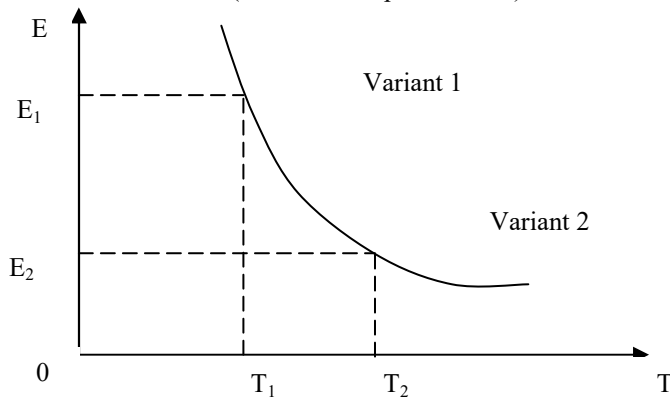
The basic concepts of the mathematical model for optimal planning of the reproduction developed by the authors are "buildings type" and "building restoration variant". Within the developed approach, the authors understand the building restoration variant as a set of appropriate technical, economic, organizational and technological solutions, differing from each other by the lump-sum and current costs values in the implementation of a particular building restoration variant (figure 7).

In the mathematical model developed by the authors, we assume that "i" is a type of organization' buildings, and "l" is a building restoration variant. Then we take "L<sub>i</sub>" as a set of building restoration variants that can be implemented for the buildings type "i", and define "t" as the stage number of the planning period (quarter, half, year),  $t = 1, 2, 3$ . Indicator "k" will be the serial number of the capital investments type, which is involved in the program of capital assets reproduction (credit, gross profit, etc.),  $k = 1, \dots, S$ . We accept "p<sub>i</sub>" as the organization buildings number of the type "i", which are need to be restored (in m<sup>2</sup> of the operated area), and "Q<sub>kt</sub>" – the capital investments value of the type "k" allocated for capital assets reproduction of the stage "t" in the planning period. Then let's assume that:

$q_{ilk}$  – the need for capital investments of the type "k" at the stage "t" within the realization of the restoration variant "l" of the building type "i";

$c_{il}$  – the cost of the restoration variant "l" of the buildings type "i" (in rubles per 1 m<sup>2</sup> of the operated area);

$X_{il}$  – the number of organization buildings type "i", which will be restored through the realization of restoration variant "l" (in m<sup>2</sup> of the operated area).



**Fig. 7.** The lump-sum-current costs curve (E – lump-sum costs, T – current costs)

The mathematical model is formulated in the accepted designations in the following way. It is necessary to determine  $X_{il} \geq 0$ , at which the reproduction cost minimum value of the organization capital assets is achieved:

$$L = \sum_{i=1}^n \sum_{l \in I_i} c_{il} X_{il} \rightarrow \min \tag{1}$$

with next conditions:

$$\sum_{l \in I_i} X_{il} = p_i, i = 1, \dots, n,$$



$$\sum_{i=1}^n \sum_{l \in I_i} q_{ilk} X_{il} \leq Q_{ki}, k = 1, \dots, S; t = 1, 2, 3.$$

Essentially, the objective function (1) is the task of making the optimal decision for the purpose of the planning reproduction under the constraints (2) – (3). The named process is characterized by high complexity on condition that simple search of decision variants is considered. Therefore the authors consider an expedient use of a branch and bound method for the purpose of the decision search as one of the methods used to linear programming problems.

## 5 Conclusions

The scope of investigation conducted by the authors allows to conclude that the reproduction planning of capital assets is characterized by the complicity and complexity of the processes particularly when the company's management is aimed at achieving maximum efficiency of the restoration work with the restriction of allocated capital investments. The authors' research and development of scientific results (particularly, approaches to the survey and monitoring of building technical condition) proposed for the use are important due to the necessity of the technical condition proper assessment of the buildings at the operation stage in order to prevent the occurrence and development of structural defects. Scientific development in the article allows increasing the efficiency decisions of management concerning the reproduction of capital assets and there by determining the prospects of organization production activities.

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