Systemic integrated method as the basis for high-quality planning of construction production

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Abstract. The construction production technology of a large-scale investment project is an integrated process that involves diverse contracting organizations each with its own mechanical equipment, managers, engineers and workers. Operations of hundreds of participants are interrelated. These interrelations give rise to multiple factors of various nature and frequency that introduce substantial changes in the construction technology due to disruption of the preset progress rate. Multiple diverse factors affecting the behavior of a construction system call for appropriate research in this area and developing adequate managerial tools in order to achieve the project’s quality targets. It should be noted that a contracting organization is an important structural subdivision of a construction system. In this connection, there is a need for setting integrated scientifically complex tasks and holding appropriate research with a view to developing models and tools of integrated operational management of a construction project. Before a management system for construction of buildings and structures is designed, information should be collected about external and internal factors affecting a structural subdivision of a construction project. An integrated nature of a construction subdivision is among the critical indicators in this regard. Having analyzed and weighted each factor, a certain tool should be developed to identify the dependence of the integration indicator of the construction subdivision on these factors. It implies the development of an algorithm and models based on a mathematical approach with subsequent experiments, description of the findings and increasing the flexibility of the management system being developed. This research will apply a systemic approach based on system engineering that involves the study of characteristics of a project as an integrated whole, a unified system proceeding from the idea that the integrated whole has some qualities that are extrinsic to its constituent parts. Consistent and predicted results are achieved more efficiently and successfully when operations are coordinated, and all processes are interrelated and focused on attaining a common objective. It is important to note a prevailing problem of combining various professionals in a single team tackling a shared
engineering task. Understanding an organization’s environment is a process. This process involves a number of factors that affect the intention, objectives and sustainability of construction companies.

1. Introduction
This research is focused on a scientific challenge of organizing efficient management systems for a large-scale investment project, a challenge that can be addressed by theoretical substantiation and working out a method of formation of a systemic integrated approach to a construction project and integrated procedures of its practical implementation.

The set of methodological approaches being developed in this study should include methods of integrated evaluation of a production potential (power) of a construction system (company) and its balance equation with the implementation program of a large-scale investment project, as well as formation of an efficient organizational structure of the construction project management system [1].

Most authors view the production potential of a construction system (company) as a set of sources, reserves and means that are available and can be mobilized and put into operation in order to ensure a balanced combination of production factors and to achieve the full potential output power. The production power is understood as a scope of construction and installation works (in cost or physical indicators) that can be contracted and/or performed using the company’s own resources within a certain period of time and under certain operational conditions.

The organizational and technological potential of implementation of an investment construction project is determined as a parameter characterized by numeric values of elements of the project that is expressed as a construction system (design, technical, technological, organizational and managerial), their balanced combination and temporal development at a determined level of organizational and technological reliability and taking into account the dynamic integrity of permanent and temporary operational infrastructures as well as the influence of certain external environment factors [2]. The organizational and technological potential (OTP) of construction operations is an indicator of the organizational and technological sustainability (OTS) of a construction process resulting from an integrated assessment of organizational and technological decisions taken at the design or implementation stages of this process. The OTP of a construction project means “an integral indicator that makes it possible to forecast a final result of construction depending on the accepted variants of organizational, technological and managerial decisions” [3]. The OTP of a construction project is analyzed by a consecutive analysis of singular OTPs of separate elements of the construction project.

The directions of scientific research on the OTP include:

1) Research on the factors affecting the construction site’s potential indicator (implementation of an construction investment project);
2) Environmental load of construction projects;
3) Formation of the construction site’s infrastructure.

Further research on the OTP should focus on the formation of complexes of singular integral potentials, formulation of their mathematical models, studying their influence on each other and the general OTP, as well as building a mathematical model of an integral potential of organizational, technological and managerial decisions in construction operations based on singular integral potentials.

Study of academic papers in the field of the OTS and formation of organizational structures of construction operations management with a view to defining and determining the significance and the scale of the scientific problem under review has revealed that organizational and technological scientific aspects of construction operations management have been deeply analyzed [4, 5]. However, organizational structures of construction operations as a controlled subsystem have not in fact been reviewed anywhere. Moreover, findings of available research on designing management organizational structures lead to a conclusion that, with regard to construction companies, the matters of designing and improving the organizational structure of construction operations and determining a reasonable numerical strength of line managerial staff have not been sufficiently explored. Occasional papers dealing with applied research tasks in this area appeared in the 1980s, but their use in contemporary studies requires much adaptation and updating.

2. Methods

The tasks of developing universal methods of sustainability assessment and determining the directions of improvement of corporate operations and concurrent enhancement of sustainability on the basis of less costly methods with the highest economic benefits have been tackled for over thirty years. The number of factors to be taken into account in the models under development has been continuously growing thus making these tasks ever more complicated. In general, analysis of the problem-solving methods for organizational and technological sustainability of construction operations and implementation of construction investment projects shows that researchers offer assessment criteria that reflect the process parameters from one of the possible perspectives - economic, social, timing, etc., or several perspectives proceeding from the assigned task. All this has led to considerable diversification and complication of the applied mathematical apparatus making its practical use difficult as noted by many researchers. Statistic (dynamic) management of the construction quality improvement process – as the OTS is neither more nor less than improvement of the quality of construction operations – will likely require another assessment category rather than the organizational and technological sustainability [5].

If a construction company is viewed as a complex and dynamic operational system, it can be described as a set of interrelated positive and negative feedback loops. The fundamental idea of such system is homeostasis, i.e. ensuring equilibrium with the environment as the key element of survival. This approach is shared by all researchers engaged in complex dynamic system modelling. It is noted that “survival and maximization of vitality are a key function of any business. Real business logic
implies an expanded reproduction of the business’s resource base if this business is successful and developing, and contraction, using up and dissemination of this base if the business is stagnating or declining or suffering losses”. Survival of construction companies in Russia’s construction market is a hot issue of vital importance at the current stage of the national development that calls for research on corporate sustainability.

3. Discussion
Research on the issues of corporate sustainability modelling and assessment of the strategy of development of companies as a production system, particularly in the construction industry, has so far been limited [6-8]. Most research and guidance papers deal with financial and economic aspects of the problem of improving sustainability of companies. They offer definitions as follows:

“Sustainability of a company” means the financial standing of a company whose business operations ensures, under normal conditions, fulfilment of all its obligations to employees, other organizations and the state thanks to sufficient revenues and matching of revenues and expenses;

“Financial sustainability of a company” is an indicator of the risk level of the company’s operations from the point of view of balanced revenues and expenses or excess of revenues over expenses;

“Absolute financial sustainability of a company” means a situation in which its working capital is sufficient for full formation of reserves and making all required expenses (for the short term).

Economic sustainability of a company means that it has achieved an economic standing that will ensure its efficient operations and development affected by external factors that produce an impact on its production output, cost reduction and raising its rate of return.

Among research papers on economic sustainability issues particular attention should be given to scientific works by professors A.A. Petrov and S.P. Baranenko, who have substantiated the need to assess the impact of parameters of the organizational structure of a controlled subsystem (correspondingly – construction and production operations) on sustainability indicators. A.A. Petrov has defined organizational and economic sustainability of a military construction company as “a capability of ensuring and maintaining an organizational condition in which it (the company) efficiently functions and develops within prescribed limits on the basis of a full and efficient use of the company’s potential in the market environment”.

An important result of research by A.A. Petrov and S.P. Baranenko is the identification of a high level of impact on a company’s organizational and economic sustainability (correspondingly – military and construction and industrial) of its management structures, and the development of organizational models of controlling
subsystems. However, they have not reviewed organizational structures of controlled systems in construction operations.

This study is focused on achieving a guaranteed level of sustainability of construction companies in present-day conditions at the construction operations planning stage that can be achieved by:

- Theoretical substantiation of sustainability indicators assessment methods;
- Development of quantity assessment methods for sustainability indicators, including formation of a synthetic integral indicator of sustainability;
- Development of theoretical, scientific and system technic principles of ensuring a guaranteed level of sustainability of construction companies amid uncertainties of construction operations;
- Development of a method and integrated techniques of formation of a systemic and dynamic management structure for construction operations ensuring the system’s adaptability to fluctuations in production loads and a guaranteed level of sustainability of a construction company.

The proposed solution to this scientific problem will contribute to the development of concepts of systemic thinking in the management of construction operations and a company as a whole.

It will make it possible to understand and assess the dynamics of operational situations, to set the rules of balancing the company’s production load and its organizational and technological structure, as well as to determine the content, particular features and organizational and technological mechanisms of management of the structure of a construction company as an object of management.

It will also allow to review cooperation processes in connection with risk assessment, to generate tools of cyclical development and target mobility of management structures on the basis of systemic and dynamic modelling with due regard for economic interests of the parties involved in construction, and to set rational parameters of production components of a construction company in the context of ensuring its general sustainable development.

4. Conclusion
Thus it can be argued that organizational and technological aspects of sustainability in construction operations have in fact been neglected by researchers. The issues of the impact of construction operations as a controlled subsystem on sustainability of a construction system have not been analyzed. The issues of operational sustainability of construction systems, their resource potential and cooperation, organizational structures of low-level production subdivisions and methods of their dynamic formation associated with current risks and uncertainties of construction operations have not been explored and require an in-depth study.
References

[1] A. Kazaz and S. Ulubeyli. Drivers of productivity among construction workers: A study in a developing country. Building and Environment, 42(5), 2132-2140, 2007.

[2] A.A. Lapidus and A.N. Makarov. Formation of an organizational and technological potential of roof structure production for multi-storey residential buildings. Bulletin of the Moscow State University of Civil Engineering, No.8, pages 150-160, 2015 (Russian).

[3] M. Liu, G. Ballard and W. Ibb斯. Work Flow Variation and Labor Productivity: Case Study. Journal of Management in Engineering, 27(4), 236-242, 2011.

[4] K. M. Harmon and B. Cole. Loss of productivity studies- Current uses and misuses. Constr. Briefings, 8(1), 1–19, 2006.

[5] I. Abramov. Formation of integrated structural units using the systematic and integrated method when implementing high-rise construction projects HRC 2017 (HIGH-RISE CONSTRUCTION-2017) E3S Web of Conferences 33. 03075 https://doi.org/10.1051/e3sconf/20183303075

[6] V. Y. Mishchenko, D.I. Yemelyanov and A.A. Tikhonenko. Developing a method for optimized resource distribution in calendar planning based on genetic algorithms. Voronezh State University Architecture and Civil Engineering p. 76-78 (Russian).

[7] I. Abramov. Systemic Integrated and Dynamic Approach as a Basis for Ensuring Sustainable Operation of a Construction Company. IOP Conference Series: Materials Science and Engineering 2018. Vol. 463, Part 2. 463 032038 https://doi.org/10.1088/1757-899x/463/3/032038

[8] A. Lapidus and I. Abramov. Formation of Production Structural Units within a Construction Company Using the Systemic Integrated Method in High-Rise Development Projects. HRC 2017 (HIGH-RISE CONSTRUCTION-2017) HRC 2017 E3S Web of Conferences 33. 03066 https://doi.org/10.1051/e3sconf/20183303066