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CONTEMPORARY APPROACHES FOR SELECTING AND EVALUATING ORGANIZATIONAL SOLUTIONS

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Abstract

The process of selection and evaluation of organizational solutions is considered. Five approaches to the evaluation of organizational solutions used in domestic practice are disclosed, indicating the area of their application. Based on a comparative analysis, the paper provides evidence for the fundamental distinctions between the mathematical and applied methods of selecting optimal solutions. The mathematical process is presented as a search for the best solution to problems and as a process of finding an extremum. The applied process is presented in the form of various indicators and their combinations. The arguments presented suggest that relying on a singular approach and a single metric for evaluating organizational solutions is deemed unfeasible. The paper substantiates the provisions of probability theory and mathematical statistics in the design of transport facilities, organization of construction, and operation of roads. Ensuring the specified reliability of a transport facility requires taking into account probabilistic factors both at the design stage and at the stages of construction and operation of the facility.

Keywords : Deterministic Calculations, Elasticity Moduli of the Roadbed, Geometric and Strength Characteristics, Road Pavement, Structure Reliability, Structural Layer Thickness, Strength of the Structure.

I. Introduction

The organization of construction production is the most important component of the construction system, largely determining its efficiency. Decisions regarding the organization of construction production are integral throughout various phases of an investment project's lifecycle. These pivotal stages include pre-project and project preparation, production readiness of the site for construction, and execution of works during the primary construction phase. The modulus of elasticity for the roadbed, sub-base, foundation, and covering can deviate from the values used in deterministic calculations by around 10 to 20%. Maintaining the exact thickness of the structural layer during production is challenging, leading to allowances for deviations from the design thickness of up to 10% in finished layers. These deviations, if not accounted for in construction organization projects (COP), can create unfavorable combinations that weaken the structure's strength and overall reliability. Subsequently, in work execution projects (WEP) for individual components, the construction organization must provide detailed adjustments to address these deviations while preserving the project's core aspects such as construction duration and capital distribution. As a rule, the organizational solutions taken are selected as a result of their multi-variant elaboration using various criteria and evaluation methods. In theory and practice, there are several different approaches to choosing organizational solutions, each of which certainly deserves to be used. However, to date there is still no answer – can there be a single integral indicator of the quality of organizational solutions and is the decision taken optimal?

II. Materials and Methods

Since the 1940s, the problem of evaluating and selecting organizational solutions for construction production has been actively discussed. An important impetus for the validity of organizational solutions was the fundamentally new theory developed in 1932-1934 – flow-line methods, which provide for the continuous and uniform use of labor and material and technical resources with the simultaneous achievement of maximum reduction in the duration of construction and installation work [XXII,VIII]. As a result of the introduction of this theory and its subsequent development [XX], a whole series of new organizational indicators appeared – uniformity, continuity, combination, rhythm, and intensity of work production, which allowed to significantly expand the area of development, evaluation, and adoption of organizational solutions. Ultimately, five approaches to the evaluation of organizational d solutions have been formed.

The first approach involves the use of traditional indicators of construction production – construction duration, cost and equipment intensity, labor intensity of products, etc. [IV, V, VI]. But these indicators reflect not only the influence of the organization of construction production, technology, and mechanization of construction and installation works, but also the volumetric planning and design solutions of buildings and structures. Therefore, such indicators are rather the result of the entire process of creating an object, i.e., the final technical and economic result of the completion of the pre-investment and investment phases of the investment project.

The second approach evaluates the extent to which the adopted organizational and technical decisions include advanced methods of organizing construction production, a flow-through method of work, complete block and node methods of constructing industrial buildings, mobility of construction organizations, and the use of network modeling. [XV]. Nevertheless, these indicators solely measure the extent to which the volume of work is covered by modern forms and techniques of organizing construction production. They do not ascertain the extent of efficiency improvement, and therefore, cannot be relied upon as a comprehensive evaluation of organizational solutions.

The third approach suggests using the indicators of uniformity, continuity, combination, rhythm, and intensity of work production to evaluate organizational solutions. In this case, one of them is used as the main indicator. Most often, such an indicator is the uniformity (unevenness) [XXXIII , XIX, VII] and rhythm [XIV, XII] of work production. Of course, these indicators comprehensively characterize the process of constructing an object, but, unfortunately, they cannot be used to evaluate organizational solutions at other stages of construction production – all types of preparation of the object, material, and technical support, etc.

The fourth approach consists of various indicators that are recommended for assessing organizational solutions by various authors – deviations in the duration of work, downtime at work, parallelism of processes, rates of work production, level of mechanization of work, degree of prefabrication of structures, etc. [XIX, XVIII, I]. However such indicators characterize only individual aspects of the organization of construction production, for example, the level of industrialization of work or the degree of intensity of their implementation, and therefore it is advisable to use them as additional indicators for a more in-depth analysis of processes.

The fifth approach is formed by organizational solutions, the choice of which is made using mathematical methods and software packages, which guarantees a high degree of validity as the best results [IV, V, XXIII]. The theory of correlation and regression analysis is extensively utilized for this purpose, enabling the identification of relationships between variables (such as influencing factors) and the depiction of these relationships through a regression equation. This equation helps in defining the parameters of the relationship and assessing their reliability. Another widely used tool is mathematical programming, encompassing both linear and nonlinear methods. It is instrumental in devising efficient plans for construction and installation projects, determining optimal resource allocation strategies, addressing transportation challenges, and more.

The use of flow-through methods in construction makes it possible to use resources more efficiently, since the building is divided into captures, that is, certain parts, each of which employs one team. However, the workflow is not carried out on all the captures simultaneously, which would lead to an increased need for labor resources, and is not carried out sequentially on all captures by one team, which would increase the duration of construction. Therefore, each team does its job, having worked on the first capture, it moves on to the next, and another team comes to this capture. In this way, labor resources are optimally used and the duration of construction is reduced.

In foreign practice, serious attention is also paid to the assessment of organizational solutions, the approaches to which are basically similar to domestic ones. For example, most investment project solutions are necessarily assessed by such general indicators as cost and duration of work [XVIII, XIX, XX, XXI]. But at the same time, all evaluation indicators are considered through the quality control system of construction products, which ultimately allows for monitoring all stages of work and tracking changes in decision efficiency indicators [IX, XXI, XXXII, XIII].

A detailed analysis of approaches to assessing organizational solutions makes it necessary to answer the question: are the selected solutions the best? The fact is that in Russian literature, the best solutions are called optimal, and the process of choosing them is called optimization. The use of these terms has become so commonplace that they have practically lost their original meaning. The need for an integrated approach can be seen in the following example. Even with advanced construction technology, top-notch materials, and adherence to operational standards, a bridge will not function properly if there are design flaws. At the same time, a well-designed project does not guarantee bridge reliability if construction compromises the quality of materials or technology, or if operational guidelines are neglected (e.g., exceeding permissible loads). Traditional deterministic calculations often lead to errors (or, more precisely, to miscalculations) due to the probabilistic nature of geometric and strength characteristics in road surfaces, structures, and building materials. This highlights the importance of considering two key interpretations in research:

1. Finding the best solution to a problem under given constraints and conditions;
2. Other ways to find the extremum of a function.

The first concept characterizes the solution of a large class of planning and management system problems. In such problems, as a rule, a considerable number of factors are typically taken into account in the form of varying quantities. These quantities can be interconnected by linear and nonlinear equations and inequalities characterizing the specified restrictions and conditions. If it is possible to formally record the objective function, the solution to the problem is reduced to finding the maximum or minimum value of this function. Such problems are solved by mathematical programming methods, including linear, nonlinear, dynamic, and integer programming. For example, linear programming methods are used to solve large-scale transportation and distribution problems, and nonlinear programming methods are used to solve much smaller problems that more accurately reflect the processes being described.

The second concept is the reliability of a transport facility. Various interpretations of this term can be found in the literature, particularly in foreign sources. We will adhere to the definitions and concepts of GOST 27.003-90 "Reliability in Engineering," which contains 24 terms in the field of reliability of technical systems. In the context of a transport facility, reliability is defined as an indicator that signifies the ability of the facility to maintain normal operational functionality over a defined period while operating under prescribed (standard) conditions. The reliability of a transport facility is measured by the probability that the facility will retain its basic parameters at least for a specified time when operating under specified conditions.

III. Results

The term "integral" or "generalizing" indicator of organizational solutions is often used in research. For example, multiple regression equations are used for this, in which factors (arguments) are most often determined through expert assessments. But at the same time, the integral indicator (function) characterizes the development of any one process – a change in labor productivity when performing a certain structure of work, the choice of rational means of mechanization, etc.

The concept of reliability is inextricably linked with the concept of quality (quality of materials, quality of work during construction and operation, quality of the project, etc.). All of the above allows us to state that the issue of reliability is a complex technical and economic problem. Any increase in the reliability of a structure, the quality of materials, and construction and installation work, as a rule, entails an increase in cost. In many cases, it is more profitable to ensure the high reliability of a structure at the design stage than to spend large amounts of money on its repair and maintenance at the operation stage [XXVII, XXV, XXIV, XXVIII].

So, why are different approaches used to evaluate organizational solutions, but none of them is integral? The life cycle of an investment project for the creation of an object consists of several interrelated stages, each of which has its specific features. For example, pre-project preparation includes the development of planning and land surveying projects, urban development plans for land plots, holding an auction, forming initial permit documentation, etc. The main period is characterized by the performance of various types of construction and installation work, delivery of various construction materials, etc. At the same time, such functions as input and operational control, operational dispatch control, etc. are carried out in parallel. However, if organizational solutions for the production of work can be assessed by the indicators of the third approach, then how can organizational solutions of pre-project preparation be assessed? Moreover, even within almost every stage of the investment project, processes cannot be assessed by the same indicators. Consequently, each stage of the investment project includes multifunctional processes, each of which has its own local goal. It is for this reason that it is impossible to use only one approach and a single indicator for assessing organizational solutions.

At the same time, the achievement of local goals ultimately realizes the general goal of capital construction – a comprehensive assessment of the reliability of transport facilities (objects of general transport infrastructure) based on a statistical experiment. Another conclusion follows from this: statistical data on the state of the structure are displayed in the form of a dynamic series, i.e., a certain function of time, called a trend. A trend allows you to establish a tendency to maintain or lose the main parameters of a structure, but for this, you need to be able to identify the presence of a trend and describe it as a function. However, achieving the best value of one indicator usually leads to a deterioration in the values of other indicators used. As a result, at least two schemes for the comprehensive assessment of organizational solutions are born:

Scheme 1. The best value of one (main) indicator is recorded at any values of other indicators of the comprehensive assessment of the organizational solutions;

Scheme 2. The value of one (main) indicator close to the best is recorded at high values of other indicators of the comprehensive assessment of the organizational decision.

As the long-term practice of applying the theory of flow-line organization of construction shows, Scheme 2 is more effective. It is widely used in the development and selection of organizational solutions in operation schedules for construction and production of construction and installation works.

Thus, the search for the best organizational solution is based on its complex comprehensive assessment, and this process itself has nothing in common with the mathematical process of optimization [XXVI, XXIX, I II, XI].

Researchers often say that it is necessary to conduct a comparative analysis and evaluation of various methods or approaches to evaluating organizational and technological solutions. However, each method involves evaluating organizational and technological solutions based on a certain set of indicators, and it cannot be argued that a specific set of indicators or a specific approach evaluates organizational and technological solutions better than others. On the contrary, only the combined use of these methods allows for an exhaustive assessment. At the same time, an aggregating or complex indicator is formed, which will best evaluate organizational and technological solutions.

IV. Discussion

When conducting a technical and economic justification of the reliability indicators of a structure, it is necessary to proceed from the condition.

$$C_{\sum} = C_{con} + C_{op} + C_f \cdot n_f \rightarrow min,$$

where $C_{\sum}$ — total costs of construction and operation of a structure with the appropriate reliability indicator for the estimated period of operation; C_{con} — costs of constructing a structure with a given reliability indicator; C_{op} — operating costs of a structure that do not depend on the occurrence of failures; C_f — cost of fixing one failure; n_f — number of failures during the estimated period of operation.

The reliability index of a structure I_r affects the cost of construction and the number of failures, i.e., $C_{con} = f(I_r)$ and $n_f = \varphi(I_r)$. Therefore, the optimal reliability of the transport structure I_r^f should be calculated according to the condition

$$\frac{dC_{\Sigma}}{dI_{r\,opt}} = 0.$$

The calculation of the reliability of a transport structure should begin at the design stage when the fundamental design solution has already been adopted (the length of the bridge, the number and length of spans, the bridge layout, etc.). But for this, it is necessary to have a mathematical model of expected failures (or at least their expected distribution over time). An a priori model of failures, built by expert means, can be used. Such a model can be created based on the methods of probability theory or mass service theory. In certain situations, it is feasible to create a structure or building with a specified level of reliability without needing to anticipate potential failures. This can be achieved through a statistical evaluation of material quality and technological advancements, rather than relying on predicting failures. When organizing construction work, the arrangement of equipment by sections and objects is of great importance. The productivity of each machine is a random variable with its mathematical expectation and standard deviation, calculated based on statistical reporting on previously completed work. Usually, the standard productivity of machines, adopted according to the Uniform Standards and Prices or established by calculation using traditional deterministic methods, is taken as the mathematical expectation.

V. Conclusion

Statistical regulation of product quality is intended to control production by intervening in technological processes and preventing defects. Another group of statistical methods is used to perform incoming, intermediate, and final control of finished products for their compliance with technical requirements or quality requirements agreed upon by the customer and the manufacturer (supplier). These methods do not directly affect production, but they do indirectly affect it by identifying defects in finished products. Control of all manufactured products of an enterprise is impossible either for economic reasons or because of the need to destroy the structure when checking its strength characteristics. Therefore, in practice, selective control is used, which consists of checking samples from a product batch. The results of the check allow us to conclude the quality of the products. Statistical methods of selective control assume justification of the sample size even before the control is carried out. In this case, the product batch must have uniform production conditions (all products must be manufactured in one shift, on one line or one machine, by the same division). The decision to accept or reject a batch is made depending on whether the values of the controlled parameter are within or outside the tolerance limits.

As the analysis has shown, the primary focus lies on conducting a thorough evaluation of organizational decisions, aiming to achieve an optimal level of the main reliability indicator for the structure. This cannot be solely determined through statistical quality control methods. Therefore, there are two approaches to the analysis of the reliability of transport structures:

• a priori (based on a certain hypothesis formed taking into account experience and intuition or using failure models);

• a posteriori, based on statistical test data. It operates with quantitative statistical characteristics of the system or its elements. The mathematical apparatus of the a posteriori method is statistics.

Thus, the selection of organizational solutions should be understood as the process of finding such an organizational solution that ensures the close achievement of the main indicator to the best value with high values of other indicators of the comprehensive assessment. The actively developing direction of assessing organizational solutions using mathematical methods and software packages that ensure reliability and a high degree of objectivity of the results is extremely promising.

Conflict of Intrest

There is no conflict of interest regarding this article.

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