Multi-criteria assessment of the development options for organizational and technological systems

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Abstract. Practical justification and decision-making in construction is a difficult task. The customers formulate the terms of reference, on the basis of which, using the methods of comparing the solution options, determining their priority based on the degree of influence of organizational, technological, technical, economic and other factors, the solution options are developed and, therefore, a construction management system is formed as a whole.

The development of the required action scenario is aimed at achieving the optimal end result. The decisive factor in this case is the final result of the functioning of the organizational and technical structure.

This approach is fundamental in the formation of the organizational - technological management system, considered as a subsystem in the general system of construction production. Decision making is carried out in order to achieve the optimal (or most rational) end result when choosing a reliable technical or organizational-technological option. The backbone decisive factor is the specific system’s outcome.

Introduction
The development of organizational and technological systems (OTS) is the basis for the effective solution of the problems of construction production.

At various stages of the planning of the OTS development, there is a need to solve the problems of choosing the options from several or a large number of possible ones. Only in this case positive results can be achieved in the field of development and implementation of the design solutions and in the operation of constructed buildings and structures. [1]

Timely implementation of systemic and multi-purpose assessment of the decisions made allows to choose the rational resource and energy-saving options from the several possible ones, to direct the main resources to the implementation of the most effective solutions.

Decision making when choosing a reliable technical or organizational-technological option is carried out in order to achieve the optimal (or most rational) finishing result. The backbone decisive factor is the specific outcome of the system. [1]

This methodological position is taken as the main one when choosing rational technical solutions (TS) and organizational and technological solutions (OTS), considered as the subsystems in the general system of building production. In other words, the general system is divided into the subsystems based on the application of the decomposition principle. Moreover, the decomposition of the system is carried out only on such elements that contribute to the achievement of a given goal. The
The functional systems are heterogeneous, that is, they consist of the heterogeneous elements, each of which carries its own functional and specific load in achieving the result. From these positions, it is obviously legitimate to include such heterogeneous subsystems as volume-structural solutions of construction objects, work methods and management of the decision-making system in the composition of a functional system. These subsystems, in turn, are divided into a number of heterogeneous elements, which until recently have been considered separately and outside a single functional system created to achieve the common result.

The effectiveness of the new technology being created or the application of the already known one depends to a large extent on the methods used for the system-technical evaluation of the solution options and the controls for this evaluation. The greatest attention is paid to the management of technology at the stage of performing processes for the manufacture of building structures in the factory and, to a lesser extent, to processes carried out at the construction site. [2,3]

The process of technology management is staged and includes the five stages of multi-purpose selection.

Stage I. Design and preparation of construction production (information support);

At this stage, the requirements for the quality of the result of the technological process and for the development of methods for the process in specific construction conditions are formed. Stage I in the general case includes the processes of design and development, drawing up a technical project, design expertise, preparation of construction production. The composition of these processes depends on the content of the project development order. The output of the stage is the project of the object being developed and the organizational and technological documentation.

The main objectives of the operation of Stage I are as follows:

- the selection of optimal (rational) solutions at the design stage (optimization approach);
- the determination of compliance of decisions made with some pre-established requirements - verification at the stage of examination (normative approach).

It should be noted that Stage I is the most important in relation to other stages due to the fact that at this stage the level of future technology, its novelty, efficiency, prospects and production costs (labor, financial, material, energy and etc.).

Stage II. The construction products’ production;

It includes the creation of the necessary conditions for the products’ manufacturing at the factories of the construction industry. At the same time, the compliance with the technology requirements that are provided for in the project is mandatory. Consequently, the input of the Stage II is the results of the Stage I, concerning the construction industry technology. The output of the Stage II is the finished product (semi-finished products, materials, building parts, building structures) that meets the requirements of the project and is suitable for use.

Stage III. Assembly, shipping, warehousing.

Stage III is aimed at the technological equipment and transportation of necessary resources, means of labor (including their storage) to construction sites. The Stage III input is information received from the Stages II and I on the properties of the manufactured products and on the quantity needed to complete stage IV (based on the results of stage I). The output of the Stage III is to provide the Stage IV with all the necessary resources.

Stage IV. Processes at the construction site. Stage IV is designed to implement the technological solutions provided for by stage I on the construction site. The input of the Stage IV is information on the requirements for the Stage IV (based on the results of stage I) and the necessary resources received (in stage III). The output of the Stage IV is the finished construction products that satisfy the requirements designed in the Stage I.

Stage V. Operation of construction products. The stage is implemented at the stage of operation of construction products. This process is aimed at finding and implementing the rational technology modes during the operation of individual structural elements (roofs, facade surfaces, etc.) and buildings and structures in general. In this case, the implementation of rational modes is understood as
the periodicity of the individual structural elements’ repairs, the terms of current and major repairs, and the provision of reconstruction opportunities (necessary). The input to the stage is the performance indicators achieved as a result of the implementation of the Stage IV. The output of the Stage V is the construction products, the quality of which changes in time by the value provided for by the Stage I.

In general, the work organization on the design decisions management is presented in Figure 1.

**Figure 1.** The ODS development options’ multicriteria assessment

Conducting systems and multi-purpose assessment (SMPA) of decisions made is necessary at various stages of the project, because they make it possible to develop the activities that contribute to reducing the labor costs, reducing the time of work and substantiating design decisions at various stages of preparation for construction production. Carrying out SMPA creates the opportunity to perform a comparative assessment of a large number of the possible options, using the results of analysis at all stages of preparation for construction production - from the calculation of the main building structures and all types of the design work associated with them (determining the estimated cost and economic efficiency and costs of basic material, energy and labor resources at various stages of the production of prefabricated elements and processes) and before the design of processes carried out on the construction site. The SMPA implementation at the early stages of the project makes it possible to identify the factors that impede the achievement of the stated indicators. [4-6]

Any project of a building or structure is characterized by technical and economic indicators – the indicators, which, as a rule, are expressed in numerical evaluation, qualitative characteristics cannot always be evaluated by the indicators having a specific dimension.

Qualitative characteristics can be additional requirements of a predominantly social nature, the non-observance of which can lead to undesirable consequences affecting the environment, creating adverse or dangerous working conditions, leading to discomfort in operation, to reduce the durability of individual structural elements or buildings and structures generally.

External parameters are indicators-requirements and describe the adopted TS and OTS, as well as decisions on the technology of operation and on the predicted recombination of buildings or structures from the point of view of the customer. The external parameters, as a rule, are the cost, operating costs and characteristics of a building or structure, annual reduced costs, duration of construction, frequency of ongoing and overhauls, etc. The external parameters are the subject to the restrictions that determine the values required by the design specification parameters or areas of permissible changes (restrictions on cost, duration of construction, consumption of certain types of resources), properties of the obtained
the construction products (i.e., its physical characteristics, quality indicators) and so on. [7]

At the stage of the design solutions’ development, maximum attention to a multi-criteria assessment of the development options for OTS, i.e. justification and choice the most optimal methods of work, providing the cost savings compared with other compared solutions.

As a result of developing a solution, a positive effect can be achieved only with the rational and economical use of the resources at all stages of the construction production. [8-11]

With TS, the effectiveness of any variant of the decision being made is compared with the effectiveness of solutions similar in functional purpose, which are the most effective of those previously developed.

An analysis of the TS implementation shows that when developing a new organizational and technical solution and choosing the similar projects for comparison, it is impossible to compare them only for one constructive solution due to the effect on the performance indicators of differences in other types of solutions. However, the exceptions to this rule are possible in cases where the project is being developed with full compliance with the space-planning parameters and other characteristics of the original project.

OTS as a management object, provides four techniques for its use:
1. Graph theory for building a network graph or calendar-network planning and management.
2. “Methodology” of project management as an independent section of the construction organization management.
3. Organizational procedure based on the mathematical modeling tools’ use for organizational project management.
4. Information modeling methods allowing to process significant amounts of the source data, as well as use the results to develop and make organizational and technological decisions.

In order to reduce the duration of the work, as well as the rational distribution of the resources required to complete the work, the critical path methodology tools are used.

The basis of the method is the calculation of the maximum duration of work (tasks) from the beginning to the completion of the project. In this case, the assessment is made taking into account all the relationships and external influences. When changing any task that is on a critical path, the entire project implementation period is adjusted, which requires additional analysis, identification of “problem tasks” and risks, and therefore the additional optimization measures’ adoption. [1,2]

Along with determining the total duration of work at the facility, the critical path also allows to identify the options for reducing the time of work, modeling the overall structure of the production cost depending on the technology used for the production of work, the possibility of using the materials - analogues (i.e. materials with no properties lower than declared, but more economical in cost), etc. [3] The options for setting the objectives can be displayed as follows:
The problem formulation

The external factors’ analysis

Costing standard database

Scoping

Project, TEE

The internal factors’ analysis

Labor definition

Definition of captures, priority of work

Evaluation of technological solutions

Development of solutions

Determination of performance indicators of decision

Duration of work

Production

Labor input

Automation and mechanization

Material resources volume

Resources cost

Energy cost

Economical effect

Determining the weights of the decision effectiveness

The effectiveness weighted average indicator criteria calculation of the decision made by the option

Calculating the OTS development options

Determining the need for human resources

Determining the need for inventory and tools

Determining the need for material resources

The choice of a rational option according to the established project

Determining the need for machines and mechanisms

Determining the energy requirements

Resource Saving Definition

The OTS functioning TEP calculation

**Figure 2.** Multicriteria assessment of OTS development options
• reduction of the work terms on the resource allocation basis, taking into account the restrictions;
• saving resources with possible changes in the project timing;

The task solution may be complicated by the time constraints established by the Project customer with the activity of other project participants (subcontractors, etc.).

The unifying factor is the presence of a common dependence - the work is carried out within the framework of one project, and the number of implemented projects is determined. In this situation, there is no single effective algorithm for solving the task, therefore it is necessary either to determine a separate task, form a separate algorithm, and if it is impossible to reassess the tasks.

Therefore, a variant design with the use of various design solutions with subsequent TS is necessary. In this case, the technical-structural-technological solution acts as an analogue object, which are used later for variant modeling (Figure 2).

The main condition for variant modeling is the comparability of the compared solutions in all parameters and indicators that are not directly related to the design decisions adopted in the projects, but characterize other aspects of the decision.

In case of variant design, the design options are considered, the materials’ specification is compiled for the individual options, the total material consumption for individual design options is determined. Based on the results the following was determined:

- total cost of the options;
- total consumption of materials by the options;
- transport needs by the options;
- the need for the options’ mechanization;
- estimated cost of manufacturing individual building structures.

The final choice of an option is carried out on the basis of analysis and determination of the most preferred option for the works production. If necessary, it is possible to perform the additional calculations to verify the reliability of the adopted construction option.

Summary
The analysis showed that at each stage of the functioning of organizational and technological building systems, it is exposed to probabilistic influences that do not allow determining the mutual influence of organizational and technological problems.

The parameters of these processes change with a certain degree of probability, therefore, in controlling the various objects, it is necessary to take into account the influence of various factors on the planned course of the work program. Thus, in the most general case, the task of ensuring functioning is reduced to taking into account the action of various factors on the object and making decisions on choosing the best option for implementing the work included in it, in order to reduce the uncertainty in achieving the goal.

References
[1] Zavadskas E K 1991 System-engineering assessment of construction production decisions (Leningrad, Stroiizdat) 256.
[2] Seferyan L A, Zilberova I Yu 2014 Stimulation of enterprises in the sphere of management in the absence of market motivation Scientific Review 10-2 508-511.
[3] Petrov K S, Efisko D E, Nagorny V S 2017 Modern approaches to the modernization of construction organization processes Engineering Herald of the Don 1. Information on ivdon.ru/ru/magazine/archive/n1y2017/405
[4] Palepu K G, Healy P M, Bernard V L et al 2007 Business Analysis and Valuation IFRS Edition. (London, Thomson Learning) 788.
[5] Nebritov B N 2017 Prioritization of construction projects Engineering Bulletin of the Don 4. Information on ivdon.ru/ru/magazine/archive/n4y2017/4501
[6] Borisov A N, Alekseev A V, Merkuryev G V 1989 Fuzzy information processing in decision-making systems Radio and communication.
[7] Belousov V E, Gaiduk A V, Zolotorev V N 2006 On the problem of solving multicriteria optimization problems *Control Systems and Information Technologies* 3 (25) 34-43.

[8] Barkalov S A, Belousov V E, Urmanov I A 2009 An algorithm for constructing private decision rules in the analysis of organizational management systems *Bulletin of Voronezh. state tech. un- that.* 5 (2) 129-133.

[9] Ransom W H, Spon E & F 1987 Building Failures, Diagnosis & Avoidance, 2d Ed. (New York). ISBN 0-419-14270-3.

[10] Schreiber S K 2018 Ways to improve the efficiency of the implementation of regional programs for the overhaul of the common property of apartment buildings *Bulletin of MITU-MASI* 1.

[11] Yaskova N Yu, Karasik D M 2012 Program-targeted methods for the development of construction. The modern format of urban targeted programs *Bulletin of MGSU* 3.