

Increasing of effectivity of construction project on account of integration of information technologies

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Abstract. A conceptual methodology for increasing the efficiency of organizational and technological aspects of construction production by developing a predictive tool for participants in a construction project is described here. The initial direction of activity for working off the possibility of implementing the indicated methodology has been determined. During the analysis of a domestic experience of construction companies, the conditions for unlimited and constant integration of information technology (IT) were identified. The importance of constant tracking of innovations in the field of information technology for the selection of the most promising areas and methods of their integration, allowing the participants in a construction project to increase their efficiency at the lowest cost, was found. The description of the principles of systems engineering for the development of monitoring models in the field of IT is brought. The primary classification of information technologies from the point of view of the application in the construction industry is carried out. Based on consultations held with the leaders of construction companies there were defined the groups and subgroups of parameters, that may influence the effectiveness of realization of the construction project.

1 Introduction

Construction activity is the brightest marker of the condition and level of development of the economy and society. Considering the condition of the construction industry on different stages of human development, we may assert with high reliability, that construction activity correlates greatly with the condition of scientific-technical progress and kind of social relations. Analysis of constructive production allows highlighting the two most vital directions of its development, namely: organizational and technological, the synthesis of which makes it possible to obtain the most sustainable way to achieve the goals of a construction project.

The "organizational direction" of a construction project is understood as a set of solutions of the Developer, the Technical Customer, and the General Contractor, which are

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supposed to be structured in the form of a multi-branch scheme - a set of links between various participants in the construction project. These links have various parameters and characteristics that have a significant impact on the success of a construction project. The organizational aspect in construction consists of the choice of different ways and technologies of communication of the great number of participants.

The technological aspect appears in the material-technical basis of the construction sphere. When creating one building or structure, a large number of different technologies of construction production can be applied, which can be variably adapted to external and internal conditions. External conditions can be understood, for example, various climate weather factors that significantly affect the technology of installation of monolithic reinforced concrete structures. Internal conditions mean the interaction and interconnection of various technologies and technological streams. Moreover, in the composition of each technology, there is great variability in the use of various machines and mechanisms that will significantly affect the key parameters.

It seems impossible to detect - which of the aspects considered is the foreground for the construction sphere because each of them influences enormously on the branch as a whole and each project in particular. It can only be unambiguously asserted that increasing the efficiency of the implementation of construction activities, which can be achieved by the most effective combination of organizational and technological parameters, is the most important subtask of a construction project.

It is supposed that it is possible to form a complex modular system for evaluating the adopted organizational and technological solutions, due to which it becomes possible to produce a result in the form of a level of efficiency of the construction process. This mathematical model should carry an algorithm that will increase the level of efficiency by searching for the most effective combinations of management and technological solutions.

2 Materials and methods

For structuring, analyzing, and adapting the received complex and heterogeneous information that prevails in the construction industry to the project's tasks, two basic principles of reasoning are possible:

1. A consistent linear approach to analysis and synthesis - according to which it is necessary to obtain and assess many separate conclusions. Then it is necessary to determine the non-inconsistency of possible generalizations. This method ends by integrating the information received into a specific system. The most widespread method for implementing this approach is linear regression analysis.

2. Holistic approach - in which all the factors under consideration and the criteria influencing them are presented in the form of a network structure (hierarchies). There are links between the indicated parameters, to which the boundary conditions and functional dependencies are determined. This method allows you to analyze and synthesize complex multi-dimensional systems. The most common methods for implementing this approach are systems engineering [1] and hierarchy analysis [2].

In the given study, it is proposed to create an integrated modular system for assessing and predicting the effectiveness of the implementation of the construction industry due to both of the above mentioned principles of reasoning.

For instance, for the structuring and analysis of organizational and technological processes, it is suggested to use the Analytic Hierarchy Process (AHP) method by Thomas L. Saaty [2], which consists in the possibility of comparing complex multi-criteria systems by comparing relative, quantitative or qualitative pairs of parameters, based on which it is possible to carry out a comprehensive assessment of the adopted organizational and technical decisions of the construction project.

The implementation of this method can be schematically represented in the form of a three-level hierarchy, which is shown in Figure 1.

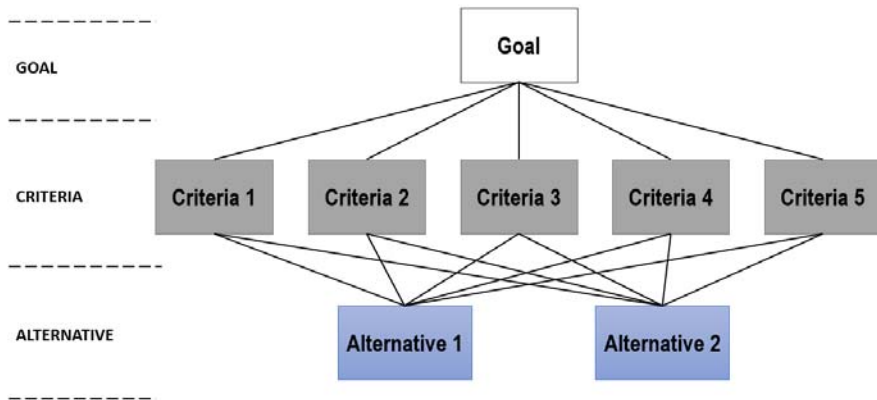


Fig. 1. Analytic Hierarchu Process (AHP) by Thomas L. Saaty

Based on the results of this assessment, it is assumed that it is possible to determine the most effective way to implement the project. This can be achieved through the development of a predictive tool - an automated comprehensive assessment and control of the effectiveness of construction projects.

A comprehensive performance indicator [3] is planned to be formed based on both the traditional method of systems analysis and AHP, and on the basis of modern principles of data analysis and machine learning. The implementation of this tool is assumed to be carried out through the evaluation of already implemented projects, which will allow obtaining a system capable of giving a predictive qualitative assessment at any stage of the construction project, both as a whole construction project, and its stages. It is also planned to develop a technology for the automated collection and processing of information about a construction project and a system for an integrated assessment of its condition, which will create a management system for the complete life cycle of construction of facilities and urban infrastructure. Based on the results of this study, specialized engineering software will be developed that implements the functions described above.

Because of the complexity of the implementation of the set global goal and the attempt to present it in the form of a modular system, it is assumed that the indicated technology will be tested on the first module.

The first module will be understood as an integrated system (a tool for participants in construction production) that will assess the current level of implementation of information technologies in a company during the implementation of a construction project. To enhance the efficiency of construction activities, this tool will have to provide a predictive assessment of changes in efficiency when introducing new information technologies and specific programs.

Having analyzed the experience of different construction projects in the Russian Federation, European countries, countries of the Middle East, and the USA, we suppose it is possible to identify a set of variative and invariative parameters, allowing to combine the experience of the construction community into the single general indicator of effectiveness, for determination of the most effective organizational and technological decisions.

At this moment it is possible with a certain degree of reliability to assert, that the variative part of parameters, on which we may influence with the possibility of increasing the project effectiveness and which demand minimal investments - is the integration of information technologies (IT). Using the information technologies is possible to achieve a

considerable increase in the quality of finished products and effectiveness. This is reflected mainly in the fact, that IT simplify the decision of many problems in people's activities, for example in communication between themselves and delegation of many routine operations to the modern information systems. The given approach is the most actual in the construction industry, due to the involvement of the great number of participants, which need constant communication, and the great number of difficult, dynamic, and qualitatively non-uniform problems, demanding a quick solution.

Under the concept of information technologies, we understand the combination of the ways and methods of collection, storing, processing, and transferring of information, that is realized using the program-technical means, which allow increasing the effectiveness of economic activity of separate persons, separate companies and especially of great holdings. Further, we'll consider the applicability of IT in the spheres of organization of activity of companies in general and for the realization of local organization-technological aspects of constructive production in particular.

The integration of different modern information technologies in industries may be marked as the target, but the permanent target, because it is not finally achievable, due to the constant development of information technologies. On the basis of aforesaid, we may conclude, that one of the most actual questions at the discussion of the applicability of information technologies in different branches of economy, is the constant monitoring and actualization of methods of using of modern IT. Such monitoring will allow detecting the most promising IT, integration of which with minimal capital investments will make it possible to increase the effectiveness of organizational and technological measures at projects realization, to decide the problems with the best quality indicators, to form the stable development of construction project [4].

Based on system engineering principles [1], organization-technical reliability [5,6], the functional systems theory the construction project is considered as a functional system (objecting function) aimed at achieving the desired result - the purpose of the whole project. Having the objective function, describing a difficult appearance, we may assert, that it depends on different variables in the form of subsystems, having their specific local aims, achieving that brings closer the successful completion of the whole project. It's also worth noting, that each correctly organized functional system must have the features of homeostat [7], so it must be self-organized and be able to suppress the influence of any disturbances on the stable condition of construction objects.

Construction object, as a functional system, is constantly complicating. It is connected with the following main reasons:

- increasing of the number of subsystems involved, that form the system;
- change of ways and kinds of subsystems communication;
- qualitative change of properties of subsystems, associated parameters, by means of which the subsystem is formed.

The complication of the construction project assists the fact, that at its realization the huge massive of information flows are generated, which may be successfully analyzed only using information technologies.

The structure of approach to the decision of project problems on the basis of system engineering for any project may be schematically presented as V-diagram, which is shown in Figure 2.

According to the given structure, it's possible to see the multi-level type of analysis and synthesis based on system engineering principles, where on the left falling down branch the analysis of the appearance and its decomposition is situated, and on the right is the synthesis where at the output we obtain the working system.

During the study of a similar multi-level system on the beginning stage, it's supposed to investigate the degree of influence of information technologies integration to the

construction sphere. For that it's necessary to define the criteria of effectiveness of the construction project for different participants of the project, so we could correlate them with certain criteria of IT monitoring. On the basis of certain parameters, it's necessary to work out the systematic model, answering the question of the final user: "Which information technologies, with the minimal investments, can we integrate into the operating activity of the company, to increase the effectiveness of its activity?"

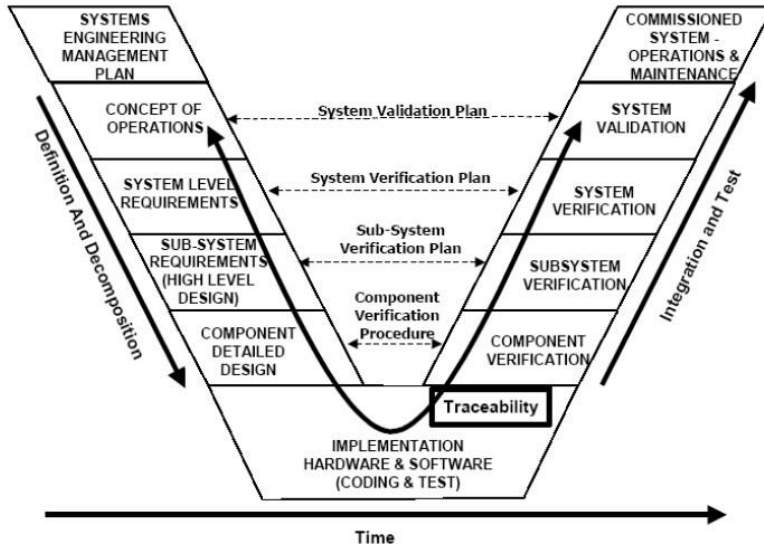


Fig. 2. V-diagram of system engineering

3 Methods, that will make possible to detect the necessity of integration and degree of influence of information technologies on the effectiveness of construction works

For the most successful realization of the problem assigned, namely, for determination of the most important aspects of information technologies for the construction industry as a whole and the ways of its integration in certain companies, it is supposed to create two models that should give out similar information. The models will be formed on the basis of principles of regression analysis [8] and self-learning neural network [9-13]. At the output, the models given have to provide for the final user information about the most important aspects of information technologies, which are missing in their production, but which will be able to increase the effectiveness of their work.

Due to the difficulty of performing natural tests, for the formation of a representative sample, it is supposed to use the qualimetric analysis method [14], namely, expert estimation method [15].

For the beginning of construction of the scientific hypothesis [16], it is supposed to perform classifications of information technologies, producing the greatest influence on the construction industry, and organizational-technical subsystems, having the greatest influence on the effectiveness of construction project.

4 Investigation results

The classification of information technologies in the first approximation is performed as follows:

On the basis of technological principles of the work with project information:

- CRM (Customer Relationship Management), in the form of models, allowing to simplify and automate the communication both between the internal and external participants of the project.
- ERP (Enterprise Resource Planning), as a strategy model for integration of company resources (labor, material, financial, etc.) into the single system for search of the most effective way of regulation.
- CAD (Computer Aided Design) - in applied sense, represents the set of technologies, allowing to form the systems of automation of working out of project documentation for construction, solving the vast range of problems from calculations to design of sections.
- BIM (Building Information Modeling) [4] - direction, which we may consider as CAD subsystem, represents an approach, connected with modeling of construction objects in the 3D information environment, allowing to unite in a single model all the elements of construction project (calculation strength model, architectural models, engineering systems).

On the basis of certain program complexes and devices, which allow to work effectively with project information:

- to simplify the project management - program complexes such as MS Project, Asana, Bitrix etc.;
- simplifying creation of construction design - program complexes such as AutoCAD, NanoCAD, ArchiCAD, Revit, etc.;
- simplifying carrying out of calculations - program complexes such as Lira, SCAD, Robot, etc.;
- simplifying the organizing of documentation because of documents formation in electronic form;
- program complexes, allowing to create and edit documents (production of MS Office, LibreOffice, etc.);
- simplifying the communication between project participants - that is a great quantity of programs for exchange of messages and files on different devices (e-mail, WhatsApp, etc.), mobile connection devices with enhanced possibilities (smartphones, tablets, ultrabooks, etc.), cloud data storages (on servers of companies Yandex, Mail, Google, etc.) and for example, in construction sphere - great technical saturation of the objects with radiocommunication devices);
- simplifying accounting and control of financial operations of organizations, in any average firm in the Russian Federation there are accounting program complexes (1C, Contour Elba, etc.) and different online client-banks.

Classification of organizational-technical subsystems, influencing the realization of the construction project, is performed on the basis of consultations held with the leaders of construction companies. On this stage of primary estimation the next "longlist" of criteria was formed:

Dependence of effectiveness of the project realization from judicial project participants:

- Influence on the project of its internal participants (developer, technical customer, general designer, general contractor, other contractors, subcontractors, etc.);
- Influence on the project of its external participants (Ministry of construction, State Construction Supervision, project documentation expertise, Russian Technical Supervision, etc.).

Dependence of effectiveness of project realization from project documentation:

- Quality of source documentation (urban planning plan of the land plot, cadastral plan, technical conditions for connection);
- Quality of engineering-exploration documentation (engineering-geodesic, engineering-geological, engineering-ecological reports);
- Quality of design and working documentation;
- Quality of executive documentation.

Dependence of effectiveness of project realization from lawful situation:

- Contradictions detected between regulative documents;
- Insufficiency of explanation of legislative and regulative base.

Dependence of effectiveness of project realization from quality of materials:

- Expenses on the carrying out of additional measures at incoming inspection: measurements, tests (control of actual cross section of cable cores, verification of geometric parameters etc.);
- Expenses on the carrying out of additional measures at incoming inspection: verification of documents on corresponding to the design, on authenticity).

Dependence of effectiveness of project realization from competence of physical performers:

- low-quality education of contractors;
- Insufficient experience of contractors;
- Type of contractor's motivation (presence of material and immaterial motivation of contractors);
- Way of payment to contractors (possibility of definition of the key parameters of effectiveness for piece payment).

5 Conclusion

The main ways of creating a complex-modular tool for increasing the efficiency of construction production, which allows both to assess the current level of organizational and technological solutions, and to predict the most effective variations in managerial and technological solutions, are outlined and determined.

It is detected and proved, that information technologies allow to decide complex and difficult scientific and technical problems. The application of IT makes it possible to increase the effectiveness of accomplishment of construction work, diminish the resource expenses.

Integration of IT into the construction sphere is an important and actual task. The difficulty of this task consists in a great number of organizational-technological aspects of constructive production and a great number of methods, technologies, and program complexes, relating to information technologies. Determination of the most rational, effective, and least expensive way of IT integration into constructive production is the foreground for the author of the article.

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