Innovation Intelligent Control Systems in Construction

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Abstract. In the article the authors study the design of construction processes. The first part describes that the design with the solution of a number of organizational and technological problems. One of these problems is to determine the reliability of not only the construction teams, but also the transport and technological flow in accordance with the planned parameters. The authors suggest not only to determine these indicators correctly, but also to manage them with the help of automatic intelligent integrated systems. This will allow you to reliably determine and adjust the timing of work and their cost at the design stage of construction of the complex. The authors have developed an algorithm for assessing the organizational and technological reliability of related construction and mechanized processes. Mathematical calculations of mechanization of construction and installation works are given. The algorithm of integration of crews of construction transport and technological and a stream in a uniform functional cycle is given.

1. Introduction

The design of construction processes is associated with the need to solve a number of organizational and technological problems. One of these problems is to determine the reliability indicators of not only construction crews, but also the transport and technological flow in accordance with the planned parameters. The authors suggest that it is required not only to correctly determine these indicators, but also to manage those using automatic intelligent integrated systems. This will reliably determine and adjust the timing of the production of works and their cost even at the design stage of the construction of the complex. We propose an algorithm for assessing the organizational and technological reliability of related construction and mechanized processes, developed for use in innovative intelligent systems such as "SiGma". The calculation is made on the basis of basic processes. An example of such a process, analyzed in the article, is the mechanization of construction and installation works. To fulfill the production program of a construction organization, it is necessary to integrate construction crews and the transport and technological flow into a single functional cycle.

To assess the organizational and technological reliability of the transport and technological process, the authors of the article proposed a simulation model and introduced the concept of the considered reliability as the probability of the achievement of a complex of machines and mechanisms of the final goal when carrying out a construction project. At the same time, the process of performing construction and installation works in the field of civil engineering and in the field of industrial construction is adopted as a stochastic system with many coordinated direct and feedback links. The classical model is not considered, since it does not substantially correspond to the real conditions of the construction of buildings and structures. Using the proposed approach to the evaluation of the
organizational and technological reliability of excavators with small improvements can be extended to any type of equipment, and will provide the numerical values of the reliability assessment, which is very important in choosing not only the type of technology, but also its speed and cargo characteristics [1].

Issues of organizational and technological reliability were studied in the work of O.A. Pobegaylov and O.V. Klyuchnikova, which refers to the close relationship of intelligent systems with the organization and management of the construction project. L.K. Petrenko, S.E. Manzhilevskaya consider the problem of innovation in construction technologies and investments in the sector, taking into account innovate. O.A. Pobegailov, O.E. Gaybaryan and G.I. Myasishchev talk about the role of document flow and information support of the company when the investor-customer chooses a contracting organization [2-4].

American scientist P. Bernst expounds general theory based branches of national economy of the choice of strategy. Issues of innovation policy are studied in detail by A.V. Baranov. He prepared several scientific papers on this issue. Thus, summarizing the material studied and their own research in this area, the authors of this article point out the objective need for solving the problem.

2. Materials and methods
At present, the issues of improving organizational and technological reliability (OTR) based on the definition, taking into account organizational and technological factors have a great influence on the efficiency of construction production, and the methods of managing these factors are of particular relevance. The absence of unambiguous methods for taking into account the probabilistic nature of construction production leads to a decrease in the reliability of organizational, technological and managerial decisions in the industry. In this case, the feature of these works is the unity of the process of erection of objects in the structural separation of organizations. In this regard, civil organizations interested in taking the designers of effective solutions to improve OTR in design and construction [8].

At the same time, factors of automation of the process play a special role in managing reliability, translating them into system environments controlled by artificial intelligence. In this case, OTR as the ability of technological, organizational, managerial decisions to achieve the specified result of construction production under random disturbances inherent in construction as a complex stochastic system, is represented by a complex software algorithm that allows you to quickly respond to changes and predict the occurrence of instability. In many methods of programming and calculating the stabilization of managerial reliability, the control algorithm is an estimate of the likelihood of a project being completed within a specified period and differentiating deviation with their subsequent stabilization [9-11].

In determining the OTR in the design process, it is necessary to develop such information programs that would ensure the rhythm of work of construction and installation organizations, while respecting the estimated dates for commissioning the facility. In accordance with this approach are discussed below to determine the organizational and technical solutions related construction and mechanized processes single integrated construction and assembly process.

In order to determine the OTR indicator and the degree of risk of participants in the investment process, research was carried out using the example of general contracting construction organizations in Rostov-on-Don. In the planning and implementation of the annual production program of the construction company used the methods and models of network planning and construction management. The flow method was adopted as the base method, which ensures the systematic, continuous and rhythmic work of the performers. [1 – 4].

So much for the Russian Railways network diagrams was drawn up for the construction of each item of the annual program, taking into account the principles of the implementation of the program stream. As an example, we considered the network schedule for the construction of 7-9- floors residential buildings. A unified list of construction and installation works adopted in the practice of housing construction was adopted as a list of works[12].
The definition of OTR indicator and the degree of risk of the investment cycle participants in the project implementation process is carried out in the following sequence[13].

1. A list of types of work is determined, with an indication of their code, actual duration, time reserve, and labor intensity, optimistic and pessimistic estimates of work are established.
2. The network schedule is under construction.
3. The stress coefficients are calculated for each individual path of the network model. (1).
4. The integral coefficient of tension is calculated according to the network graph as a whole through the weighting factor. As the weighting factor is taken the complexity (2).
5. The probability of execution of works in the contractual terms of the method of A.A. Gusakov based only on the work of the critical path and the degree of risk of participants in the investment cycle (3, 4).

\[
K_{nij} = \frac{t[L_{max}] - t[L_{cr}]}{t[L_{cr}] - t'[L_{cr}]},
\]

Where \(t[L_{cr}]\) – the lasting of the path \(t[L_{max}]\), coincides with the critical path; \(t[L_{cr}]\) – the lasting of the critical path; \(t[L_{max}]\) – the lasting of the maximum path passing through this work.

\[
\sum K_{uvi} = \sum_{i=1}^{n} K_i \cdot T_i = \sum_{i=1}^{n} K_i \cdot \sum_{j=1}^{m} T_{ij}
\]

Where \(K_i\) – reliability coefficient of \(i\) work; \(T_i\) – laboriousness of \(i\) work; \(\sum T_i\) – general laboriousness.

The calculated data suggests that it is impossible to perform work on a contractual basis, since \(\sum K_{uvi}\) should be between 0.35 … 0.5.

3. Results and discussions

Based on the research, a model was developed to determine the optimal reliability of organizational and technological design of various types of residential buildings by the criterion of achieving maximum profit for the contracting construction organization. The essence of the model is to establish the boundaries of OTR, under which profits can receive plus, minus and zero values, depending on the reduction of the calculated level of reliability, taking into account the balance of costs for restoring reliability and paying fines if these are not met[14].

OTR makes it possible to evaluate the established calendar plans for the construction of facilities not only in terms of the quality of organizational and technological characteristics, but also in terms of the risk of achieving them. In the construction of objects of great importance is the rational use of construction machines. The organizational and technological reliability of the construction of facilities largely depends on the effective use of machines.

The criterion for evaluating the OTR of construction machines can be any indicator in the sample, including productivity, duration of work, energy intensity, unit cost, profit, etc. The main indicator for assessing the performance of machine complexes is to be considered the cost of production.

One of the main factors of OTR work of construction machines is the level of their use over time. To assess the OTR work of construction vehicles at the Siberian State University of Communications, a database has been created on the results of field tests of excavators, dredgers, excavators, etc. [5].

To prove the validity of the database of values based on the results of field tests were carried out two stages of verification:

- logical - according to the observations of the observer, values that are not related to the normalized process are excluded from the series;
- mathematical - using the methods of mathematical statistics determine the legality of deviations.

After forming the sample in accordance with GOST 8.207-76, its belonging to the law of normal distribution is determined and a normal distribution curve is plotted.
It is known that if the area bounded by the normal distribution curve is taken as 1 or 100%, it is possible to calculate the area enclosed between the curve and any two ordinates. Organizational and technological risk (as a percentage) of the performance of the complex under consideration (set, individual machine) $x_t$ is calculated using the following formula:

$$OTP = \frac{100}{\sigma \sqrt{2\pi}} \int_{-\infty}^{x_t} e^{-\frac{(x-\bar{x})^2}{2\sigma^2}} dx,$$

where $x$ - productivity of the complex; $\bar{x}$ - the arithmetic mean of the productivity of complex; $\sigma$ - complex standard deviation; $p$ - constant number; $e$ - base of natural logarithm.

Than OTR achievement of the performance under consideration by the complex $x_t$ is calculated by the formula:

$$\text{OTR} = 100 - \text{OTR}_t$$

The database [5] contains information about the use of dredges on time for months and years. As a result of working out statistical information (with monthly data on the work of excavators) using the Sample program, we obtained: the weighted average of the excavator utilization rate over time was 65.97%, the standard deviation was -7.09%, and the calculated Pearson criterion value (7, 89) less than the table value (15.49) - it means that the sample obeys the law of normal distribution. As a result of processing the annual statistical information on the use of excavators, the following was obtained: the weighted average of the excavator utilization rate over time was 65.65%, the standard deviation was -3.17%, and the calculated Pearson criterion value (1.36) is less than the table value (11.04) - means that the sample obeys the law of normal distribution. Analysis excavators work showed that at the time of their utilization in the organization in question is about 66%, and the deviation of the average utilization over time when annual reports of ± 10% and ± 21% with the monthly statements. Using the developed analytical models, it is possible, with a given organizational and technological reliability, to determine the performance of the excavator and the cost of developing 1000 m$^3$ of soil. For example, with OTR = 60%, you need to determine the performance of an excavator. In pic. 1 b we find OTR$i$ equal to 60%, and the corresponding machine capacity is 25.7 m$^3$/h.

To automate the forecasting of the lasting, cost of construction, OTR of scheduling, profit of the construction organization and other indicators, a simulation model of the flow and the corresponding software "Impotok" have been developed [6]. Under simulation modeling refers to playback of the processes occurring in the construction system with artificial imitation of the values on which they depend, these processes using a random number generator. The algorithm for calculating construction indicators was compiled using the Monte Carlo method.

Using the flow simulation model, the effect of possible changes in the execution time of individual works on the total duration of the construction of the facility as a whole, on the change in the estimated cost of construction, and on the profit of the construction organization, taking into account the organizational and technological reliability of construction, is analyzed. The construction of the annual program of "Omskstroy" was seen as an example.

In addition, methodological, mathematical and software has been developed to automate the substantiation of the sequence and timing of construction of the facilities of the construction program’s annual program “Potok” [6]. “Potok” software allows determining the optimal sequence of construction of facilities and calculating the minimum possible construction period. For optimal variant sequence incorporating objects into a stream in order to better visualize the resulting solutions are built into the program sequence diagram and a graph of the estimated cost of development.

4. Conclusion

1. When concluding contracts, it is necessary to distribute the risk among the participants of the investment project in order to be able to diversify the damage in accordance with the capacity of organizations to manage risk and financially compensate for the consequences of their occurrence. The
distribution of risk is carried out at the stage of coordination of relationships and is fixed in the contract.

To implement the task, with the help of which it is possible to optimize construction processes during the construction of objects, the proposed approach can be used, in which the OTR is determined by the algorithms for searching for probabilistic deviations of the parameters of construction flows in the network structure of construction works.

2. In order to accomplish the task of optimizing organizational and technological solutions, the proposed approach can be used, in which taking into account the reliability of the complexes, sets and individual machines makes it possible to plan their rhythmic work with greater validity, more accurately determine the time (time, duration) of construction and installation works, which affects the cost reduction and improving the quality of construction products. When concluding contracts, it is necessary to distribute the risk among the participants of the investment project in order to be able to diversify the damage in accordance with the capacity of organizations to manage risk and financially compensate for the consequences of their occurrence. The distribution of risk is carried out at the stage of coordination of relationships and is fixed in the contract. To implement the task, with the help of which it is possible to optimize construction processes during the construction of objects, the proposed approach can be used, in which the OTR is determined by the algorithms for searching for probabilistic deviations of the parameters of construction flows in the network structure of construction works. In order to accomplish the task of optimizing organizational and technological solutions, the proposed approach can be used, in which taking into account the reliability of the complexes, sets and individual machines makes it possible to plan their rhythmic work with greater validity, more accurately determine the time (time, duration) of construction and installation works, which affects the cost reduction and improving the quality of construction products.

5. References

[1] Kliuchnikova O V, Pobegaylov O A 2016 Rationalization of Strategic Management Principles as a Tool to Improve a Construction Company Services Procedia Engineering 150 pp 2168 – 2172
[2] Petrenko L K, Manzhilevskaya S E, Bogomazyuk D O 2016 Mathematical Simulation of SiO2 Leaching from Silicified Soils: Innovative Approach Procedia Engineering 150 pp 2302 - 2307
[3] Pobegaylov O A, Myasishchev G I, Gaybarian O E Organization and Management Efficiency Assessment in the Aspect of Linguistic
[4] Bernst P 2011 Strategic analysis 410 p
[5] Baranov V V 2010 For a Construction company Planning and analyziz 150 p
[6] Wissema H 2000 Strategic management and entrepreneurship: opportunities for future prosperity: Trans. from English 420 p
[7] Kostyuchenko V V 2013 Strategic management: a tutorial. (Rostov-on-Don Rostov State Construction University) 156 p
[8] Larionov N K 2014 Strategic management 235 p
[9] Nebitov B N 2016 Engineering Bulletin of the Don 1 URL: ivdon.ru/rulmagazine/archive/nly2016/3554
[10] Tsipes G L 2009 Projects and project management in a modern company: Scholastic allowance ZAO Olympus-Business (Moscow)
[11] Kostyuchenko V V 1998 Organization, planning and management in construction: textbooks (Rostov-Don)
[12] Mazur I I, Shapiro V D, Karolinska I M 2001 Management of projects High School (Moscow)
[13] Gaybarian O E, Myasischev G I 2017 Engineering Bulletin of the Don 4(47) p 193
[14] Shirina E V, Myasishchev G I 2017 Engineering Bulletin of the Don 4(47) p 121