

Assessment of organizational and technological reliability of a construction organization during contract bidding

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Abstract. In the current system of contract bidding, there are a number of problems, one of which is the imperfection of the evaluation criteria by which applicants are selected. The article presents a methodology for assessing the organizational and technological reliability of a construction organization and its competitive offers for tenders for construction and installation works. It is proposed to use the indicator of its organizational and technological reliability as a criterion for evaluating a construction organization that claims to fulfill a construction order. To determine the reliability of a construction company, information about the intensity of development of capital investments is used. This indicator allows you to assess how much the bidder can ensure the maximum return on the construction equipment and workers used, reduce the cost of construction using modern construction materials and resource-saving technologies. Each construction and installation organization will have its own intensity of development of capital investments. It depends on the qualification of employees, the availability and use of a fleet of construction machines and mechanisms, construction production technologies, construction organization methods, etc. As an indicator that characterizes the relative change in the actual development of capital investments from the standard or calculated value, the capital investment development index is used. Using retrospective data on the speed of capital investment development for similar objects or using variant design of the construction process, curves of accumulated probabilities of capital investment development indices are constructed, which are used to determine the organizational and technological reliability of the contract bidder. The proposed assessment of the reliability of a construction organization allows the customer (investor) to choose a reliable partner – contractor that best meets their requirements.

1. Introduction

At present, the key element of the state construction order implementation process is the contract system in the field of procurement of goods, works and services. Within the framework of contract bidding, the level of competitiveness of organizations of the construction complex that claim to win is evaluated. The creation of a system of

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competitions for placing state and municipal orders meant improving the quality of construction projects, stimulating competition and economic interaction in the construction contract market.

In practice, the current system of contract bidding demonstrates a number of problems that hinder the realization of its potential. One of the main reasons is the imperfection of the evaluation criteria used to select companies - applicants. When evaluating bids, customers traditionally focus on such competitive advantages as work experience, the use of advanced technologies in the implementation of construction and installation works, and the availability of qualified personnel. However, these indicators are no longer adequate to reality and do not show the reliability of the contractor in the construction services market.

As a criterion for evaluating a construction organization that claims to fulfill a construction order, it is proposed to use the indicator of its organizational and technological reliability.

The first definition of organizational and technological reliability was given by A. A. Gusakov [1]. By this term he understood the possibility of building a system designed to preserve quality in the conditions of disturbing factors. A.V. Ginzburg under the organizational and technological reliability understand the ability to achieve a given uncertainty in the external environment [2].

It should be noted that the concept of reliability is widely used in the study of socio-economic, technical and production systems. If we omit the current concept of reliability in specific areas of human activity, such as medicine, then it is possible to limit the scope of this indicator to production socio-economic and organizational and technological systems. Such systems should include construction.

It is important to emphasize that long-term use of the concept of reliability in research and practical activities of enterprises, did not lead to a unified approach to quantification of this category, including with consideration of its application. Only the assessment of the technical reliability of machine systems and mechanisms has a whole set of standards that set requirements for the source information and determine the methods of mathematical calculations of the quantitative value of the "reliability" indicator. If we group methodological approaches to quantifying the "reliability" indicator in relation to systems in which human actions play an important role, it is easy to identify several of the most widely used tools, which include:

- the theory of probability [3];
- the theory of risk [4];
- methods of expert assessments [5];
- methods for predicting and preventing failures [6].

The application of risk theory to assess the reliability of organizational and technological solutions [7], including at industrial and energy enterprises does not provide a level of reliability, it is necessary when predicting the duration of construction and installation work. The study of failures, including in socio-technical systems [8], does not provide the required reliability in predicting the intensity of construction of buildings and structures. From the author's point of view, the methods of probability theory are most suitable for assessing the reliability of organizational and technological solutions in construction. These methods are widely used in calculating the quantitative value of organizational and technological reliability [9], including in the preparatory period [10], as well as organizational design and project management systems [11].

The purpose of the research is to propose a procedure for evaluating the organizational and technological reliability of a construction organization during contract bidding.

2. Materials and Methods

The paper uses methods of probability theory. The accumulated probability curve is constructed based on data obtained from design estimates and regulatory documentation.

3. Results

One of the main indicators of reliability of a construction organization is the duration of production of construction products, which determines the construction lines. The duration of construction production depends on the duration of individual stages of construction, the types of construction products produced, as well as the potential of the organizational, technological, technical and financial capabilities of the contractor. Therefore, when assessing the competitiveness of a construction company, the customer is interested in predicting the probability of completion of the construction project on time.

To determine the reliability of a construction organization, it is proposed to use information about the intensity of development of capital investments. This is due to the fact that the cost of work and the duration of individual construction stages are calculated based on specific organizational and technological solutions. Organizational and technological solutions, in turn, depend on the machines and mechanisms used, the types of technological processes, the volume of work and regional features of construction.

Thus, when choosing a construction company, the customer must assess the level of its organizational and technological reliability based on the intensity of capital investment development. This indicator allows you to assess how much the applicant can provide the maximum return on the construction equipment and workers used, reduce the cost of construction using modern construction materials and resource-saving technologies.

In previous works [12], it was shown that the intensity (or speed) of capital investment development is a probabilistic value and varies depending on the types of work performed. Therefore, it was proposed to use the capital investment development index as an indicator that characterizes the relative change in the actual development of capital investments from the standard or calculated value. Formula for calculating it:

$$t = \frac{W_f}{W_N} \quad (1)$$

Where W_f is the value of the actual development of capital investments per unit of time;

W_N – the amount of development of capital investments per unit of time, which can be determined on the basis of standards or can be proposed in the construction organization project.

Since the intensity (speed) of capital investment development is a probabilistic value, the capital investment development index is an uncertain value and its changes are subject to the law of normal distribution [13]:

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-t_{cp})^2}{2\sigma^2}} \quad (2)$$

Where $f(t)$ is the differential function of the normal distribution;

σ – mean square deviation;

t – the index of development of capital investments;

t_{cp} – average value of the capital investment development index.

The integral function or distribution function is calculated using the formula:

$$F(t) = \frac{1}{\sigma\sqrt{2\pi}} \int_0^{+\infty} e^{-\frac{(t-t_{cp})^2}{2\sigma^2}} dt \quad (3)$$

Graphs of the integral and differential functions of the normal distribution of the capital investment development index are shown in figure 1.

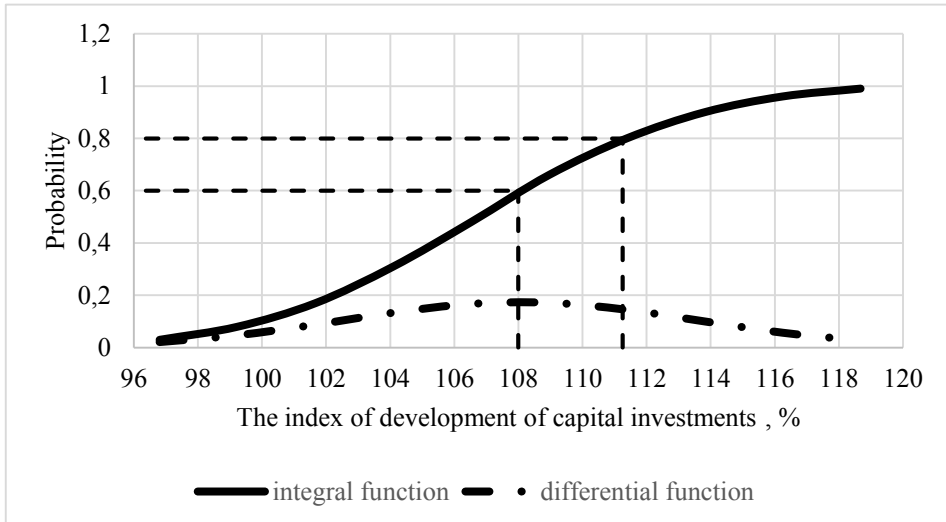


Fig. 1. Integral and differential functions of the law of normal distribution of the capital investment development index.

On the basis of the integral function, the probability of building an object on time with the specified values of the capital investment development index is calculated. Figure 1 shows that if the rate of development of capital investments exceeds the average value by no more than 8%, the probability of construction of the object on time will be 0,6. If the rate of development of capital investments exceeds the average (or standard) indicator by no more than 11,25%, then the probability of building construction on time will be 0,8.

A. A. Gusakov, the founder of system engineering in construction, believed that the probability of building a construction object on time should be in the range of 0.6 – 0.75. Thus, if the value of the index of development of capital investments of a construction organization corresponds to a value less than 0.6 for the distribution function, then the organizational and technological reliability of the organization is low, if it is in the range from 0.6 to 0.8 – normal, above 0.8 – high.

Each construction and installation organization will have its own intensity of development of capital investments. It depends on the qualification of employees, the availability and use of a fleet of construction machines and mechanisms, construction production technologies, construction organization methods, etc. The index of capital investment development for the same organization may vary depending on the type and type of building being built.

To assess the organizational and technological reliability of a contractor, the most promising approach from the author's point of view is to build curves of accumulated probabilities. To do this, it is necessary to collect retrospective data on the contractor's performance of construction and installation works. And based on information about the volume of capital investment development for a certain period (1 day, week, 10 days, etc.), build curves of accumulated probabilities for various types of buildings and structures. Work logs and primary documents can be used as a source of information. These curves

will show the reliability of the construction organization for construction on time with the specified estimated cost of the construction object.

To assess the organizational and technological reliability of bids, an organization that conducts auctions based on data for all similar objects builds an average curve of accumulated probabilities of capital investment development indices. The construction and installation organization participating in the auction is invited to provide information about the cost and timing of construction of five similar objects. According to formula 1, the average intensity of development of capital investments is calculated from the bidder's tender offer and the reliability of construction of the object on time is determined using the averaged curve of accumulated probabilities.

If data on development of capital investments on facilities analogues no, in this case, you can use the method of trial design and on the basis of design estimates of standard projects of buildings and structures, the integrated cost indexes of construction works, normative documents, (GEES, FER, TER, etc.), possibilities of the average contractor in the region to build the curves of the accumulated probabilities at the species and types of buildings and structures.

As an example, let's consider the construction of a simulation model of the probability of building a 9-storey brick house with an area of 12060 m² on time.

In accordance with MDS 12-43.2008 and individual costs for construction and installation work, table 1 of the financing requirements for construction stages was compiled.

Table 1. Distribution of capital investments by stages of construction of a 9-storey brick building, thousand rubles

Type of work	1 month				2 month				3 month			
Preparatory work	4%											
Underground part					5%				7.45%			
Aboveground part												
Finishing work												
Capital investment on a weekly basis	1570.68	1570.68	1570.68	1570.68	1963.35	1963.35	1963.35	1963.35	3534.02	3534.02	3534.02	3534.02
Capital investments per month, thousand rubles	6282.71				7853.39				14136.10			

continuation of **table 1**

Type of work	4 month	...	11 month	12 month
Preparatory work				
Underground part				
Aboveground part	8%	...	8%	8%
Finishing work				

Capital investment on a weekly basis	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35	3141.35
Capital investments per month, thousand rubles	12565.42		...			12565.42				12565.42			12565.42

Using variant design, all possible alternative technologies for performing simple construction processes are formed, as well as possible solutions within each technology, which are determined by the potential of the available organizational and technological resources of an average contract construction organization in Moscow.

The variants of the monthly rate of development of capital investments obtained for each type of construction work are presented in table 2.

Table 2. Development of capital investments in the construction of a 9-storey brick house, thousand rubles

Alternative ways to develop capital investments			
2011	3651	3647	2113
1974	3721	3784	1991
2215	3725	3556	2176
2054	3574	3634	2300
2355	3655	3927	1871
2080	3652	4021	1957
2175	3863	3883	1936
2146	3690	3657	2193
2107	3722	3727	2085
2089	3493	3878	2302
2070	3682	4009	2143
2087	3718	4211	2136
2117	3925	4032	2099
2076	3639	3903	2102
2115	3457	4146	2156
2132	3721	3943	2017
2014	3547	3919	2053
2302	3607	3720	2218
2143	3719	3422	2335
2019	3612	3489	2098
2340	3440	3410	1944
2095	3642	3968	2296
2244	3532	4056	2229
2159	3455	3861	2093
3934	3648	3965	2132
3674	3678	3854	2109
3864	3503	3728	2107
3651	3572	3760	

Formula 1 calculates the intensity of development of capital investments (table 3).

Table 3. Variant indices of development of capital investments in the construction of a 9-storey brick house

Variant indexes of capital investment development, %
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102.43	105.29	103.19	107.64
100.54	105.40	107.07	101.43
112.82	101.13	100.62	110.85
104.62	103.42	102.83	117.17
119.95	103.33	111.12	95.31
105.94	109.31	113.78	99.69
110.78	104.41	109.87	98.62
109.30	105.32	103.48	111.72
107.32	98.84	105.46	106.21
106.40	104.18	109.73	117.27
105.43	105.21	113.44	109.17
106.30	111.06	119.16	108.81
107.83	102.97	114.09	106.93
105.74	97.82	110.44	107.08
107.72	105.29	117.32	109.83
108.59	100.36	111.57	102.75
102.58	102.06	110.89	104.58
117.25	105.23	105.26	112.99
109.15	102.20	96.83	118.95
102.83	97.34	98.73	106.88
119.18	103.05	96.49	99.03
106.71	99.94	112.28	116.96
114.29	97.76	114.77	113.55
109.97	103.22	109.25	106.62
111.32	104.07	112.20	108.61
103.96	99.12	109.05	107.44
109.34	101.07	105.49	107.34
103.31	105.21	106.39	

Based on the information received, a statistical series is compiled (table 4).

Table 4. Statistical series of variant indices of capital investment development during the construction of a 9-storey brick house

Interval, %	95.31	97.77	100.23	102.69	105.15	107.61	110.07	112.53	114.99	117.45
	-	-	-	-	-	-	-	-	-	-
	97.77	100.23	102.69	105.15	107.61	110.07	112.53	114.99	117.45	119.95
Frequency	5	8	10	17	26	17	11	8	5	4
Probability	$\frac{0.0}{5}$	0.07	0.09	0.15	0.23	0.15	0.10	0.07	0.05	0.04
The cumulative probability	$\frac{0.0}{5}$	0.12	0.21	0.36	0.59	0.75	0.85	0.92	0.96	1.00
Average, t (%)	106.87									
Meansquare deviation, σ (%)	5.31									
Coefficient of variation, V	0.41									

A curve and a polygon of accumulated probabilities are plotted based on the statistical series data (Fig. 2).

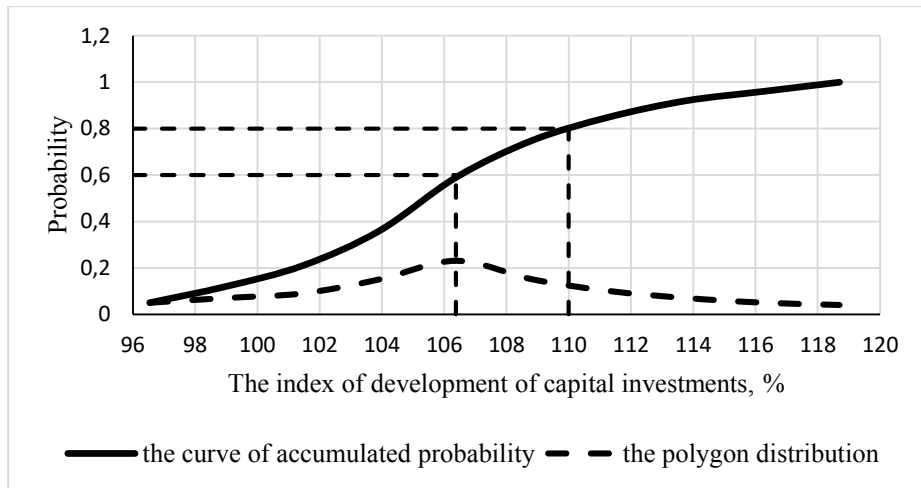


Fig. 2. Polygon and curve of accumulated probabilities of capital investment development indices during the construction of a 9-storey brick building

Figure 2 shows that the bidder must offer the speed of development of capital investments at least 6-10% higher than the Directive value, in order to increase the organizational and technological reliability of the construction of a 9-storey brick building on time.

The proposed mechanism makes it possible to assess the reliability of contractors when performing construction and installation works and their tender offers.

4. Conclusions

Using retrospective data on the speed of development of capital investments for similar objects or using variant design of the construction process, curves of accumulated probabilities of indices of development of capital investments are constructed, on the basis of which the organizational and technological reliability of the contract bidder is determined. The proposed assessment of the reliability of the construction organization allows the customer (investor) to choose a reliable partner – contractor that best meets its potential and requirements, and the contractor has an incentive to increase labor productivity and improve the quality of construction and installation work.

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