Analyzing quality of interaction between participants in the construction control system

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Abstract. The construction control system is complex and its functioning requires coordinated and prompt interaction without the occurrence of failures and conflict situations. The paper identifies factors influencing the operation of the system and specific processes, the approach to which should be reconsidered. The research methods used included the method of expert assessments, statistical data analysis, and the Varimax rotation method. As a result of the study, the 3 most significant factors influencing the construction control system were identified, and the need to introduce a Unified Information Environment was substantiated. Reducing the level of influence of factors will contribute to more successful functioning of the construction control system and the interaction of system participants with each other.

1 Introduction

The construction control system is very complex, because it requires coordinated and prompt interaction of its participants with a widely developed structure of this interaction.

Despite comprehensive delineation of tasks and responsibilities for these participants in regulatory documents, certain problems during construction may still arise, resulting in economic losses and project delays for various reasons. Most often, these problems arise precisely because of the imperfect interaction of participants in the construction control system during construction and installation work, and specifically a large number of documents that require creation, approval and signing, which in turn can take a decent amount of time.

The activities of the construction control system at construction sites have been studied in different areas. The issues of conducting construction control during the construction of complex objects, the tasks of participants in the construction control system during implementation were considered [1-3].

As a result of the research, various methods and ways to solve problems were proposed, for example: optimization of the process of carrying out construction control by unifying control measures, identifying factors taken into account when carrying out construction control [4,5].

Certain tasks and roles within the construction control system lack specific regulatory deadlines, thereby impeding the effective planning, organization, and management of capital construction or reconstruction projects [6 7].

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Clearly, the only way to, if not completely, then partially solve the most significant emerging problems is to optimize the processes of interaction between participants in the construction control system. Before direct optimization, it is necessary to identify the problems that arise most often in the construction control system, and for this it is necessary to find out the opinion of specialists about the interaction of participants in the existing construction control system, who are directly involved in this interaction.

2 Materials and methods

Since the issue of interaction between participants in the construction control system has been little studied, the method chosen for the study was to analyze the statistical data that needs to be obtained by interviewing direct participants in the construction control system.

To successfully conduct a study, it is necessary to obtain data on the interaction of participants in the construction control system. This goal can be achieved by conducting a survey both among people working in the construction industry and participating in the construction control system, and among people who often encounter the activities of the construction control system.

When drawing up questions for the survey, the following principles were observed:

- The first question in the questionnaire should determine the respondent's involvement in the construction control system in order to structure the data. After receiving this information, respondents should be presented with relevant questions [8].

• Next, for the study it is necessary to collect basic information about the professional activities of the respondent:

1. Position held, since it is necessary to understand the respondent's area of responsibility. The answers to this question will be a ranking scale [8];

2. Work experience, since the amount of experience of the respondent directly affects the objectivity of his attitude towards the interaction of participants in the construction control system. The answers to this question will be a ranking scale [8];

3. What objects are being implemented by the organization in which the respondent works, since the level of responsibility during construction control varies, depending on the functional purpose of the object and specific type of financing of these objects. The answers to this question will be a ranking scale;

- In the main part of the questionnaire, respondents had to answer questions about:

1. Difficulties in interacting with other participants in the construction control system and the reasons for the occurrence of these difficulties, in order to determine the conditional "level of conflict between participants in the construction control system" ;

2. The main problem in the interaction of participants in construction control, in order to identify non-obvious factors influencing the interaction of participants in the construction control system;

3. The efficiency of interaction between participants in construction control based on their own experience or the experience of their colleagues. Thus, it will be possible to determine the conditional "level of efficiency in the interaction of participants in the construction control system";

4. Their attitude to the statement: "Within the existing construction control system, bureaucratic procedures significantly influence operations due to the substantial accountability in production and the prevalent hierarchical structure within construction companies. Consequently, a common scenario arises where locating responsible individuals, due to the need for their physical presence (e.g., for document signing), consumes a considerable amount of time." This will make it possible to find out the conditional "level of influence of bureaucratic processes on the quality of interaction between participants in the construction control system";

• In the final part of the questionnaire, respondents were asked to get acquainted with the idea of introducing into the construction control system an auxiliary tool for all participants in construction control, aimed at eliminating factors affecting the quality and efficiency of interaction between participants in the construction control system, called the "Unified Information Environment". The answers to this question will allow us to determine the factor "Attitude towards the idea of introducing a "Unified Information Environment" into the existing construction control system." After becoming familiar with this idea, respondents could express their thoughts about it, and could also express their own ideas about improving the interaction between participants in the construction control system.

Twenty-seven independent specialists in the field of construction, from different organizations engaged in various activities, took part in the survey.

All respondents' answers to the mandatory survey questions were scaled for correct data entry into the IBM SPSS Statistics program for statistical data processing and further analysis.

The first step is to identify the main factors that determine the attitude of respondents to the quality of interaction of participants in the existing construction control system, for which the method of factor analysis of data using the maximum likelihood method was used.

The second step of the study is to calculate and analyze factor loadings. We use the Varimax rotation method of the originals for a visual interpretation of the solution. This method will allow us to trace a clear factor structure and identify variables marked by large values of correlation coefficients with a particular factor. To apply the method, it is necessary to correlate all factors using IBM SPSS Statistics.

In addition to the questions that revealed the respondents' attitude towards the existing building control system, the questionnaire also contained questions that provided additional information for the study regarding the role performed by the respondent in the building control system (Question 1), as well as their opinions on the proposal to introduce Unified Information Environment into the existing building control system.

The next step was to establish relationships between additional and identified variables.

To solve the problem, it is necessary to apply contingency tables and the Pearson chi-square test, which allows you to test the hypothesis about the independence of characteristics.

3 Results and discussion

Let's look at the results of the study.

As a result, the following factors were identified:

The first factor is "The level of conflict in the existing construction control system." The explanatory "power" of the factor, or factor weight, is 18.22%.

The second factor is "The degree of influence of bureaucratic processes on the efficiency of interaction between participants in construction control." Factor weight – 17.11%.

The third factor "Level of efficiency of interaction between participants in the construction control system." Factor weight – 11.12%.

The factor values of the first, second and third factors were divided into groups. As a result of the partition, three new factor variables were obtained, which will be denoted f_1, f_2 and f_3.

For the first factor, the value 0 corresponds to the position "No problems arose", 1 – "Problems arose with specific participants in the construction control system" and 2 – "Problems arose with many participants in the construction control system".

For the second factor, a value of 1 corresponds to the answer "Disagree", 2 – "Agree, but not completely", and 3 – "Completely agree".

For the third factor, a value of 1 corresponds to the rating "Satisfactory", 2 – "Good", and 3 – "Excellent".

Using the "Contingency Table" tool of the IBM SPSS Statistics program, a joint distribution of such variables was obtained: f_{11} – role in the construction control system, f_{12} – opinion on the proposal to introduce the Unified Information Environment in the construction control system, f_{21} – role in the construction control system, f_{22} – opinion on the proposal to introduce the Unified Information Environment into the construction control system, f_{31} – role in the construction control system, f_{32} – opinion on the proposal to introduce the Unified Information Environment into the construction control system. The distribution of these variables served as the initial data for calculating the Pearson $\chi 2$ criterion, and also made it possible to analyze which values of the factor variables f_1, f_2 and f_3 are more pronounced for each group.

The use of the chi-square test made it possible to test hypotheses about the independence of signs f_{11} - role in the construction control system, f_{12} - opinion on the proposal to introduce the Unified Information Environment in the construction control system, f_{21} - role in the construction control system, f_{22} - opinion on the proposal to introduce the Unified Information Environment in the construction control system, f_{31} – role in the construction control system, f_{32} – opinion on the proposal to introduce the Unified Information Environment into the construction control system.

Analysis of tables 1 and 2 shows that in the target sample, the second and third values of the factor variable $F1$ are most strongly expressed, which mean that 70% of respondents encountered problems when interacting on work issues, the consequences of which were construction delays or additional work on construction production.

Table 1. Contingency table for factor F_1 and f_{11}

Role in the construction control system	F_1 (Factor 1) Pearson's χ^2: 2.917; p (two-sided asymptotic significance) = 0.817; $\alpha = 0.05$			Total
	0 – "No problems arose"	1 – "Problems arose with specific participants in the construction control system"	2 – "Problems arose with many participants in the construction control system"	
Design supervision	1	2	2	5
Construction control of the customer	7	8	3	18
Construction control of the contractor	0	1	0	1
Does not take part in construction control	1	1	1	3
Total	9	12	6	27

Table 2. Contingency table for factor F_1 and f_{12}

Opinion on the proposal to introduce a Unified Information Environment into the construction control system	F_1 (Factor 1) Pearson's χ^2: 5.755; *p* (two-sided asymptotic significance) = 0.218; α = 0.05			Total
	0 – "No problems arose"	1 – "Problems arose with specific participants in the construction control system"	2 – "Problems arose with many participants in the construction control system"	
This would greatly help the respondent	6	5	1	12
It would complicate the work, it would help	2	7	4	13
The respondent is satisfied with the system	1	0	1	2
Total	9	12	6	27

According to the criterion "Role in the construction control system" for the first factor, based on the results of the chi-square test, the difference in the level of conflict between participants in the construction control system is insignificant (p=0.817> α=0.05).

The data in Table 2 shows that respondents who were interested in the proposal to introduce a Unified Information Environment into the construction control system (92.6% of respondents chose option 1 or 2 to answer the question), while encountering problems when interacting on work issues, the consequences of which were construction delays or additional work in construction production account for 62.96% of the total number of respondents. At the same time, the chi-square test indicates a slight difference in the level of conflict between participants in the construction control system in the target sample (p=0.218> α=0.05).

Analysis of tables 3 and 4 shows that in the target sample, the second and third values of the factor variable F_2 are most strongly expressed, which mean that 92.6% agree with the statement: "In the current construction control system, bureaucratic processes play a very large role due to the high responsibility in production and a wide-ranging hierarchy of management in construction enterprises, which, in turn, leads to a common situation where it takes a lot of time to find responsible persons due to the need for their physical presence (e.g., to sign a document)".

According to the criterion "Role in the construction control system" for the second factor, based on the results of the chi-square test, the difference in the degree of influence of bureaucratic processes on the efficiency of interaction between participants in construction control is insignificant (ρ=0.317>α=0.05) [34].

The data in Table 4 shows that respondents who are interested in the proposal to introduce a Unified Information Environment into the construction control system (92.6% of respondents chose option 1 or 2 to answer the question), while agreeing with the statement presented in question 8 account for 88.89% of the total number of respondents. At the same time, the chi-square test indicates a slight difference in the degree of influence of bureaucratic processes on the efficiency of interaction between participants in construction control in the target sample (ρ=0.092>α=0.05).

Table 3. Contingency table for factor F_2 and f_{21}

Role in the construction control system	F_2 (Factor 2) Pearson's χ^2: 6.234; *p* (two-sided asymptotic significance) = 0.397; α = 0.05			Total
	1 – "Disagree"	2 – Agree, but not completely"	3 – "Completely agree"	
Design supervision	1	4	0	5
Construction control of the customer	1	13	4	18
Construction control of the contractor	0	0	1	1
Does not take part in construction control	0	2	1	3
Total	2	19	6	27

Table 4. Contingency table for factor F_2 and f_{22}

Opinion on the proposal to introduce a Unified Information Environment into the construction control system	F_2 (Factor 2) Pearson's χ^2: 7.999; *p* (two-sided asymptotic significance) = 0.092; α = 0.05			Tota l
	1 – "Disagree"	2 – Agree, but not completely"	3 – "Completely agree"	
This would greatly help the respondent	1	7	4	12
It would complicate the work, it would help	0	11	2	13
The respondent is satisfied with the system	1	1	0	2
Total	2	19	6	27

Analysis of tables 5 and 6 shows that in the target sample, the first and second values of the factor variable $F_{3§}$ are most strongly expressed, which mean that 85.18% of respondents believe that the efficiency of the construction control system can be increased.

According to the criterion "Role in the construction control system" for the third factor, based on the results of the chi-square test, the difference in the level of efficiency of interaction between participants in the construction control system is insignificant (ρ=0.113>α=0.05).

Data from Table 5 show that respondents who are interested in the proposal to introduce a Unified Information Environment into the construction control system (92.6% of respondents chose option 1 or 2 to answer the question), while believing that the efficiency in the interaction of participants in the construction control system can be improved, account for 81.48% of the total respondents. At the same time, the chi-square test indicates a slight difference in the level of efficiency of interaction between participants in the construction control system in the target sample (ρ=0.192>α=0.05).

Table 5. Contingency table for factor *F*3 and *f*31

Role in the construction control system	F_3 (Factor 3) Pearson's χ^2: 10.282; *p* (two-sided asymptotic significance) = 0.113; α = 0.05			Total
	1 – "Satisfactory"	2 – "Good"	3 – "Excellent"	
Design supervision	4	1	0	5
Construction control of the customer	6	9	3	18
Construction control of the contractor	0	0	1	1
Does not take part in construction control	1	2	0	3
Total	11	12	4	27

Table 6. Contingency table for factor F_3 and f_{32}

Opinion on the proposal to introduce a Unified Information Environment into the construction control system	F_3 (Factor 3) Pearson's χ^2: 6.104; *p* (two-sided asymptotic significance) = 0.192; α = 0.05			Total
	1 – "Satisfactory"	2 – "Good"	3 – "Excellent"	
This would greatly help the respondent	3	8	1	12
It would complicate the work, it would help	7	4	2	13
The respondent is satisfied with the system	1	0	1	2
Total	11	12	4	27

Using the methods of applied mathematics and factor analysis, in particular the use of variance analysis, data correlation, contingency tables and the Varimax rotation method of the initial ones, the reliability and significance of the survey conducted among construction control system specialists was proven. The identified factors made it possible to identify specific processes, the approach to which should be reconsidered. The most significant factors were:

- The level of conflict between participants in the construction control system;
- The level of influence of bureaucratic processes on the quality of interaction between participants in the construction control system;
- The level of efficiency of interaction between participants in the construction control system.

4 Conclusion

The analysis of the quality of interaction between participants in the construction control system carried out in the study indicates the imperfection of the existing construction control system.

The identified factors play a significant role for the participants in the performance of their direct duties. The conclusion follows from this: it is necessary to make changes to the construction control system aimed at improving the quality of interaction between its

participants. Specifically, the changes should be associated with reducing the level of conflict between participants in the existing construction control system, reducing the influence of bureaucratic processes on the efficiency of interaction between its participants, and directly with optimizing this interaction to improve efficiency.

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