METHODS OF INCREASING RELIABILITY TO REDUCE THE CONSTRUCTION RISKS OF HIGH-RISE MONOLITHIC REINFORCED CONCRETE BUILDINGS

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Abstract

Since the construction of high-rise monolithic reinforced concrete buildings is a complex and dynamic system and it is influenced by a large number of factors, the quantitative indicator of organizational and technological reliability is probabilistic in nature, their assessment can be solved by mathematical statistics by interviewing experts. In our republic, the volume of construction of high-rise monolithic reinforced concrete buildings has reached a record level. Statistics show that the construction of monolithic reinforced concrete buildings in the republic is 86.0% in housing construction. This makes it relevant to study and develop methods for improving the organizational and technological reliability of high-rise monolithic reinforced concrete buildings.

The assessment of the organizational and technological reliability of the construction of monolithic reinforced concrete buildings includes such issues as the probability of completion of construction, that is, the implementation of a construction project on time and within budget, with the necessary quality. Thus, it is necessary to analyze in more detail the factors determining the reliability of the construction of monolithic reinforced concrete buildings using the methods of probability theory and mathematical statistics.

Keywords: reliability, expert assessment, high-rise, monolithic reinforced concrete, construction production, organizational-technological problems, quality control

I. Introduction

To improve the quality and competitiveness of manufactured construction products, it is required to perform work in the shortest possible time, with minimal costs and high quality, which is one of the main directions of effective production organization. Ensuring that the work is carried out according to the planned schedule depends on the overall reliability and durability of the construction complex. Both in our country and in the world, monolithic reinforced concrete construction retains its dominance in the construction of buildings and structures. Statistics on the construction of monolithic reinforced concrete buildings in our country show that the construction of monolithic reinforced concrete buildings in our republic accounts for 86.0% in housing construction. This makes it relevant to increase the organizational and technological reliability of high-rise monolithic reinforced concrete buildings.

To manage the process of business organization, it is proposed to use such a criterion as organizational and technological reliability (OTR). Quality is understood as the ability of technological, organizational, managerial decisions to provide a certain result of construction production in conditions of random violations inherent in construction as a complex stochastic system.

During the construction of monolithic reinforced concrete buildings, issues of organizational and technological reliability should be addressed in order to make rational decisions that reduce the time required to perform more labor-intensive work, reduce costs and improve the quality of construction products. Since construction production is a complex and dynamic system and it is influenced by a large number of factors, the quantitative characteristics of organizational and technological reliability are probabilistic in nature, their assessment can be solved on the basis of mathematical statistics by means of a questionnaire.

Thus, construction is the most important stage in the development of an effective means of preventing the occurrence of factors that negatively affect the timing, estimated cost and quality of the object, ensuring the reduction of construction risks and increasing its organizational and technological reliability.

Since construction is a complex production system, there is a noticeable increase in the number of factors that can negatively affect the timing, cost and quality of the construction of an object, acting as the main criteria for its organizational and technological reliability[1]. Therefore, the risk of making probabilistic decisions has a high degree, which makes it important to study and develop methods to ensure the reliability of construction.

II. Methods

The methodological basis of the research is a systematic approach aimed at studying and solving the works of domestic and foreign scientists dealing with the problems of reducing the risks of construction of high-rise monolithic reinforced concrete buildings and increasing its organizational and technological reliability.

During the research, methodological guidelines of leading scientific institutions dealing with the problem of improving the organizational and technological reliability of the construction of monolithic reinforced concrete buildings, statistical data obtained during quality monitoring, regulatory legal acts, as well as actual materials of a number of contractor construction organizations performing large volumes of monolithic reinforced concrete works were used.

The method of expert assessments, probability theory and mathematical statistics, reliability theory, graph-analytical method and mathematical modeling methods were used as the research methodology.

III. Results

3.1. Research of the indicator of organizational and technological reliability of quality improvement.

The object of the study on the basis of analytical research and scientific approach was chosen the construction of high-rise monolithic reinforced concrete buildings and structures representing a more complex construction technology. The analysis showed that currently the weakest point of the existing organization of the production of monolithic reinforced concrete buildings is the efficiency of the construction organizations and all project participants. Failure to complete the construction stage on time, a decrease in the quality of work, high labor intensity of technological operations-all this affects the reliability of the construction object as a whole. Accordingly, the most important direction of improving the technology of construction of monolithic reinforced concrete buildings is the development and implementation of organizational and technological solutions that reduce the time required to perform technological operations with greater labor intensity in the construction of monolithic buildings and structures, improve the use of machinery, mechanisms and equipment, increase labor productivity, improve the quality of construction and installation work.

Currently, the issues of increasing OTR, determined by taking into account organizational and technological factors, have a great impact on the efficiency of construction production, and management methods of these factors are becoming especially relevant. In this regard, the optimization of organizational structural and production processes in the construction of monolithic reinforced concrete buildings, which reduces the risks of construction and increases its organizational and technological reliability, is the most important stage.

Based on the analysis of regulatory documents and technical literature in the field of organization of construction production and technology, the main indicators of organizational and technological reliability of the construction of monolithic reinforced concrete buildings affecting safety and quality were identified, unresolved problems affecting the efficiency of construction processes were identified. These data allow us to conclude that it is necessary to develop new methods to improve the organizational and technological reliability of the construction of monolithic reinforced concrete buildings.

The research work under consideration is devoted to the development and formation of organizational and technological solutions, thanks to which it is possible to avoid an increase in construction time due to certain violations and to increase the OTR of the construction of monolithic reinforced concrete buildings.

The scientific hypothesis of the research work is the possibility of improving the quality of the organization and efficiency of the functioning of production processes in construction on the basis of increasing the organizational and technological reliability of the construction of monolithic reinforced concrete buildings.

Table 1: *The distribution of demand violations in percentages identified by representatives of construction organizations during construction expertise.*

Detection (non-compliance) of a demand violation	**The value of the discrepancy as a percentage**	**Accumulated percentage**
When performing concrete works	30%	30%
When performing reinforcement work	27%	57%
When performing earthworks	22%	79%
When performing mold work	11%	89%
When performing pile work	7%	96%
When performing preparatory work	3%	99%
When performing other work	1%	100%
Total:	**100%**	

As can be seen from Table 1., about 80 percent of discrepancies occur with 20 percent of the reasons that significantly improve the quality and efficiency of construction using monolithic reinforced concrete technologies.

In this case, the 80/20 rule shows that the result is mainly affected by :

- violations when performing concrete work, including when performing monolithic concrete work in winter;
- violations during the performance of reinforcement work;
- violations when performing earthworks.

The largest number of deviations identified in the construction control was revealed during the organization and production of concrete works. As a rule, the concreting stage, which includes control of access of materials to the process of pouring concrete mixture and preparation of equipment, has the longest duration of all other related work. Violations detected at the concreting stage can significantly increase the overall construction period. Thus, the elimination of the causes

of violations and inconsistencies identified during the performance of concrete works will improve the quality and organization of construction work from monolithic reinforced concrete as a whole [3].

The material for constructing the Pareto diagram (Fig.1) is systematized by the nature of violations by groups within the framework of the main technological stages of work. The following groups of violations should be taken into account:

-inconsistencies in the control of primary permits;

- inconsistencies during access control to working documentation;

- inconsistencies in the quality control of the maintenance of executive documentation;

- inconsistencies in the input control of materials, structures and equipment entering the facility;

- non-compliance with the requirements of the organization of construction production;

- non-compliance with the requirements of the project documentation;

-inconsistency of organizational and legal norms, occupational safety and health, fire safety requirements, sanitary and epidemiological requirements and environmental protection requirements;

- inconsistencies during laboratory tests.

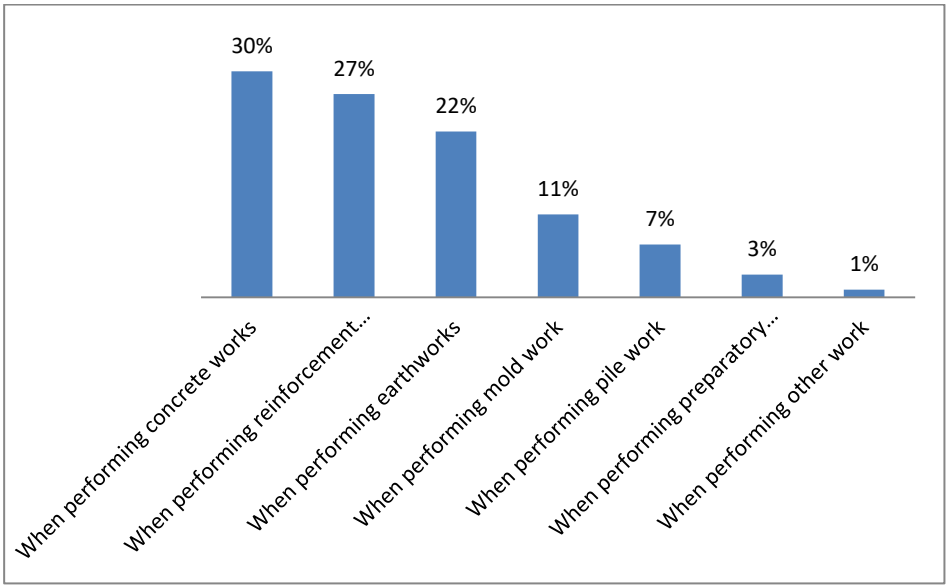

Figure 1: *Pareto diagram*

But the combination of various reasons for the formation of deviations can lead to a complete or partial failure of the production system. Therefore, in order to identify the root causes of failures in the production system, it is necessary to quantify the degree of their impact on the organizational and technological reliability of monolithic construction. According to the assessment of construction reliability indicators, we classify the main types of inconsistencies and failures of the production system according to the degree of their impact on the operational condition of the facility.

3.2. Methods for determining the reliability of the construction of high-rise monolithic reinforced concrete buildings.

The reliability of construction production can be considered as the reliability of the results of activity, the ability of an object to keep all parameters within specified limits in terms of time. Thus, reliability in construction is a complex characteristic that depends on the quantity and

quality of the components of the construction process and production units, their relationship, the tendency to failures and the ability to correct them. The reliability of construction production combines the following indicators: continuity, durability, maintainability and storage capability.

Continuity is the property of an object to maintain its operability continuously for a certain period of time and throughout the entire period of operation. The probability of continuous operation is the probability that there will not be a break in the operation of the system in a given period of time.

Durability is the property of an object to maintain a state of operability until the final state is reached in the installed maintenance and repair system. Durability is laid down during design, provided during production and maintained during operation.

Maintainability is the property of an object to remain in a state of operability through maintenance and repair and suitability for restoration of operability.

Storage capacity is the property of an object to keep within specified limits the values of parameters characterizing its ability to perform the necessary functions during and after storage or transportation

The construction of high-rise monolithic reinforced concrete buildings is a complex production system consisting of numerous interconnections and elements. In accordance with this, the determination of the reliability of the construction of monolithic reinforced concrete buildings comes from a comprehensive assessment of the reliability indicators of all elements of the construction process. The process of erecting buildings or structures using monolithic reinforced concrete technology is characterized by the life cycle of the object and consists of several stages: design, manufacture, operation. Figure 2 schematically shows the organizational and technological reliability of monolithic reinforced concrete construction, taking into account its forming factors.

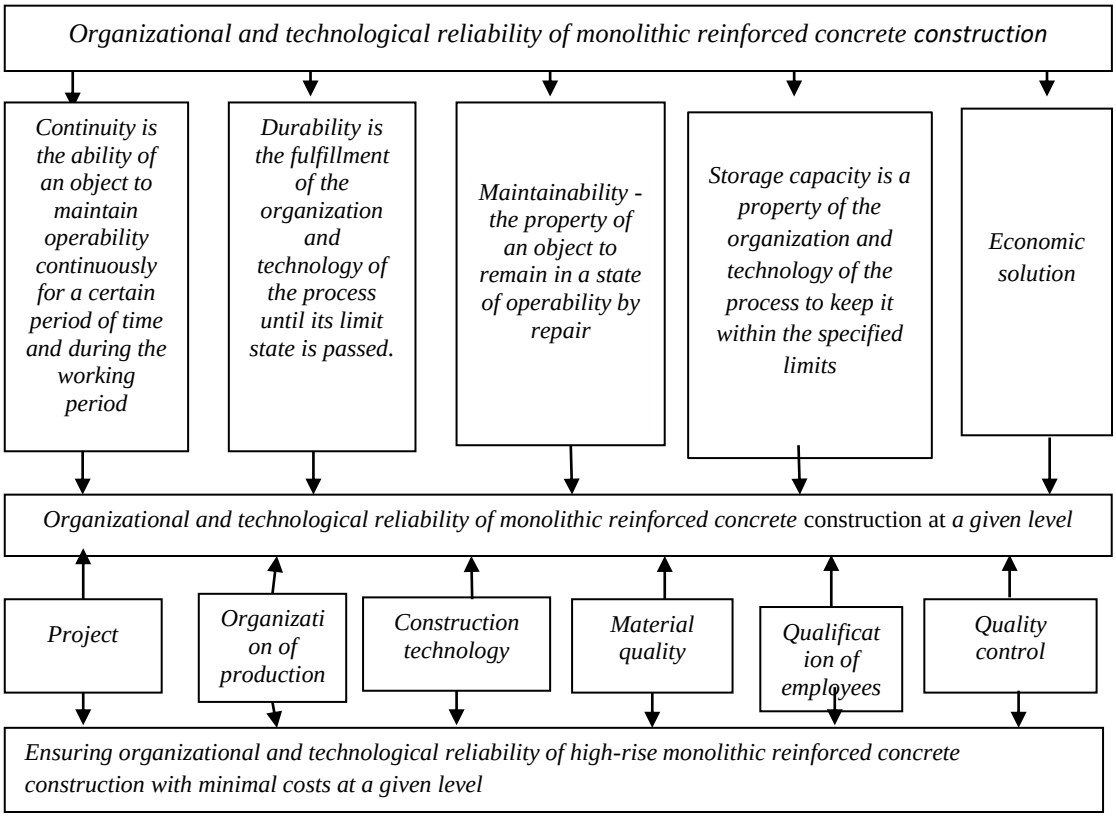

Figure 2: *Organizational and technological reliability of the construction of monolithic reinforced concrete buildings*

The features of monolithic reinforced concrete construction consist in the relationship of reliability, technology and organization of work of OTR in a timely manner and with a given quality of work project development, as well as quality control of materials and work at all stages of the life cycle of a construction object [4]. The task of OTR is to significantly reduce the cost of operating the facility and maximize the compliance of the production system with the reliability level set in the project.

The description under consideration allows us to understand that each stage of the object's life cycle affects the reliability of monolithic reinforced concrete construction. At the same time, the object itself may be in one of several states during the life cycle (serviceable, faulty, inoperable, inactive, extreme, defensive, dangerous). The transition of an object from one state to another occurs as a result of defects, injuries and failures, restorations and repairs.

A defect is a phenomenon of violation of the serviceable condition of an object.

Damage is a defect in which an object is in a faulty state, but at the same time is able to perform certain functions.

A break is an event associated with a malfunction of the object [6]. In order for the construction object to be in working condition, it is necessary to eliminate defects, damages and ruptures of the production system in a timely manner, while the values of all parameters comply with the requirements of regulatory and technical documentation. To do this, it is necessary to determine the factors that have a greater impact on the functional state of the object.[7]. Earlier, we found that the reliability of the facility is disrupted as a result of interruptions.

The failure of the production system is considered as events that occur under the influence of many random factors. Quantitative indicators of random events are based on a probabilistic measure and are determined statistically. The construction of monolithic reinforced concrete buildings is a complex probabilistic system in which it is impossible to take into account in advance all the circumstances affecting the functioning of the technological process. When erecting a building, the construction time, estimated cost, labor intensity, etc. are taken into account. such indicators as may be possible as a result of the influence of random factors, therefore they should be characterized by distributions reflecting the probability of achieving the projected number of these indicators [2]. This requirement fully applies to the construction of monolithic reinforced concrete buildings within certain limits and depends on the likely change in the initial data (design decisions) and the influence of external conditions (construction and operation processes, both internal and external influences). Based on the study of a large set of random events, collecting data on violations and interruptions of a typical production system, it is possible to conduct a systematic analysis and identify the most significant factors that ensure the reliability of the construction of monolithic reinforced concrete buildings.

A quantitative assessment of reliability is the probability of an object performing its functions. The assessment of the organizational and technological reliability of the construction of monolithic reinforced concrete buildings is possible due to the assessment of the probability of fulfilling the construction goal, that is, the successful implementation of the construction project on time within the established budget with the necessary quality. Changes in the established deadlines, cost and quality of the construction object are more influenced by violations identified at the production stage [8,9]. Thus, it is necessary to analyze in more detail the factors that form the reliability of monolithic construction, using the methods of probability theory and mathematical statistics.

IV. Discussion

In the production process of construction of high-rise monolithic reinforced concrete buildings, deviations are influenced by the following group of factors: technological, technical, organizational, climatic, social. The influence of external and internal random factors leads to the

fact that the course of the production process goes beyond the previously planned factors. In this regard, the management system should develop (B) and implement (P) measures that exclude negative deviations and ensure that the control object achieves the desired result.

The ability to perform these actions at this level of the management system p determines the reliability of the functioning of the management system p (U)considered at the management level U:

$$p(U) = p(B, P). \quad (1)$$

The solution of the reliability problem according to this formula consists in the development and implementation of measures (plans, organizational and managerial decisions) that ensure the achievement of the result set by the management object.

As is known in probability theory, there is a probability multiplication rule, which for dependent events states: the probability of two events occurring together is equal to the conditional probability of the second event calculated from the probability of the first event. Analyzing this rule, it is possible to interpret with the utmost certainty the interaction between the subsystem of solution development and the subsystem of their implementation.

Then the expression can be expressed as follows:

$$p(U) = p(B,P) = p(B) \times pB(P), \quad (2)$$

where p(B) is the probability of developing solutions that ensure the achievement of a certain goal of the system; pB(P) is the probability of the system implementing the developed solutions to achieve a certain goal of the system.

It follows from expression (2) that the possibility of developing solutions and the possibility of their implementation can be considered separately. This result defines two directions in the practice of solving the problem of reliability: consideration of the reliability of the development of solutions and ensuring the reliability of the functioning of the system in the process of implementing solutions

V. Practical Importance

The results of the study can be applied in the activities of enterprises engaged in the construction of high-rise monolithic reinforced concrete buildings. It can also be successfully used by contractors engaged in the construction of high-rise monolithic reinforced concrete buildings to reduce production risks, increase organizational and technological reliability, improve the quality of construction products, effective management and the development of promising concepts. It is also possible to ensure the creation of a cheap construction product in the construction market.

VI. Conclusions

1. Evaluation of the construction of high-rise monolithic reinforced concrete buildings is possible on the basis of the theory of organizational and technological reliability (OTR).
2. It is possible to increase the manufacturability, efficiency and quality of production processes by increasing the organizational and technological reliability of monolithic reinforced concrete construction.
3. To develop an effective system of technical support for the construction of high-rise monolithic reinforced concrete buildings, such organizational and technological models as the construction organization project (COP) and the work production project (WPP) should be used.
4. As a result of the analysis, it was found that changes in terms of time, cost and quality, which is the main criterion of quality of OTR, are more influenced by violations identified at the production stage.
5. The conducted analyses led to the development of a modern methodology for operational

assessment and management of organizational and technological reliability of the construction of high-rise monolithic reinforced concrete buildings.

6. The conducted analyses require the development of a modern methodology for operational assessment and management of organizational and technological reliability of the construction of high-rise monolithic reinforced concrete buildings.

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