Risk management in monolithic construction

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Abstract. Current statistics with regard to the impact of various random factors on the condition of structural units, building elements and structures clearly indicate a number of problems associated with construction safety in general. Prevention of typical frequent accidents requires that methodological recommendations are in place to control or mitigate risks. Risk management in construction operations is to a large extent focused on the relative safety concept. The main tasks are integrated risk assessment, minimization, identification, and analysis, as well as the development and substantiation of managerial solutions. A vital issue reviewed herein is the problem of insufficient use of the risk management system by building companies. This article identifies the main directions of assessing risk events and the degree of damage in construction projects. Analytical research findings have led to a conclusion on the need for development of risk assessment methods to be applied in the organization of construction operations.

1. Introduction
The issues of safety and quality management systems have received much attention from various scholars [1-4]. In particular, this problem has been reflected in the works by V.N.Telichenko, M.Yu. Slesarev, A.Kh. Baiburin et al. However, it requires an integrated approach, because construction accident statistics [5-7] point out that strict control of compliance with regulations is not the main solution.

First, it is necessary to define a risk and the degree of its impact on operations performed by building companies. Risks can be both positive in the form of new opportunities arising from activities of an organization and negative (unfavorable consequences and threats). Risks combine the probability of occurrence of results and their impacts. Thus, risks represent a qualitative assessment of a hazard emanating from a certain process. The negative result of risks is the probability of inflicting damage to human life and health or to the environment and fauna, including the expected levels of negative consequences during a certain period (expected damage, the probability of accidents with certain consequences). Ensuring construction project safety requires an analysis of risk events in the construction industry and an assessment of the technical condition of projects. Accordingly, risks can be assessed proceeding from the potential extent of damage, the probability of a risk event, the time of its occurrence, and additional circumstances.
2. Research methodology
The probability of an accident is determined as a product of the probability of triggering events (causes of an accident) and the probability of collapse of structural units at the occurrence of these events. The probability of collapse depends on the initial strength of the building, i.e. its failure-free properties ensured in the course of construction. Risk assessment is associated with the hazard level of the products determined by severity of damage. The overall risk assessment process in accordance with these methods includes the following main stages:

- Determination of the range of products or the system to be assessed;
- Identification of inherent hazards in these products;
- Determination of products assessed in terms of conformity;
- Determination of the quantity of products that fail to meet the established requirements (products with hazardous deviations);
- Determination of the probability of inflicting damage to human life or health, property, or the environment (quantity of products with hazardous deviations / total quantity of tested products);
- Expert (professional) assessment of severity of consequences caused by products with hazardous deviations from the norm;
- Quantitative assessment of the risk of operation of these monolithic reinforced concrete structural units (frequency of manufacturing of products with hazardous deviations from the norm, severity of consequences of the use of such products);
- Risk assessment procedure and determination of the conformity assessment form.
- It is appropriate to use integrated methods of risk event assessment in the development of a complete and efficient set of measures of tackling problems associated with emerging risks. For this purpose, the choice of methods should be substantiated in terms of applicability and suitability.

Accordingly, two practical directions of construction risk assessment should be identified [8]:
- Risk level assessment at the design level;
- Verification assessment with measurements and calculations in the course of construction works.

The first direction of assessment enables an early optimization of construction operations and reduction of the overall costs at the design stage of construction works. The second direction makes it possible to assess the current risk level of a construction project on a real time basis with introduction and exclusion of individual engineering processes and operations.

Coordination of all technological processes, individual operations, transportation and warehousing of materials, etc., leads to higher efficiency characteristics of the construction project in general and lower qualitative and quantitative indicators of risks. Risks of viability and operations of a construction project can be generally assessed in quantitative terms by analysing individual risks and reviewing their quantitative characteristics. Findings of this analysis will enable ranking of construction operations by risk exposure, elaboration of construction site optimization schemes with account of risk exposure, and rational development of process engineering documents with reference to the layout of engineering and auxiliary equipment.

In light of the importance of the safety issue, it becomes vital to develop methods allowing an assessment of risks of construction of monolithic reinforced concrete structures. There are tolerable hazard rates established scientifically and empirically. Determination of potential and acceptable risks requires information about the frequency of occurrence and severity of consequences of this type of risk events. For this purpose, it is necessary to identify, firstly, the limit states of nonconforming products, parts or elements of a product and, secondly, any states outside the established safety levels. However, the latter is quite difficult to determine and properly identify in a statistical way [9]. At present, this problem can be solved by risk management. Its main tasks are identification, assessment, analysis and management of risk situations in the course of the life cycle of a product. Risk
management can be of assistance in forecasting the future of a business, evaluating the process of its development, and analysing the past and the present of the project under review [1]. The regulatory technical base for assessing risks of products currently includes the following documents: State Standard 17666, State Standard 51897, State Standard 17776, State Standard 51901, State Standard 61160, etc. However, they are not actually used in construction operations. In this connection, it seems expedient to develop, on this information basis, industry-specific methods of assessing product risks, including those in monolithic construction. The main difficulty in practical implementation of risk assessment is obtaining the required input data.

All the aforesaid necessitates the creation of an operational system of collecting and processing information about manifestation of hazards and gravity of their consequences, as well as the generation of organizational and methodological documents based on the risk management system for assessing the collected information. It is proposed in this study to develop algorithms of addressing the management tasks for organization of construction supervision with account of potential risks of collapse of structural units and occurrence of certain types of defects and violations. In addition, it is necessary to build a mathematical model of the business process of organization and management of construction supervision. It also includes the development of methods of decision-making in the event of nonconformities in the process of organization of construction supervision. The following forms of expert analysis and risk assessment have been developed for implementation of these methods:

- Questionnaire form;
- Summary table form for risk event assessment and analysis;
- Table of frequency levels of occurrence of hazards;
- Gravity category scaling table for consequences of hazards;
- Rules of comparing risk situations.

In the proposed method, the analysis of potential risks includes three automated blocks:

1. Identification of potential risk. The analysis is based on a systematic analysis of the received input data and expert assessments.
2. Qualitative and quantitative risk analysis. It allows you to use a mathematical tool to identify the most likely risks to implement, as well as the risks that can cause the most significant damage.
3. Planning the response to identified risks. A list of recommendations is formed for the decision-maker, which aspects of the project under consideration should be paid attention to and how.

Execution of the selected risk management stage. This section includes the choice of methods for managing risk in practice and implementing it in practice.

Monitoring results. The block assumes feedback from the decision-maker: from the occurrence/non-occurrence of the considered risks to the effect that the implemented risk event had.

Potential risk identification involves identifying a risk event specific to the construction project under consideration [10-11].

Qualitative risk analysis includes an analysis of the sources and causes of the risk, at what stages of work it can be implemented, what consequences may follow from the implementation of this risk event, as well as an assessment of the effect that this risk may have on the groups of its influence.

Management planning involves selecting a method of exposure to the identified risk in order to reduce its effect.

Algorithm for quantitative analysis of identified potential risks of a construction project.

After identification of potential risk events, as well as qualitative analysis of identified risks, the methodology includes a quantitative analysis of identified potential risks, the purpose of which is to determine the probability of occurrence of the considered risk, as well as to assess the effect that its implementation can have.

To rank risks, we propose a method based on the risk significance Index, calculated based on the collected expert assessments of the professional community conducted in the framework of the study.
The risk significance index allows you to identify the most dangerous risk events, since its calculation involves taking into account such combinations as:

- the most likely risk is the greatest impact on the object
- the most likely risk is the average level of influence on the object
- the most likely risk is a small impact on the object
- Formation of recommendations for management of identified risk events.

The proposed methodology assumes that the collected estimates will be constantly updated by receiving "feedback" from the person making the decision to implement a particular risk event.

Improving the organizational and technological reliability of the construction organization is achieved by:

- Advance provision of special measures to manage potential risks of various organizational and technological subsystems of construction: preparation of construction, design, scheduling, logistics, organization of logistics, construction control;
- Formation of effective practices for managing the construction organization in the field of risks using an automated system;
- Creating a comprehensive understanding of the project's weaknesses (contractors, subcontractors, workers, designers, etc.).

Special measures to manage potential risks of organizational and technological subsystems, depending on the identified risk event, include the selection of an additional contractor, supplier, work with working personnel, organization of special motivational programs for engineers and workers, as well as the formation of requirements for the design process and calendar planning.

The method includes the following steps:

- creating a "potential risk report" for the decision-maker based on potential risk analysis;
- formation of recommendations (methods) for risk management and implementation of the proposed management methods in practice.

The proposed method is implemented using a developed automated information system that allows self-improvement of recommendations for managing potential risks by filling out a feedback questionnaire: after completion of construction, the decision-maker answers the questions of the information system, entering data on risks realized during construction with high, medium and low risk significance index, on the management methods used, on the impact of implemented risk events based on the organizational and technological reliability of the project: construction schedule, logistics, terms and cost of construction.

The authors believe that the proposed methods will improve business continuity of building companies at the market, as its ultimate objective will be reducing the probability of a risk event and the damage caused by it.

3. Conclusions
The effectiveness of the proposed methods was calculated as follows:

- the number of "white" spots of the project, elapsed time and financial resources to analyze the methods: comparing the number of considered risk/time/financial resources "before" and "after" application of methods of analysis and risk management;
- effect on the rate of organizational and technological reliability of construction production index in relation to yourself "before" and "after" application techniques.
- During the implementation of the methodology within the company, work was carried out on:
  - Filling out the Developer's form;
  - Filling out the contractor's form;
  - Filling out the project form;
  - Creating a final report for the Company's management with suggestions for managing identified potential risks.

The report for the company's management contained 3 sections:
1. Report on resources spent (time and full name of employees who performed the analysis and report generation)
2. Graphical representation of the most significant risk events of the analysed project
3. List of suggestions for managing significant risk events.

As part of the automatic operation of the system, the following was performed:

- Assigning increasing coefficients for risks that are characterized by extreme values of the corresponding indicators when entering input data
- Exclusion of risks that are not inherent to the object under consideration (risk sources are not used/planned in the project. For example, the object under consideration does not provide for international certification, which means that the block of risks associated with this procedure is excluded).
- Forming a matrix of potential risk events specific to the project under consideration
- Calculating the significance index for each identified risk (qualitative and quantitative analysis)
- Forming a matrix of the most likely and significant potential risk events.

These methods can be used by analysts and risk managers, customer companies, customer engineering supervision services, building laboratories, etc., and also by students, graduate students and postgraduate students of higher educational establishments in the study of impacts of various defects on finished monolithic reinforced concrete structural units. The proposed model is applicable, because it does not conflict with the generally accepted standards, but only makes the standard organizational and technological supervision scheme more stringent.

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