Problems of the model of managing the integrated risk assessment for humans and environment in construction activities

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Abstract. The article discusses the risk assessment methods, the influence of safety threats on the occurrence and likelihood of risks, the difficulties encountered before risk assessment, raises issues of planning and extent of the construction entity's influence on risk assessment and construction protection. Particular attention is paid to the processing of results and analysis of threat assessment. An assumption is made that planning can be used as a risk assessment tool, and a way of using this tool to protect against emerging threats is suggested.

1 Introduction

Construction activity is one of those industries where risk assessment is described as a precognition of possible risks, assessment of their influence on the activity and development of necessary measures to mitigate the consequences.

The establishment of the acceptable safety and risk levels requires for a scientific analysis of social, economic, environmental, demographic, anthropogenic and other factors that determine the development of society, taking into account the links of interdependencies. Assessing the risks of construction activities will always be relevant, since the risks directly associated with construction impose internal threats, which the President of the Russian Federation speaks of in the Strategy of national security [1-3].

2 Materials and Methods

For a forward-looking and more complete assessment of the risk to humans and the environment with the task of identifying the patterns of the socio-economic system "reaction" to the influence of negative impacts on engineering and geological construction, it is necessary to:

- identify negative impacts;
- characterize and assess the identified impacts;
- estimate the expected damage with an adjustment for its likelihood;
- assess the effect of taking measures to counter the influence of risks and threats on engineering and geological construction.

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Identification of negative impacts that fall within the competence of the construction management system is a problem yet to be solved methodologically. Most of the sources suggest a classification of threats or, more rarely, risks; even fewer sources contain methodological developments in assessing negative impacts, and there is virtually no research on their identification. In all fairness, there are studies on the identification of threats and risks, but such studies often cannot be put into practice without assessing the current situation of the object under study. Such an assessment is one of the steps in the algorithm for assessing negative impacts. The amount of risk and threats is rightfully considered to be dependent on the system under consideration and on their functional influence. Thus, the functional influence is considered, in fact, through the identification of the type (sort, class) that a particular negative impact should be attributed to. The methods appropriate for identifying threats and predicting the consequences include monitoring of risk assessment indicators, expert assessment, scenario analysis and handling, multivariate statistical analysis, optimization method, situation analysis, etc. It should be noted that a simple description of methods without argumentation for the rationality of their use can hardly be considered a methodological tool for detecting or identifying negative impacts. The uncertainty of the outcomes of the negative impacts development justifies the use of probability theory methods for their identification. The methodological apparatus of probability theory has been developed and adapted to solve a wide range of problems with an uncertain outcome, including objects of both socio-economic and natural origin, an assessment of the risk to humans and the environment from natural disasters such as earthquakes, landslides, funnels, soil liquefaction, debris streams and rockfalls among them. At the same time, methods of risk assessment for humans and the environment do not fully use the scientific mathematical tools. Incomplete application of methods of probability theory in solving development problems is determined by:

a) at the methodological level:

– the complexity of modeling the real assessments of processes risk for humans and the environment and modeling the relationships of the internal and external environment;

– the difficulty for managers to understand the existing models of estimating uncertain outcomes, and, consequently, distrust of results and / or inability to use results in practice;

b) at the organizational level:

– the absence of regulations obliging management to identify and quantify negative impacts;

– the absence at the administrative level of a safety policy with clearly defined interests of the construction management entities;

– the absence or insufficient organization of the activities in the executive authorities to monitor the occurrence and development of negative impacts.

3 Results

To overcome the limitations of a methodological nature, it is necessary to offer a method for assessing negative impacts that, on the one hand, would be simple enough, on the other hand, would allow identifying impacts that are relevant to the processes risk assessment for humans and the environment. For the purposes of controlling the system under the influence of negative impacts, the quantification of the likelihood of damage is of particular importance. To solve this problem, let us use the apparatus of probability theory. Let Ω be a finite probability space of negative impacts on the risk assessment for humans and the environment:

$$\Omega = \{\omega 1, \omega 2, \ldots, \omega n\} \quad (1)$$

Each new negative impact determined in assessing the situation we associate with a nonnegative number $P(\omega k)$, which is the probability of the actual influence of the negative impact, that is, the probability of damage. With that said, the numbers must add up to one.

$$P(\omega 1) + P(\omega 2) + \ldots + P(\omega n) = 1 \quad (2)$$

This expression reflects the effect of the combined influence of negative impacts on the management system under assessment, which increases the reliability of the described model in respect to the real conditions of the construction organization at the occurrence of a risk to humans and the environment from natural disasters.

Let us now consider the events A, being damage caused to the system, which depends on the fact that "ωi and / or ωj, ..., and / or ωk occurs". If the outcomes are favorable for causing damage A, then by definition the probability of event A will be equal to the sum of the probabilities of the outcomes favorable to it:

$$P(A) = P(\omega i) + P(\omega j) + \ldots + P(\omega k) \quad (3)$$

Assuming that all elementary outcomes are equally probable, that is,

$$P(\omega 1) = P(\omega 2) = \ldots = P(\omega n) \quad (4)$$

we obtain the following

$$P(\omega 1) = P(\omega 2) = \ldots = P(\omega n) = 1/n \quad (5)$$

Then for the event A = {ωi, ωj, ..., ωk}, according to (3), we have

$$P(A)=k/n \quad (6)$$

When assessing the risk to humans and the environment from natural disasters during the activity of a construction organization, a threat of an occurrence of an accident is formed, this accident implying the following events:

1) earthquake (with a possibility of causing fatal damage);
2) landslide (with a possibility of causing fatal damage);
3) funnel (without a possibility of causing fatal damage, but with a possibility of causing collateral damage);
4) soil liquefaction (without a possibility of causing fatal damage, but with a possibility of causing collateral damage);
5) debris streams (without a possibility of causing fatal damage, but with a possibility of causing collateral damage);
6) rockfalls (without a possibility of causing fatal damage, but with a possibility of causing collateral damage).

We assume that all possible outcomes are equally probable. It is required to identify the negative impact and thus to find out the likelihood of damage from the occurrence of this event.

4 Discussion

Applying the proposed method to identifying negative impacts at the level of risk assessment management is difficult because of the need to create an accurate list of all possible risks and make an assumption that they are equally probable. For the purposes of the safety management, it is necessary to minimize the influence of threats, that is, at least not to allow risks to escalate into threats. At the same time, many negative impacts in the phase of risks are difficult to control, or, most often, even impossible. Therefore, it seems reasonable to control the risks with greater probability of causing damage. For this purpose it is necessary to detail the selected phases by introducing additional control elements. The list of events that are a consequence of the emerged negative impact is possible to be formed when using expert assessment methods. These methods are used due to the high degree of uncertainty of events, to the large number of factors affecting them and to the multiplicative effect. Among the variety of the consequences, the researcher needs to determine those having the closest connection with the phenomenon under study. It is equally important to determine the level of consequences, that is, to choose the consequences of the 1st, 2nd or ... level.

The problem of safety assurance is not limited to and not based only on identifying negative impacts. For construction management, the solution of additional problems is crucial, these problems including, in particular:

1) since the potentially negative impact may escalate from the risk phase into the phase of threats, the prevention of the transition and timely decision-making requires for controlling the possibility of such a transition;

2) in the absence or insufficiency of information on the trends in the influence of a number of negative impacts, the adoption of preventive measures requires for the determination of the possibility of causing damage under the combined influence of negative impacts on the protected system.

To solve the first problem, we denote negative impacts of the risk phase by β and the ones of the threat phase by ά. The event β represents a formation of risk, which is capable of escalating into a threat represented by event ά. Formation of any risk is caused by risk-forming factors, and only m out of the set of factors N are conditions for risk formation. Let β be determined to have occurred. This means that one of the m outcomes forming β has come. We denote the probability of the transition of the risk β to the phase ά by P(ά/β). Those outcomes that favor both ά and β are denoted by the symbol k. It is clear from the above that there is a probabilistic problem requiring for the concept of conditional probability to solve it. In this case, the conditional probability of the transition of risk into the threat phase will be considered as the ratio of the number of outcomes that favor both ά and β to the number of all outcomes that favor β, hence

$$P(ά/\beta)=k/m \tag{6}$$

In fact, the emergence of a risk is facilitated by certain factors and threats (such as incorrect choice of the construction site, poor design of the logistics routes map, etc.). Therefore, the organization needs to take measures to improve the quality of control of those activities in the organization that have allowed such threats to emerge. To apply the proposed method, the entity should possess system knowledge, which includes but is not limited to the knowledge of the socio-economic situation in general. With that said, as the analysis shows, the investigated object does not include divisions that would constantly monitor the dynamics of the formation of negative impacts in the internal and external environment; moreover, the present-day system of professional education often does not provide training for performing this work.

To solve the second problem, we use the concept of total probability.

Let the system be affected by the negative impacts of the risk phase H1, H2, ..., Hn, which form a complete group of unrelated negative impacts. Upon the occurrence of each of them, for example Hi, the damage A can occur with a conditional probability P(A/Hi), which is caused by the transition of negative impacts from the risk phase to the threat phase.

To find the probability of causing damage A, we can use the addition theorem of probability. Since the negative effects of H1, H2, ..., Hn are mutually exclusive,

$$P(A)=\sum_{(i=1)}^{n} 〚P(Hi)\ P(A/Hi)〛 \tag{7}$$

The economic system is affected by the risks of probability, which are identified using the risk assessment method. The escalation of risks into threats is calculated using the method of assessing the negative impact in the phase of threats. The combined negative impacts are in the phase of threats, but at the stage of threat-forming factors; therefore, to ensure safety, the control system requires the earmark of resources to counteract the impact only of H1 risk. The influence of negative impacts predetermines the need for protection, that is, for mobilization of the economic potential to ensure the state which would be considered as safe.

Many methods are proposed for assessing damage, the essence of these methods being either the identification of losses of direct or indirect cost, or the identification of additional expenses with the option value. In the context of safety, direct losses are reflected in a reduction in construction funds allocated to safety. An option value should be understood as the amount of additional budget expenditures of the organization or the construction itself to ensure the reference requirements under the active influence of risks and threats on the system.

The stated problems of risk assessment in such a wide field as construction predetermine the need to investigate the interaction between the main components of the construction planning, i.e. strategic and tactical planning, the effectiveness of such investigation predetermining the effectiveness of risk assessment.

Solving the problems of risk assessment implies transformation of the approach to the interaction of strategic and tactical planning basing on changes in the targeted priorities.

At present, the main indicator of the risk assessment effectiveness is the maximization of users ready to provide an accurate and comprehensive solution of the problem given, and the means to achieve such effectiveness is monitoring of risk assessment indicators, expert assessment, analysis and scenario handling, multivariate statistical analysis, optimization method, situation analysis, etc. These methods of analysis are reflected in the formulation of strategic objectives of construction. However, increasing the use of materials for assessment and the analysis of incoming research results does not yet indicate a satisfactory risk assessment and may lead to losses due to the lack of measures to protect the enterprise from threats. In this regard, the decision to start construction activities and to invest in processes allowing to accelerate the necessary impacts or just to make them should be based on an assessment of the level of threats, that is, on the formation of a single space of internal planning objectives, which should be implemented within the purposes of managing the level of risk assessment.

All of the foregoing causes the urgency of the problem of risk assessment at the planning stage and its practical significance. When assessing the risks of construction activities, it is necessary to take into account a large number of facts and factors that not only affect the final solution, but also provide an accurate estimate of how the built object would behave in a given situation.

5 Conclusions

A discussion of how a construction organization can and should protect its property may take long, but the main thing is that this protection must be present and the following conditions must be met:

- clear and strict compliance with the law;
- knowledge of the market of competitors and counterparties;
- preliminary risk assessment of the analogues of construction sites;
- exact compliance with deadlines for risk and threat assessment operations.

1. The construction entity should know exactly where its prepared or planned object will be exposed to threats and risks. A new challenge, new solutions, especially in such a field of knowledge as construction, not always imply something unknown and newly created. Often, builders use ready-made modules to solve the day-to-day tasks, and for crucial problems they use their own vision of the solution.

2. The construction entity should not defer the assessment of the risks and threats that will protect its property. The assessment can be started as soon as the necessary documents are prepared and the calculations are made. This situation requires for immediate actions because new challenges, threats and dangers can appear at any time, and quite often do appear, and underestimation or late assessment will not be of use, still taking money for its implementation.

3. The construction entity itself can and must prepare measures and solutions that will not allow any threat to act effectively and without the knowledge of the entity. The construction entity should not only prepare the ground for the future development of its construction, but also leave excess strength to protect against future threats.

References

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