Production Risks Assessment as a Method of Construction Industry Safety Management

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Abstract The dynamics of occupational injuries with fatal consequences in Ukraine was considered in the article. The main reasons that significantly affect the injuries level in the construction industry and in the construction materials industry have been identified and analyzed. The results of the production process factors comprehensive survey, which allow to assess the safety state, provide a basis for the analysis of working conditions and the operational management actions development in the construction industry and in the building materials production industry were considered. The concept of risk, main stages, methods and criteria of risk assessment are defined. The main activity directions of state and branch management bodies on reduction of risks occurrence are also recommended. It is explained in detail why risk assessment as the safety management method of technological processes and production, and as a means of practical measures implementation of industrial hazards prevention or reduction should be part of a systematic approach to the labor process implementation.

Keywords Construction industry · Occupational safety · Production risks · Production traumatism · Risk assessment

1 Introduction

The construction industry is one of the most promising and profitable economic activities, but at the same time – problematic and dangerous. Analyzing the circumstances and causes of the construction site accidents, it was established that the

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main accidents causes at work are organizational, technical and psychophysiological causes. Organizational causes predominate among the fatal accidents causes (58, 7%). That is, employees ignore the requirements of labor protection instructions and job descriptions; violate the rules of safety and technological process. The second place in the anti-rating (26.4%) is occupied by psychophysical, man-made, natural, environmental and social causes. In third place – technical causes (14.9%) [1–3]. But it is impossible to improve the activity conditions, to increase security with the help of organizational measures alone. Certain technical measures are required. Mistakes of various kinds can cost lives, deteriorate health, and cause significant material loss. Absolute safety cannot be achieved in practice, there is always some excess risk.

Risk is a measure of expected failure, failure to act, the adverse effects risk on human health; certain phenomena that are accompanied by possible material losses. Risk is characterized by surprise, the sudden onset of a dangerous situation, which involves rapid and decisive action to eliminate or reduce the danger source impact. The risk concept combines two elements: the frequency (probability) with which a dangerous event occurs and the adverse effects consequences.

In the article, the construction industry and the construction materials industry are considered as industries in the traditional definition. The construction industry includes enterprises and companies engaged in activities related to the design, construction and operation of buildings and structures. Production risks inherent in the enterprises activities in the construction industry and the construction materials production, are determined primarily by the content of these activities. Analysis and assessment of occupational injuries are necessary conditions for the successful operation of any system, including – labor protection. Based on the dynamics, it is possible to judge to what extent the state of the system has become better or worse compared to the base period, to assess the implementation of targets and management effectiveness for the possibility of preventive measures planning. This can be done only on the basis of targets and criteria set, their numerical evaluation and comparison with set or baseline values. The determination problem of the objective quantitative indicators that characterize the labor protection state (level), production safety or hazard, the human–environment system reliability, is relevant and specific to each enterprise. However, there must be common approaches to solving it.

Risk assessment as a safety management method of technological processes and production, and as a means of practical measures implementation to prevent or reduce industrial hazards should be part of a systematic approach to the labor process implementation. With regard to practical application, it should be noted that the methodological apparatus of risk analysis and assessment is already used in various areas of economic activity. The idea of the article is to use the developed comprehensive criteria that take into account harmful production factors; justify the funds allocation to reduce occupational injuries to improve formation and evaluation methods of socio-economic measures effectiveness to improve working conditions.

2 Formulation of the Problem

The accident risks analysis and assessment methodology at the objects of the construction industry and the construction materials industry is actively developing. Therefore, the development of new and improvement of existing approaches, models and methods of accidents risk assessment, their computer implementation remains an urgent task for our state. Determination of accident risk assessment should be based on the monitoring results of the potentially dangerous objects technical condition, statistics on man-made nature accidents and emergencies, dangerous geological and hydrometeorological processes comprehensive monitoring, the natural complexes state, as well as relevant dangerous situations modeling and their public health impact.

3 Scientific Novelty

The paper further developed the scientific task of developing an effective method of applying a risk-oriented approach to the industrial hazards assessment in the construction industry and construction materials industry.

4 Analysis of Recent Studies

Analysis of risk assessment and decision-making modern methods, in conditions of uncertainty, showed that different authors consider the term «risk» differently. Most often, the concept of risk is associated with the adverse event probability.

Defining risk as the degree of a certain adverse event probability that may occur at a certain time or under certain circumstances on the high-risk facility territory and / or outside it, is to determine the accident probability at the facility for a certain period of time, as usually for a year. A.O. Imasheva uses a static method to quantify the risk, according to which the risk criteria are the average deviation and the coefficient of variation [4].

In technical systems, reliability is the property of an object to function satisfactorily for a certain time in a given mode and use or maintenance conditions [5].

Analysis of other well-known publications [6–11, 13–17] showed that although today there are some studies in the theory and practice of risk-oriented approach usage to hazard assessment. They are not enough for practical implementation in the current occupational safety management system.

5 The Aim

The aim of this article is to improve the occupational injuries analysis methodology, taking into account the accidents risks, as well as to develop measures to reduce injuries and occupational diseases.

When analyzing the enterprise activities must take into account the risks it faces. Therefore, the main tasks include the following: the study of occupational injuries existing methods; occupational injuries methods selection and improvement; identification of traumatic factors influencing the indicators of occupational injuries; study of the production risks existing methods determination.

6 The Method

The analytical method of researches is used in the work. The methodological basis of the study is a systems approach, which is based on such principles as integrity, structure, the relationship of system and environment.

7 The Main Material and Results Presentation

Construction, in comparison with the coal, chemical, socio-cultural sphere and trade, transport, etc., belongs to one of those industries that are characterized by the risks significant number probability. In addition, an important role is given to financial risks in the construction industry. These risks arise from unforeseen changes in legislation or economy. They can have a negative impact on the results, given the investment duration and the construction process capital intensity.

Currently, risk is increasingly used to assess the negative factors impact in the building materials and products production. This is due to the fact that risk as a hazards realization quantitative characteristic can be used to assess working conditions, economic losses, the number of accidents and diseases at work, as well as to form a system of social policy at the enterprise (compensation, benefits).

Quantitative risk assessment is the values assessing process of the probability and consequences of adverse events. Hazards can be realized in the form of injuries or diseases, only if the hazards formation intersects with the human activity area. In industrial conditions, it is a work area and a source of danger (one of the industrial production elements).

In modern domestic and foreign practice to formalize the risk (R) is widely used model that links the probability (P) of a negative event A (accident, catastrophe) and the probable magnitude of possible consequences (W) as a result of this event, as shown in Eq. (1):

$$\mathrm{R(A) = P(A) \times W(A)} \tag{1}$$

The probability P (A) present in this model numerically expresses the degree of negative event A possibility realization connected with an uncertain situation. The probable magnitude of the expected consequences W (A) as a negative event A result implementation depends not only on possible losses (number of dead, injuried, material losses), but also on the object vulnerability degree to event A, determined by Eq. (2):

$$\mathrm{W(A) = V(A) \times U(A)} \tag{2}$$

Where W(A)—the probable magnitude of the event A possible consequences implementation; V(A)—the object vulnerability degree for event A; U(A)—conditional total loss as a result of the event A implementation.

Thus, substituting expression (2) in Eq. (1), it could be obtained a model for determining the risk level:

$$\mathrm{R(A) = P(A) \times V(A) \times U(A)} \tag{3}$$

Where R(A)—risk (negative event A); P(A)—the probability that there is a certain risk; V(A)—the probability that risk can be avoided; U(A)—a category that determines the risk severity.

Therefore, Eq. (3) is common to all types of risks, characterized by their risk scale. But in its practical use in each case there may be a need for additional research.

The criteria for the risk degree determining in the general case should be: legislation analysis; working hours timing; connection with regulations on dangerous equipment; connection with fire safety regulations; connection with environmental regulations; analysis of injuries and morbidity in the workplace (for the last 5 years); existing risk factors and their measurement (job-places certification data); available employee complaints; job review; poll; documentation (results of various inspections); data on the service life and technological equipment wear degree; staff qualification and motivation data. The values of P and U, according to the proposed Tables 1 and 2, can be quite objectively selected from statistics (Table 3).

Systematizing information about the work process circumstances that affect risk factors by workplaces groups with similar working conditions, it is necessary to begin risk assessment. The risk degree and action in this process determination it could be determined after the risk magnitude [12]:

- more than 100—risk reduction is mandatory. If due to lack of funds it is not possible to take preventive measures, then work in the danger zone is strictly prohibited;
- 85…100—work can be continued until the risk reduce or eliminate measures are taken. If the work cannot be interrupted, then measures (collective) must be taken within 1… 3 months;

Table 1 Failure consequences (category U)

Consequences, P	Description	Rank
No effect	Failure has no serious impact on the production process	0
Not important	Very small failure (damage), significantly does not affect safety and technological process	1
Small	Failure with short-term effect, risk of personal injury and emergencies are absent	2
Medium	Failure, that may pose a risk to personnel, requires safety precautions	4
Serious	Failure creates serious obstacles to work, damage to equipment, requires special protection and safety measures, more time is needed to eliminate	6
Very serious	The failure created a serious danger, possibly a serious injury or death	8
Catastrophic	The failure posed a serious threat to the health of a large number of people	10

Table 2 Possible failure rate (probability P)

Event, A	Description	Rank
Very seldom	Failure is almost impossible	0
Seldom	Failure can occur every 2…3 years	3
Medium frequency	Failure can occur once per year	5
Frequently	Failure can occur 2… 3 times per year	8
Very friquently	Failure can occur frequently, perhaps even 2…3 times per month	10

Table 3 Work process circumstances that affect risk factors (probability V)

Impact rank	Impact description
0,6	These circumstances, which fully affect the risk factor, can lead to a significant reduction
0,8	The impact of these work process circumstances on the risk factor is not as complete as possible and may lead to a partial reduction of risk
1,0	The impact of these work process circumstances on the risk factor is negligible
1,2	The impact of these work process circumstances on the risk factor is not as complete as possible in its intensity and may lead to a partial increase in risk
1,4	These circumstances, which fully affect the risk factor, can lead to a significant increase

- 55…85—risk reduce measures are needed, but they do not have to be implemented immediately, economic considerations must be taken into account. Measures should be taken at least 3… 5 months after the risk assessment;
- 25…55—medium risk, it is necessary to clarify security measures, set priorities;
- 0…25—low risk, the order of labor management organization and labor protection is necessary.

Injuries analysis by the events main type shows that most workers in the construction industry are deceleration injured; when collapsing objects, materials, rocks, soil; actions of objects and parts that move, rotate. Injuries are often caused by unsatisfactory technical condition of industrial facilities, buildings, structures, territory. The analysis allows to determine the main directions for the measures development to improve working conditions and reduce injuries in the construction industry and the construction materials industry. An important factor in reducing injuries is the industrial discipline introduction among workers.

Accidents unfavorable trend continuation at enterprises is an obstacle to the industry effective functioning as a whole. To overcome negative phenomena, it is required high-quality, systematic and purposeful activities of state and sectoral authorities. At the sectoral level, the following areas require implementation:

- professional selection system improvement for work with dangerous and harmful working conditions;
- restoration and ensuring the medical service effective functioning at the enterprise and occupational health supervision;
- system development and implementation for the pathologies prevention after the end of work in hazardous conditions, as well as workers transfer to workplaces that do not have harmful and dangerous production factors.

8 Conclusions

The methodology of accident risks assessment analysis at the construction site is actively developing, so the development of new and improvement of existing approaches, models and methods of accident risk assessment, computer implementation remains an urgent task for our country. Determination of accident risk assessments should be based on the monitoring results of potentially dangerous objects technical condition; statistics on accidents and emergencies of man-made nature; comprehensive monitoring of hazardous production factors; the state of natural complexes; as well as the results of modeling relevant situations and their impact on public health. The use of the risk indicator allows to compare the action of different nature dangerous factors, to determine, taking into account each individual factor contribution, the integrated degree of any industrial facility danger. The application of risk assessment methodology makes it possible to develop mechanisms and strategies for various regulatory measures to improve the safety of the construction industry; set limits on the variability of risk values and uncertainties associated with limited input or unresolved scientific problems.

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