LABOR PROTECTION

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Development of a methodology for assessing professional risks in construction

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Introduction. Construction is one of the most injury-causing industries. It is connected with a large amount of operating production factors, that are constant or present potentially, which aggravate the high level of professional risks. The need to develop a methodology on the organization and performance of work in the field of labor protection in case of installation and construction works on building sites is proved in the article and by practical organizational activities of the construction entities.

Problem Statement. The objective of this study is to develop a methodology for assessing occupational risks for construction companies.

Theoretical Part. The paper analyzes dangerous and harmful production factors that affect workers of construction organizations. The emphasis is placed on practical provision of labor protection in construction. At the same time, special attention is paid to the identification of occupational risks, their assessment and management. It is proposed to take into account statistical data on injuries in construction, the content of the construction organization project, work production projects and technological maps for the work carried out in the general assessment of occupational risk in the workplace.

Conclusions. The authors propose an effective methodology for assessing occupational risks, taking into account the specifics of construction production.

Keywords: labor protection, professional risk assessment, construction, construction organization project, project of work production, flow chart.

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Introduction. Since 2011, the concepts of "occupational risk" and "occupational risk management" have appeared in the Labor Code of the Russian Federation. The Approximate Regulation on the Occupational Safety Management System, approved by Order of the Ministry of Labor of the Russian Federation No. 776n of October 27, 2021 (Regulation on OHSAS No. 776n), states that the responsibilities for the organization of the occupational risk management procedure are assigned to the employer, which, based on the specifics of its activities, independently establishes the procedure for identifying hazards, assessing and reducing the level of occupational risks [1, 2].

With the correct assessment of occupational risks, it becomes possible to take into account all hazardous events, document the results of their assessment, analyze the state of the production environment and occupational safety (OS) at the facilities of the country's economy, including checking the effectiveness of the safety measures taken and systematically monitoring occupational safety measures, their control and planning [3, 4].

In the Russian Federation, many enterprises and organizations have started work on the calculation of occupational risks as part of the occupational risk management procedure. However, in construction, risk assessment is not always carried out at the required high level, it is often reduced to blind copying of the recommendations from Regulation on OHSAS No. 776n, and the results of risk assessment are not used in practice [2, 5].

Despite the entry into force on March 01, 2022 of Order of the Ministry of Labor of the Russian Federation No. 796 "On approval of recommendations on the choice of methods for assessing the levels of occupational risks and for reducing the levels of such risks", there is no unified methodology for assessing occupational risks in the Russian

Federation, which introduces additional difficulties in the implementation of the procedure [6]. For the construction industry, which is one of the most traumatic activities, this situation is unacceptable. We need a simple and understandable, and most importantly, useful and effective method for determining occupational risks, the use of which will make it possible to provide analysis and calculation for each specific construction object and at each individual stage of construction with the involvement of line managers and construction participants (line engineers, foremen, etc.) in labor protection issues.

Problem Statement. Indicators of occupational injuries and occupational morbidity in construction are still at a high level. According to statistics, in the world every 6th fatal accident at work occurs during construction work. More than 40% of workers in the construction industry are engaged in work with harmful and (or) hazardous working conditions (assigned to Class 3 and 4), which is one of the main reasons for the high level of occupational injuries and occupational morbidity of construction workers [7, 8].

Effective occupational health and safety management is impossible without occupational risks assessment. However, construction production and the activities of construction organizations have certain specifics associated with a variety of construction projects, technologies for the construction of buildings and structures, the presence of several cycles (stages) of construction, simultaneous participation in the work of several construction organizations on one construction site, etc. This should be taken into account when developing a labor protection management system [5].

The objective of this study is to develop an effective methodology for occupational risks assessment, suitable for practical application in the system of occupational risk management of construction production.

Theoretical Part

The level of occupational injuries in the Russian Federation, even taking into account the official downward trend, remains high. Construction accounts for an average of 17.5% of injuries from total industrial injuries in the country. The causes of injuries and accidents are diverse and come from the specifics of production (Fig. 1) [9].

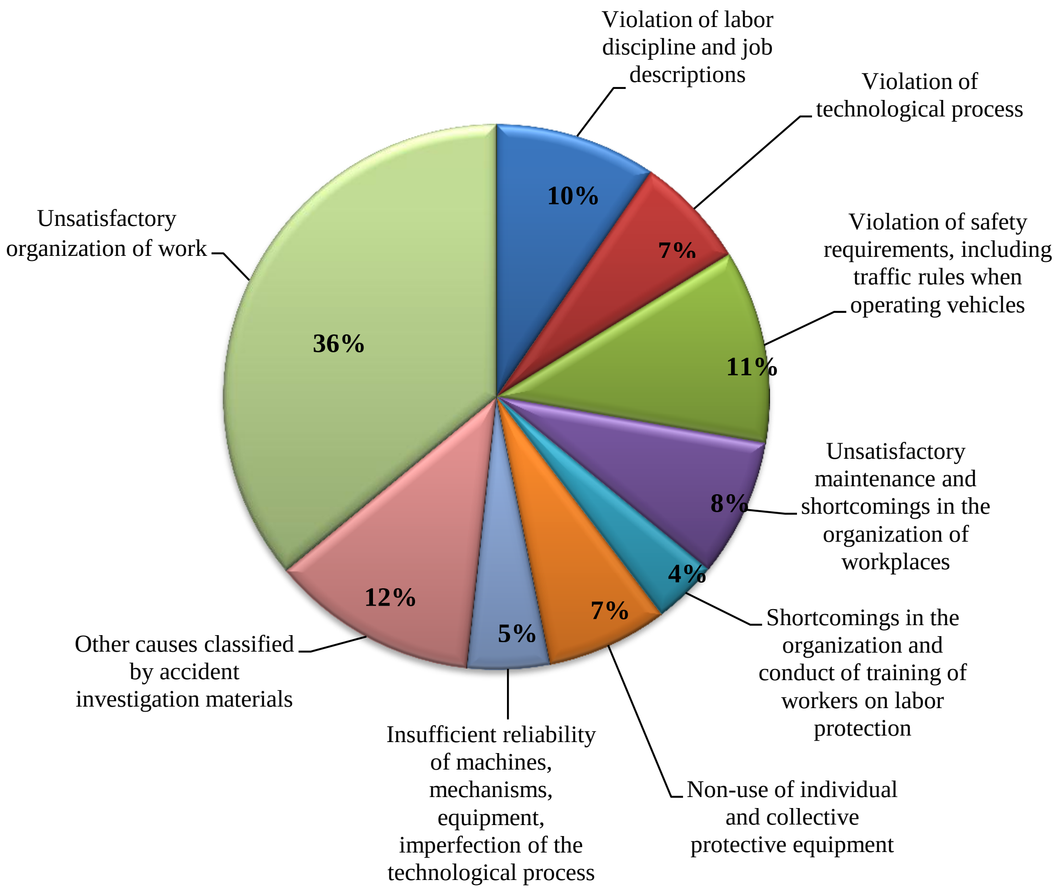

Fig. 1. The percentage of causes of injuries and accidents in construction
(compiled according to statistical data for 2010-2020)

Currently, in order to protect the life and health of employees in the course of their work, a transition to a new model of occupational safety management based on occupational risks assessment is being implemented.

In the Russian Federation, employers, including the construction industry, are invited to conduct an assessment of occupational risks using recommendation documents [6, 10-13].

It is important to emphasize that the methods proposed in the listed documents are quite complex and are intended for use in permanent, established production facilities, technological sites with an established organization of work, control and prevention of violations. At the same time, in most cases, enterprises and organizations use the services of specialized labor protection centers to determine occupational risks, which, using various methods, provide the customer with the documentation compiled in such a way that it is understandable only to a narrow circle of experts and labor protection specialists. Therefore, the possibility of its practical use directly at production sites is small. In relation to construction projects, these generalized calculations, as a rule, remain in the offices of occupational safety specialists and are presented only to officials of the State Labor Inspectorate during inspections and during the investigation of serious and fatal accidents. At the same time, the direct managers of the construction industry practically do not know the issues of occupational risk management. Thus, the effectiveness of this crucial procedure remains very low.

In general, the algorithm for assessing technogenic risk is presented in Fig. 2.

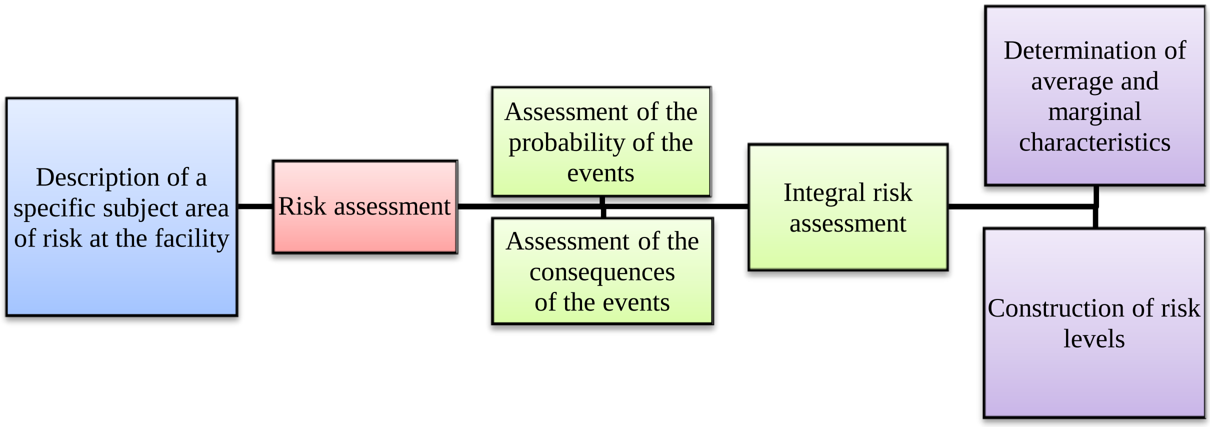

Fig. 2. General scheme of risk assessment

Risk assessment methods are usually divided into two groups: indirect and direct methods.

Direct methods use statistical information on selected risk indicators or corresponding indicators of damage and the likelihood of their occurrence, including the number of accidents when falling from a height, electric shock, etc. However, in most cases, enterprises and organizations do not have sufficiently extensive statistical data, and the statistics within one enterprise are not always objective and acceptable.

When assessing risks using indirect methods, the characteristics of possible fluctuations in indicative parameters that have a causal relationship with risks (the results of practical work, inspections and audits) are introduced.

The risk factors for accidents at work include: the presence of hazardous and harmful production factors in the work area, the physical presence of an employee in the danger zone, the absence or unsatisfactory condition of individual and collective protective equipment, and others. For construction companies, this list of factors can be specified and significantly expanded to include the following items: the quality of organizational and technological documentation, the performance of earthworks (depth, technical equipment), the construction of buildings and structures (number of floors, work production technologies), means of scaffolding, lifting equipment, etc. [14-16]

The choice of a direct or indirect method depends on the available amount of statistical information and the specifics of the tasks being solved. For a relatively small construction company, indirect methods of hazard identification and risk assessment are preferable.

The methodology proposed by the authors is based on the calculation of professional risks in a construction organization when analyzing construction organization projects (COP), method statement (MS) and technological chart (TC), which are developed for each specific object of construction of a building or structure. This choice is determined by the fact that for a purposeful and effective assessment of occupational risks at the workplaces of builders, it is necessary to know by what technology and by what methods construction and installation work will be carried out at this facility, which lifting cranes, fixtures and structures will be used, the sequence of installation and execution of special works, etc., information about which is fully presented in the technological documentation of COP, MS and TC.

Practice shows that most construction organizations do not have specialized groups (departments) on a full-time basis for the development of COP, MS and TC. This work is carried out under contracts by specialized design organizations that have certified specialists, permits of a self-regulatory organization for the right to carry out a certain type of activity in the field of construction and licenses of Rostechnadzor. Therefore, with a qualitative analysis of COP, MS and TC, it is possible to identify the main hazards to the life and health of workers, make a list of them for each construction operations cycle, as well as for almost all technological operations provided for in the technological documentation.

Risk calculation in general can be carried out according to the formula:

$$R = V \times S,$$

where R — the calculated risk; V — the probability of a hazardous event; S — the significance of a dangerous event (severity of health damage, amount of damage, etc.) [4, 13].

When calculating the risk, you can introduce a 10-point scale for the probability of occurrence of a hazardous event V (the range of changes is 0.01–1.00), the significance of a hazardous event S can be expressed in points from 1 to 10 (Tables 1, 2).

Table 1

Characteristics of hazardous events by probability

Semantic expression of probability	**Characteristic of hazardous events occurring with a given degree of probability**	**Probability of occurrence of a hazardous event**
Impossible	A hazardous event can happen only theoretically	0.01–0.19
Unlikely	A hazardous event may occur in exceptional cases with a combination of circumstances	0.20–0.39
Possible	A hazardous event does not occur under normal conditions, but with deviations in operation	0.40–0.59
Reliable	A hazardous event can occur even with minor deviations in operation	0.60–0.89
Inevitable	A hazardous event can occur even in the absence of deviations in operation	0.90–1.00

Table 2

Characteristics of hazardous events by significance

Consequences (semantic characteristic of significance)	Examples of consequences (by types of hazardous events)		Significance of a hazardous event, point
	Injuries	Diseases	
No consequences	Slight bruise, scratch	Sense of discomfort	0.0–1.9
Minor consequences	Microtrauma, bruise, abrasion. There is no disability	Irritation of the mucous membranes of the eyes, nose, larynx. General discomfort	2.0–3.9
Tangible consequences	Injury with the sick-leave (accounting)	Exacerbation of chronic diseases	4.0–5.9
Significant consequences	Fatal accident, severe and group accidents	Occupational disease	6.0–8.9
Catastrophic consequences	Group fatal accident	Acute group disease	9.0–10.0

To determine the level of occupational risk, an expert assessment method can be applied based on the existing work experience and analysis of hazardous events that occurred at this enterprise or in other organizations with a similar profile of industrial activity.

Table 3 shows the values of the risk level depending on the class of working conditions according to the degree of harmfulness and hazard.

Table 3

The value of the risk level depending on the class of working conditions

Working conditions class	1	2	2.1	3.1	3.2	3.3	3.4	4.0	4.0
Risk value, point	1	2	3	4	5	6	7	9	10
Risk level	*R1*	*R2*	*R2*	*R3*	*R3*	*R4*	*R4*	*R5*	*R5*

The risk is considered acceptable if its value falls in the range from 0 to 5.9 points (*R1-R3*). With values from 6 points and above (*R4, R5*), the risk passes into the category of unacceptable, requiring management decisions.

Thus, the algorithm for assessing occupational risk according to the proposed methodology is reduced to the following sequence of actions:

1. Development and analysis of COP, MS and TC of the object, including all stages (cycles) of construction — from the preparation of the construction site to finishing works.

2. Drawing up a register of the main hazards most likely to occur during the production of specific works and for each workplace, for each cycle of construction and installation work at the facility, presented in COP, MS and TC.

3. Risk assessment of the identified hazardous events.

4. Drawing up a risk assessment chart for each stage (cycle) of construction.

As an example of the application of the proposed methodology, we will consider the occupational risks assessment in installation and concrete work on the construction of a residential building using the technology of monolithic housing construction with retractable metal formwork.

In this case, the technological crew consisting of steelfixers, concrete workers, installers, electric welders, slingers. All members of the crew can perform various types of work provided for by this technology, have been trained and instructed on OH&S for all types of work performed.

At the first stage, using COP, MS and TC of the facility, a register of hazards is compiled for the employees of the integrated crew, depending on the types of work in this construction cycle.

List of the main types of work:

1. Erection, installation of roll-out standard scaffold and prefabricated metal formwork using a tower crane.
2. Installation and welding of rebar and reinforcement grids.
3. Concrete works (acceptance of concrete in containers, pouring concrete, vibration compaction).
4. Decoupling of the mounting formwork and tooling, removal of the roll-out scaffolding.
5. Cleaning of workplaces, moving through the floors of a building under construction.

The register of hazards most likely to occur when performing the main types of work:

1. Work at height in the absence of fences (falling from a height).
2. Impact of moving structures, metal formwork, removable lifting devices, containers, etc.
3. Danger of falling weights, objects.
4. Effect of electric current during the operation of electric welding and manual power tools.
5. Danger of using tools and mounting devices.
6. Absence of fencing openings and staircases, platforms.
7. Unsatisfactory weather conditions (snow, rain, wind gusts, low and elevated temperatures, etc.).
8. Presence of untidy and foreign objects in workplaces, playgrounds and aisles.
9. Danger associated with the non-use of collective protection and personal protective equipment.

Other types of hazards listed in Annex 1 to the Regulation on the Management System No. 776n are not taken into account, as they are close to improbability. For example, when performing the listed installation works, is it worth considering the dangers of exposure to liquid under pressure during ejection or weakening of the geomagnetic field, etc. [2].

Further, using the compiled register of hazards and data from Tables 1-3, risk levels are determined and a risk assessment map is drawn up (Table 4).

Table 4

Assessment sheet (risk assessment map)
Workplace: rebarer, concreter, installer, slinger, electric welder *

No.	Hazards register	Characteristics of events occurring with a given degree of probability		Characteristics of hazardous events by significance (severity) of consequences		Risk level value		
		Characteristics	**Probability**	**Injuries and consequences**	**Significance of a dangerous event, point**	**Working conditions class**	**Risk value, point**	**Risk level**
1	Work at height without fences	Significant, danger may occur	0.8	Significant consequences: fatal accident or long-term treatment	8.0	3.4	6.4	*R4*
2	Impact of moving structures, formwork, fixtures	Significant, danger may occur	0.7	Significant consequences: fatal accident or long-term treatment	8.0	3.3	5.6	*R4*
3	Danger of falling of weight, objects	Possible, with deviations in operation	0.5	Tangible consequences, injury	5.0	3.1	2.5	*R3*
4	Exposure to	Unlikely, the	0.3	Tangible	5.0	2.0	1.5	*R2*

No.	Hazards register	Characteristics of events occurring with a given degree of probability		Characteristics of hazardous events by significance (severity) of consequences		Risk level value		
		Characteristics	Probability	Injuries and consequences	Significance of a dangerous event, point	Working conditions class	Risk value, point	Risk level
	electric current	event may occur in the presence of several factors		consequences, injury				
5	Use of tools and devices	Unlikely, the event may occur under the circumstances	0.3	Tangible consequences, injury	4.0	2	1.2	*R2*
6	Absence of fences of openings and staircases	Unlikely, the event may occur under the circumstances	0.3	Tangible consequences, injury	4.0	2	1.2	*R2*
7	Danger associated with the non-use of personal protective equipment (safety harness)	Significant, danger may occur	0.8	Significant consequences: fatal accident, long-term treatment	8.0	3.3	6.4	*R4*
8	Adverse weather conditions	Unlikely, the event may occur under the circumstances	0.25	Minor consequences	2.0	1.0	0.5	*R1*
9	Mess in the workplace	Unlikely, the event may occur under the circumstances	0.25	Minor consequences (bruise, impact injuries, abrasions)	2.0	1.0	0.5	*R1*

*) Integrated crew: all members of the team perform the work provided by COP, MS and TC. Instruction and training on OH&S are conducted for all types of jobs and professions.

Similarly to the given example, the occupational risks assessment for other cycles of construction production is carried out: preparatory work, zero cycle work, earthwork, pile-cutting, etc.

The proposed methodology can be applied to assess occupational risks by OH&S specialists together with the heads of production sites and foremen without involving other experts and specialized organizations in this work.

Conclusions. A methodology for occupational risks assessment has been developed, the use of which makes it possible to take into account the specifics of construction work and accurately determine the probability and consequences of hazardous events that cannot be eliminated completely or in the near future.

In the occupational risk management procedure, direct managers of work (foremen, site managers) can be actively involved at the stages of compiling the register of the main hazards during construction and installation work and risk assessment of the identified hazardous events performed according to the developed methodology. This will increase the effectiveness of monitoring compliance with the occupational safety requirements at all stages of the production cycle and provide an opportunity to optimize preventive measures to reduce injuries in the construction industry.

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