TECHNOSPHERE SAFETY

Analysis of occupational injuries in the construction industry and ways to reduce it

S. L. Pushenko, **V. L. Gaponov, V. A. Kukareko**

Don State Technical University (Rostov-on-Don, Russian Federation)

Introduction. In the construction industry, there has recently been a positive trend towards a decrease in injury rates. The authors have identified the specific conditions of construction work as a source of occurrence of prerequisites for accidents. The paper provides the analysis of a statistical sample of data on accidents and occupational injuries in the construction industry, which shows that the sources of the vast majority of cases of industrial injuries are avoidable factors.

Problem Statement. The objective of this study is to determine the relationship between the accident rate in the construction industry and several factors related to the education and qualifications of employees.

Theoretical Part. As the basic information, the data of statistical reporting on occupational injuries provided by the Federal State Statistics Service, as well as materials from literary sources of domestic and foreign authors, were used. The method of complex assessment of the qualification of personnel is proposed.

Conclusions. Functional dependences of the frequency of accidents at the enterprise on the criterion of qualification of personnel are determined. Based on the results obtained, it can be concluded that the level of education of employees of construction enterprises, the correspondence of their basic education to the profile of the enterprise's activities and the frequency of professional development positively affect the overall state of the occupational safety system at the enterprise, including the reduction in the number of accidents.

Keywords: occupational safety, construction industry, occupational injuries, occupational risk, accidents at work, dangerous and harmful factors.

Introduction. One of the most important and difficult problems in the construction industry is ensuring the safety of workers, since construction is one of the industries the activities of which are associated with harmful and hazardous working conditions. However, in the Russian Federation, occupational injury rates in the construction industry have remained at an unacceptably high level in recent years. Statistical data on occupational injuries in the construction industry substantiate the relevance of reducing the injury of workers in this industry. The state of working conditions and occupational safety often remains unsatisfactory, and the number of workers in harmful conditions continues to grow. At the same time, unfavorable working conditions give rise to a high level of occupational injuries and occupational diseases.

Problem Statement. The objective of this study is to determine the dependence of the accident rate coefficient in the construction industry on a set of factors that determine the level of education and qualifications of employees.

Theoretical Part. Occupational safety at the enterprise is aimed at preservation of the life and health of employees, as well as the prevention of occupational diseases and accidents that can lead to occupational injuries [1]. In accordance with Article 212 of the Labor Code of the Russian Federation of 30.12.2001 No. 197-F3 (ed. dated 29.12.2020), the employer is obliged to provide employees with safe working conditions [2]. However, in practice, the state of working conditions and occupational safety at the enterprise often remains unsatisfactory, and the number of employees engaged in work with harmful and (or) hazardous working conditions continues to grow.

To analyze statistical observations in the construction industry, it is necessary to consider which types of work characterized by harmful and hazardous working conditions have the greatest impact on workers. Table 1 provides information on the proportion of construction industry workers engaged in work with harmful and (or) hazardous working conditions, heavy work and work related to the intensity of the labor process for 2016-2020 in accordance with the data of the Federal State Statistics Service [3].

Table 1

The proportion of construction industry workers engaged in work with harmful and (or) hazardous working conditions, heavy work and work related to the intensity of the labor process for 2016-2020.

Gender of employees	Proportion of employees by year, %				
	2016	2017	2018	2019	2020
Work with harmful and (or) hazardous working conditions					
Male	42.1	41.2	40.8	44.0	41.3
Female	15.9	14.2	13	12.3	10.6
Heavy work					
Male	24.1	24.7	25.3	27.7	26.7
Female	7.9	7.6	6.6	6.7	6.0
Work related to the intensity of the labor process					
Мужской	8.2	7	4.9	4.7	4.3
Female	2.4	1.6	1.2	1.0	1.0

According to Table 1, it can be concluded: the average proportion of construction industry workers engaged in work with harmful and (or) hazardous working conditions in 2016 was 37.9%, in 2017 — 37.0%, in 2018 — 36.7%, in 2019 — 39.4%, in 2020. — 36.9%, i.e. in the period from 2016 to 2019 the trend was upward, and in 2020 this indicator decreased. The average proportion of construction industry workers engaged in heavy work in 2016 was 21.5%, in 2017 — 22.1%, in 2018 — 22.5%, in 2019 — 24.7%, in 2020 — 23.8%, the situation is similar to the previous indicator. The average proportion of construction industry workers engaged in work related to the intensity of the labor process in 2016 amounted to 7.3%, in 2017 — 6.2%, in 2018 — 4.3%, in 2019 — 4.2%, in 2020 — 3.8%, i.e. there remained the downward trend of this indicator. The percentage of men and women employed in jobs with harmful and (or) hazardous working conditions during the study period remained approximately at the same level. Thus, in recent years, the percentage of workers associated with harmful and (or) hazardous working conditions, as well as with heavy work, only increased, but in 2020 the situation began to change slightly for the better.

Unfavorable working conditions give rise to occupational diseases and a high level of occupational injuries, which is one of the main indicators characterizing occupational risk in the workplace [4-6]. In the Russian Federation as a whole, the level of occupational injuries has remained quite high in recent years, but there is a downward trend. Table 2 shows the data of the Federal State Statistics Service on Occupational Injuries in the Russian Federation for 2016-2020.

Table 2

Data on occupational injuries in the Russian Federation for 2016-2020.

Gender of employees	Indicators by year				
	2016	2017	2018	2019	2020
Number of victims of industrial accidents, thousand people.					
Male	18.6	17.6	16.6	16.3	14.4
Female	8.1	7.8	7.0	7.0	6.1
Number of victims of fatal industrial accidents, thousand people.					
Male	1.21	1.07	1.00	0.99	0.85
Female	0.08	0.07	0.07	0.06	0.07
Number of victims of industrial accidents per 1000 employees (accident frequency coefficient)					
Male	1.6	1.6	1.5	1.4	1.2
Female	0.9	0.9	0.8	0.8	0.7
Number of victims of fatal industrial accidents per 1,000 workers					
Male	0.103	0.094	0.089	0.087	0.072
Female	0.009	0.008	0.008	0.007	0.008

According to the Table 2 the number of victims of industrial accidents in 2016 amounted to 26.7 thousand people, in 2017 — 25.4 thousand people, in 2018 — 23.6 thousand people, in 2019 — 23.3 thousand people, in 2020 — 20.5 thousand people. Of these, with a fatal outcome in 2016 — 1.29 thousand people, in 2017 — 1.14 thousand people, in 2018 — 1.07 thousand people, in 2019 — 1.06 thousand people, in 2020 — 0.91 thousand people. The number of victims of industrial accidents per 1,000 employees in 2016 was 1.3, in 2017 — 1.3, in 2018 — 1.2, in 2019 — 1.2, in 2020 — 1.0. Of these, with a fatal outcome in 2016 — 0.062, in 2017 — 0.056, in 2018 — 0.054, in 2019 — 0.053, in 2020 — 0.045. The number of victims of industrial accidents during the study period remained almost at the same level, but there was a downward trend. The percentage of men and women injured in industrial accidents remained approximately at the same level.

The number of person-days of disability for victims at work remained at the same level and amounted to 49.0 per victim in 2016, 48.7 in 2017, 49.3 in 2018, 50.6 in 2019 and 49.9 in 2020.

Funds were spent on labor protection measures per employee in 2016 — 11479.8 rubles, in 2017 — 12964.7 rubles, in 2018 — 14246.4 rubles, in 2019 — 14862.4 rubles, in 2020 — 18825.3 rubles, i.e. there was a gradual increase in this indicator.

Table 2 shows that in recent years there has been a decrease in injuries in the Russian Federation as a whole, but at the same time, the frequency of accidents at work remain almost at the same level. With the current official indicators of occupational injuries in the Russian Federation, the urgency of improving occupational safety in the construction industry is obvious.

According to the Federal Service for Labor and Employment of the Russian Federation, an analysis of industrial injuries in the Russian Federation was conducted, according to which the most significant cause of injury is unsatisfactory organization of work, resulting in a third (32.4%) of accidents. For this reason, the influence of the human factor on the occurrence of accidents at work increases: unsatisfactory organization of work, imperfection of the technological process, shortcomings in the organization and conduct of training of workers on labor protection, unsatisfactory maintenance and shortcomings in the organization of workplaces, etc. [7, 8]. To solve the problem of this study, the authors propose to introduce the following parameters related to the level of education and qualifications of employees:

1. The coefficient of compliance of the basic education (specialty, training direction) of the company's employees with the positions held α. It is calculated by the formula:

$$\alpha = \frac{K_0}{K} \times 100\%,$$

where K_0 — the number of employees with the appropriate basic education; K — the total number of employees.

2. The coefficient of the level of education of employees of the enterprise β'. It is proposed to introduce the following scale of education level:

- incomplete secondary — 1;

- complete secondary (school) — 2;

- secondary vocational — 3;

- incomplete higher education — 4;

- complete higher education — 5.

The coefficient β' is calculated by the formula:

$$\beta' = \frac{\beta}{5 \sum_{i=1}^{5} x_i} \times 100\%,$$

where x_i — the number of employees with the appropriate level of education. The parameter β is calculated by the formula:

$$\beta = 1x_1 + \ldots + 5x_5.$$

3. The coefficient of professional development by employees of the construction company γ'. Specialists in the field of construction must undergo professional training at least once every five years (Article 55.5-1 of the Town-Planning Code of the Russian Federation) [9]. Since this requirement is the minimum for this parameter, we will take the following scale: professional training 1 time in 5 years — 1; 2 times — 2; 3 times — 3; 4 times — 4; 5 times — 5. The coefficient γ' is calculated by the formula:

$$\gamma' = \frac{\gamma}{5 \sum_{j=1}^{5} x_j} \times 100\%,$$

where x_j — the number of employees who have completed professional training the corresponding number of times. The parameter γ is calculated by the formula:

$$\gamma = 1x_1 + \ldots + 5x_5.$$

The generalized function of the qualification of the company's personnel Δ is calculated by the formula:

$$\Delta = \frac{\alpha + \beta' + \gamma'}{3}.$$

This function was calculated for data provided by twenty enterprises of the construction industry in the South of Russia. The authors summarized the data for 2016-2020 in Table 3.
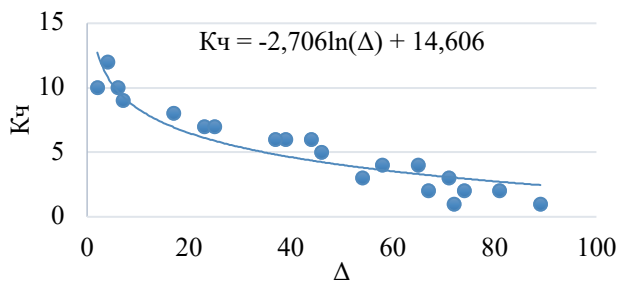
Table 3

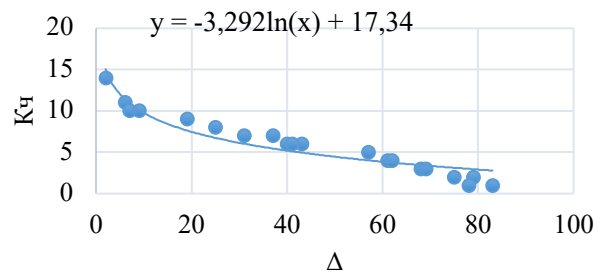Data of construction industry enterprises for 2016-2020.

Company number	2016		2017		2018		2019		2020	
	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %
1	2	72	2	75	2	71	1	87	2	70
2	4	53	3	68	1	85	4	51	3	69
3	10	1	10	6	8	12	12	5	13	5
4	6	44	5	41	6	28	8	15	5	42

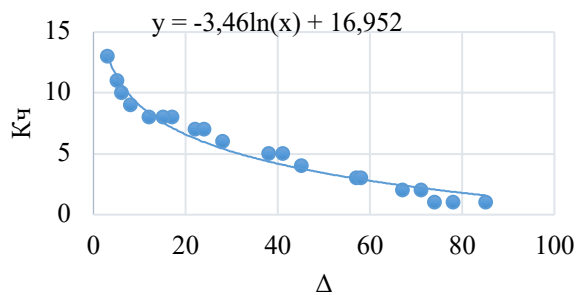| Company number	2016		2017		2018		2019		2020	
	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %	Number of accidents	Δ, %
5	4	65	3	67	4	38	2	73	6	37
6	1	89	1	83	3	68	1	91	1	87
7	2	74	4	61	1	77	4	68	2	73
8	5	46	6	43	5	41	4	46	6	32
9	3	71	2	79	4	45	3	66	5	58
10	6	39	7	37	8	17	7	27	9	22
11	2	81	4	62	3	57	1	84	3	75
12	12	4	14	2	13	3	13	1	14	1
13	7	23	8	25	7	22	5	38	7	26
14	4	58	5	57	3	57	5	54	5	68
15	8	17	9	19	9	14	10	8	9	16
16	6	37	6	42	6	24	6	33	6	31
17	10	6	11	6	11	5	12	3	11	8
18	7	26	8	31	9	8	7	24	5	46
19	8	6	10	9	10	6	9	12	8	23
20	3	67	1	78	1	74	1	85	1	82

Further, it seems possible to establish a relationship between the accident frequency coefficient $К_ч$ and the generalized function Δ, which characterizes the qualifications of the company's personnel. Figure 1 provides the calculation results of such dependencies
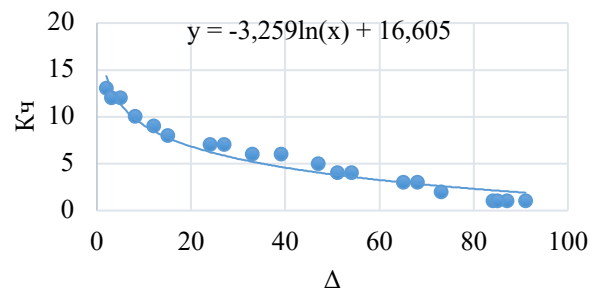

$$К_ч = -2{,}706\ln(Δ) + 14{,}606$$

a)

$$y = -3{,}292\ln(x) + 17{,}34$$

b)

$$y = -3{,}46\ln(x) + 16{,}952$$

c)

$$y = -3{,}259\ln(x) + 16{,}605$$

d)

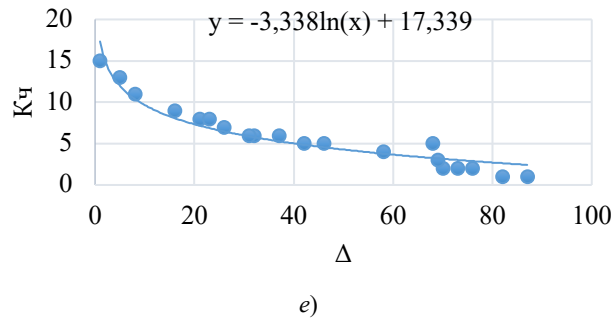$$y = -3{,}338\ln(x) + 17{,}339$$

e)

Fig. 1. The dependence of the accident rate coefficient on the education and
qualifications of employees for 2016 (a), 2017 (b), 2018 (c), 2019 (d), 2020 (e)

Conclusions.

A methodology for a comprehensive assessment of the qualifications of personnel has been developed, as a result of which it is possible to establish functional dependencies of the criterion of such an assessment with the frequency of accidents at the enterprise. The methodology has been tested on the example of a number of enterprises in the construction industry.

The level of education of employees of construction enterprises, the correspondence of their basic education to the profile of the enterprise's activity and the frequency of professional training positively affect the overall state of the occupational safety system, including the reduction in the number of accidents in accordance with certain functional dependencies characteristic of each enterprise.

It is recommended that the heads of enterprises assess the state of the qualification of personnel guided by a generalized criterion of this condition, predict the probabilistic frequency of accidents and make appropriate decisions on the modernization of OHSAS in the following directions: to recruit specialists of the appropriate level; to encourage employees to improve their skills, increase the level of education, targeted training in accordance with Decree of the Government of the Russian Federation of October 13, 2020 No. 1681 "On employer-sponsored training in educational programs of secondary vocational and higher education" (with amendments and additions); to take into account the achieved level of qualification when making personnel decisions.

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About the Authors:

Pushenko, Sergey L., Head, Department of Industrial Safety, Don State Technical University (162, Socialisticheskaya st., Rostov-on-Don, 344000, RF), Dr. Sci., Professor, ORCID, slpushenko@yandex.ru

Gaponov, **Vladimir L.,** Dean, Faculty of Energy and Oil and Gas Industry, Professor, Department of Industrial Safety, Don State Technical University (1, Strana Sovetov str., Rostov-on-Don, 344000, RF), Dr. Sci., Professor, v.gaponov6591@yandex.ru

Kukareko, Valeriya A., Post-graduate student, Department of Industrial Safety, Don State Technical University (162, Socialisticheskaya st., Rostov-on-Don, 344000, RF), valeri1394@yandex.ru

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V. A. Kukareko — formulation of the basic concept, goals and objectives of the study, calculations, preparation of the text, formation of the conclusions; V. L. Gaponov — scientific supervision, analysis of the research results, revision of the text; S. L. Pushenko — scientific supervision, analysis of the research results, correction of the conclusions.