Construction – industry with increased and uncompensated occupational risk

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Abstract. Technogenic sources and manifestations of the occupational risk of the builder are diverse. From the standpoint of occupational risk management, the factors affecting its level are of interest. The most serious result of occupational risk is occupational injuries, the frequency and severity of the consequences of which may be considered as quantitative expression of the risk level. In accordance with the provisions of economic theory, increased risk should be compensated by higher income. The purpose of this article is to assess the occupational risk in the construction industry in the regions of the Russian Federation and the extent of its compensation by wages. The analysis led to conclusions about the extremely high level of occupational risk of builders in most regions of the country, the absence of a pronounced effect of safety engineering costs on the risk exposures and the lack of risk compensation through the level of wages.

1. Introduction
Construction is one of the largest industries in the world, which provides the needs of rapidly developing economic systems and requests for construction, reconstruction, operation and dismantling of buildings and engineering structures in all countries. Reducing the risks associated with the creation and subsequent operation of construction projects - buildings, engineering and special structures - is a prerequisite for safe life and sustainable socio-economic development of the construction company, the region in which the company conducts construction activities, and of the country as a whole.

The manifestation of risk is a random event. Bogdanova points out that the study of the occurrence and development processes of random events at potentially dangerous objects cannot be one-time and represents a closed loop, including: empirical system analysis; problem-oriented description; theoretical systems analysis [1].

The number of accidents in the construction industry on a global scale is very difficult to quantify, since for many countries there is no statistical information. However, it becomes clear that the construction industry is significantly more dangerous than other sectors of economy. [2]

2. Literature review
The range of risk categories considered by modern science has expanded significantly over the recent decades. Now, risks are studied in relation to various objects and subjects and different conditions: risk of an individual person; risk of a professional group, risk of the population of a territory (a
country or group of countries). According to Roik, the study of occupational hazards as one of the types of technological risks is particularly relevant [3].

In general, factors of economic, political, scientific, technical, legal, natural, socio-cultural environment, as well as methods of corporate management, staff motivation, logistics and marketing of are among the prerequisites for the risks occurrence [4].

In the papers devoted to the risks of construction industry the following things are mainly considered as objects exposed to risk:

- object under construction. The usual subject of analysis is the retention of the functional possibilities in accordance with the purpose of the objects [5-7];
- construction company. In this case, the risk is considered as a threat to its operating, and the most hazardous manifestation of such a threat is the loss of financial stability and bankruptcy [4,8-10];
- construction project [11,12].

Human resources in construction are considered primarily as a risk factor for construction projects [13,14].

The number of works in which a person carrying out a certain type of professional construction activity is considered as an object of exposure to risk is relatively small. In [15] an overview of scientific papers on the problem of safety in construction is provided and the empirical study is undertaken. In [16] the risks of the stone works in construction are analyzed in details.

Timofeeva, Ulrikh and Tsvetkun state that the construction industry is the most dangerous sector of the economy, and analyze the methods for assessing occupational risk recommended by the regulatory documents of the Russian Federation [17].

The level of occupational risk is characterized by the following parameters [3]:

- probability of event leading to loss of earnings due to accidents at work (frequency of such events for a certain professional group during a certain period);
- types and duration of health damage (disability);
- set of compensation payments, medical and rehabilitation services required for a specific professional group.

Occupational risks of construction workers injury are associated with the specifics of the work, including high-rise work (falling from roofs, scaffolding, stairs, etc.), earthworks (trench collapse, earth-moving machinery operation), the use of lifting mechanisms (cranes and winches), the use of electrical equipment and hand tools, as well as vehicles at the construction site. Construction sites are often in disarray, cluttered, which contributes to emergency situation. [2]

Construction workers are also exposed to a number of health risks, including exposure to hazardous substances (such as asbestos-containing dust, quartz and other hazardous substances), manual movement of heavy and bulky weights, exposure to high levels of noise and vibration (both from hand tools and large cars). Back pain and other muscle injuries from lifting heavy loads constitute a large proportion of workplace injuries in the industry.

In [15], the dependences of the builders occupational risk manifestations on the type of work, age of workers and their professional experience were identified. The following types of work are most at risk: carpentry work, moving around the construction site, moving, loading and unloading materials. However, the type of work impacts on the occurrence of injuries only when work is carried out by workers, whose experience is less than 4 years. It was revealed, that work requiring a certain level of professional training gives less injury compared to that where the “physical” component dominates. Young workers with less than 4 years of experience are the group with the highest risk. Workers of 50 years and older also represent a higher risk group compared to the total number of workers.

The large number of accidents that occur in construction and the consequences it has for employees, organizations, society and countries make safety and labor protection in the industry a very important issue for all parties interested in human resources [18].

Studying technological risks exposed a person, the damage for the personnel of the company-source of danger and the people located nearby should be considered separately. Regarding to the
personnel, the management of occupational risk and management of the professional activity and safety engineering are relevant. However, the damage to the residents and the environment - natural and artificial - is often linked with the sphere of occupational risk. This approach may be explained by the fact that the risk of nearby persons is a product of someone’s professional activity [19].

3. Formulation of the problem

The purpose of the study is to assess the level of occupational risk in construction industry and the extent of its compensation in the Russian Federation.

The following questions were raised:

- Is there a relationship between the expenditure on occupational safety and the level of injuries? The formulation of this issue is due to the need to comply with the principles of target allocation and effectiveness of costs in construction organizations.
- Is there a relationship between the turnover of construction industry and the level of injury? The question is related with the fact that a larger scale of activity, as a rule, requires more complex organization and coordination and is often associated with the involvement of a larger number of unprepared or poorly trained personnel into the sphere of professional activity.
- Is there a relationship between the level of wages in construction industry and the level of injuries? The statement of the issue is based on the assumption that the level of injuries is an objective condition for the functioning of the industry, related with the technologies used, ways of organizing work, etc. In this case, in accordance with the principles of modern economic theory, wages must compensate for the risk assumed by employees.

The state statistics (www.gks.ru) for 85 regions of the Russian Federation for 2017 was used as a source of the quantitative data. Taking into account the fact that the subjects of the Federation, which include autonomous districts - the Arkhangelsk and Tyumen regions - are not homogeneous in terms of construction activity conditions, the autonomous districts and the regions without autonomous districts were counted separately.

For the analysis, the methods of descriptive statistics and elements of correlation analysis were used.

4. Main results

4.1. Model of occupational risk

Occupational risk factors affecting an employee can occur at different levels, and total risk is generated by the certain combination of these factors. The personal actions of the employee largely become the response to external conditions. The consequences of the occupational risk directly affect the employee. However, they also affect the state of the object under construction, the company, and, possibly, touch the higher levels generalization. Figure 1 shows the levels of risk factors exposure and the effects of occupational risk.

Injury is the most serious manifestation of the occupational risk in construction. Cherdenichenko distinguishes three main causes of occupational injuries [20]:

- Organizational, including poor organization of work on the construction site, insufficient training, the lack of supervision over the work conduction, violation of technology, violation of work and rest schedules, cause about 55% of accidents;
- Technical, including faulty condition of scaffolding, devices and tools, and also constructive deficiencies of machines, mechanisms, load-bearing means, and equipment, give about 35% of accidents;
- psycho-physiological and others, including insufficient attention to the performance of work, weakening the self-control and the control of activities, result in 10% of accidents.
4.2. Quantitative estimates

The main indicator of the injury rate is the indicator of the number of persons who got disability for 1 or more working days and fatalities per 1,000 employees. Indicators of correlation of the costs on safety engineering and injury rates are shown in Table 1.

Table 1. Correlation of costs on safety engineering, injury rates and financial indicators of construction activities in the regions.

| Indicator 1                                      | Indicator 2                                      | Correlation |
|--------------------------------------------------|--------------------------------------------------|-------------|
| Costs on safety engineering per 1 person working in construction industry | Number of persons who got disability for 1 working day or more and fatalities per 1000 employees in the construction industry | 0.0966 |
|                                                  | Number of fatal accidents per 1000 employed in the construction industry | -0.0986 |
|                                                  | Turnover of organizations in construction industry | 0.0128 |
| Costs on safety engineering per 1 person working in construction of buildings sub-sector | Number of persons who got disability for 1 working day or more and fatalities per 1000 employees in the construction of buildings sub-sector | -0.0222 |
|                                                  | Number of fatal accidents per 1000 employees in the construction of buildings sub-sector | 0.0348 |
|                                                  | Average monthly nominal wages of employees in the construction of buildings sub-industry | 0.1235 |

The costs on safety engineering per 1 employee in the construction industry as a whole are in the range of 702.2 rubles in the Republic of Tyva, to 81353.2 rubles in the Ryazan region, for the construction of buildings the minimum and maximum values are equal to 91 rubles. (Chechen Republic) and 170,444.2 rubles (Ryazan Region), respectively. At the same time, in the Tyva Republic, the injury rate in the construction industry is 1.2, in the construction of buildings sub-sector - 8.1, and in the Ryazan region, the similar figures were 1.2 and 0.8. In the Chechen Republic, there was a zero injury rate. Deaths were absent in all three regions mentioned.

The correlation between the injury rate and the turnover of the construction industry was equal to - 0.0609, which shows the lack of a relationship between the values analyzed. Figure 2 shows the scatterplot for ln (V), where V is the turnover of construction industry, and the injury rate. The picture allows concluding that it is impossible to build good quality regression.
The maximum value of injury, equal to 6.1, took place in the Amur region. In 5 regions, the injury rate in construction exceeded 4. For the construction of buildings, 8 regions with the average turnover of the industry equal to 7.94 billion rubles, had the injury rate exceeding 4.

In 7 regions, of which 4 belong to the North Caucasus Federal District, in 2017 the injury rate in the construction industry was zero. In the construction of buildings sub-sector, the number of regions with zero injury was equal to 13. It should be noted that the volume of construction in the regions with zero injuries in the industry in whole and in the construction of buildings sub-sector is very small: in these regions, the industry's turnover ranged from 0.3 billion rubles to 10.8 billion rubles. In 27 regions, there were no fatal accidents for the industry as a whole, while the maximum turnover of the industry in the regions of this group was equal to 21.3 billion rubles. In the construction of buildings, deaths were absent in more than half of the regions - in 45. These regions include the Khanty-Mansi Autonomous District, which is ranked 5th in terms of the construction industry’s turnover.

In 56 regions, the injury rate in construction exceeds the value of the similar indicator for all economic activity. The excess is from 1.75 (Komi Republic) to 6.57 times (Astrakhan Region). In 10 regions, the excess is more than twice. In the sub-sector of construction of buildings, the injury rate exceeded the average indicator of all economic activity in 45 regions, and the maximum excess equaled to 7.42 times (Amur Oblast). In 34 regions, the injury rate in the construction of buildings exceeded the average of construction industry.

The rate of fatal accidents per 1,000 employees in economy as the whole was ranging in regions from 0.009 to 0.012. In the Republic of Ingushetia and the city of Sevastopol, this indicator had a zero value. It should be noted that, in accordance with the concept of acceptable risk, it is considered that the acceptable average fatality rate amounts to 0.25 deaths per thousand employees per year [21].

In construction, while 27 regions had a zero value of fatal accidents, the range of the indicator for other regions varied from 0.025 to 0.823. In 55 regions, the rate of deaths exceeded the average for the economy from 1.05 to 35.22 times. In 22 regions, the level of fatal accidents exceeded the acceptable average level. For the construction of buildings, the ultra-high level of realized risk of fatal accidents took place in 21 regions.

Only in 7 regions, the wages in construction (subsector construction of buildings) were not less than the average wages in economy of the region. In 12 regions, the wages in construction equaled more than 90% of the average for the region, but did not exceed the latter. In 21 regions, the builder’s wages did not exceed 70% of the average. In the Magadan region, the average wages in the construction of buildings was equal to 21% of the average for the region.

Correlation of the wages in construction of buildings in regions with the injury rates and fatality rates constituted 0.0371 and 0.1439 correspondingly. There was no significant correlation found between the wages and costs on safety engineering, - the coefficient was equal to 0.1233.

5. Conclusions
The proposed theoretical model is based on the study of logical interrelations between risk sources and reflects. It reflects the risk factors exposing to an employee as the subject of occupational activity and
arising at different levels, and the effects of risk occurrence. To use the model as a working management tool, it is necessary to specify it, based on the classification of technological risk sources, and reliable detailed statistics on the events of occupational risk. Understanding the formation of occupational risk and its effects can be useful in development of safety policy in construction industry.

The lack of correspondence between the costs on safety engineering in the regions and the indicators of injuries and deaths, to reduce which these costs are intended, in our opinion, reflects: a) irrational organization of safety engineering and its low efficiency, b) significant differences in regional conditions for construction activities and the neglect of these differences when planning safety engineering, c) the lack of a unified policy aimed at reducing injuries and fatal accidents in the construction industry.

The largest and smallest values of injury rates both in the industry as a whole and in the subsector construction of buildings occur in regions with a small construction activity. The lack of dependence between the injury rate and the construction industry's turnover for the entire set of regions can be explained by significant differences in the availability of personnel to the construction industry and in the ratio of available qualified personnel and the need for it.

An analysis of the injury rate in construction compared to the average for the economy and the rate that is considered acceptable, shows that in most regions of Russian Federation occupation in construction is associated with the highest level of risk not compensated for by the wages. In turn, low wages reduce the attractiveness of occupation in the construction industry, reducing the quality of its human resources.

In our opinion, integrated solutions able to improve the state of safety in the construction industry and reduce the extent of the technological risks and the severity of their consequences may lie in the new technologies adoption.

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