Assessment of personal and behavioral qualities of workers in system of interactive incident forecasting and occupational safety management

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Abstract. Interactive prediction of incidents is a modern direction of labor protection, that allows managing the occupational safety level. The paper shows that the so-called "human factor", including the psychological unpreparedness of workers to perform work (both work managers and direct implementers), is the main cause of industrial injuries, in addition to technical and organizational causes. In this regard, the urgent issue is the need to take into account and analyse the psychological state of the worker for predicting incidents. The article discusses the psychological aspects of occupational safety on the example of workers performing work at height that relate to work of high danger. However, the "height factor" is common in various areas of production, which necessitates a scientific analysis of its impact on the psychological state of the worker and on the level of occupational safety. The paper provides information on the system of interactive prediction of incidents, one of the elements of which is the module of testing the psychological state of the employees for identifying workers who are least suitable for this type of work.

1. Introduction

According to statistics, in 70% of industrial accidents, the cause is a person, namely, workers' failure to comply with safety rules, disruption of the normal production process, non-use of personal and collective protection equipment, insufficient control by management, etc. [1,2]. In 73% of cases, the level of injury depends on psychological factors [3]. It is necessary to carry out accounting and assessment of these factors, along with other factors, which will allow work managers and labor protection specialists to have information about the psychological state of the worker and to carry out a prediction of the commission of incorrect actions [4,5]. This problem can be solved by automating the process of recording, analyzing, evaluating and predicting the state of an employee, taking into account his psycho-emotional characteristics [6]. At Belgorod State Technological University named after V.G. Shukhov the expert information and analytical decision support system in the field of occupational safety management is developed [7,8]. One of the modules of this system is the module of testing and assessing the psychological state of an employee.

High labor intensity, the presence of a number of dangerous and harmful production factors, the possibility of incidents and extreme situations associated with the risk of accidents and injuries remain at a high level in a number of sectors of the economy when employees perform their professional duties. The role of the psychological factor in these conditions, as confirmed by numerous studies of...
Russian and foreign scientists [9,10], is significantly increasing. The causes of 4% of all accidents at work are hazardous working conditions, and 96% are dangerous or unsafe acts or unsafe behavior of employees [11,12].

Despite the large number of studies on causes of industrial injuries, the identification of relationships between factors affecting its level – the psychological aspects of occupational safety is not sufficiently studied [13,14]. The available results of well-known domestic and foreign studies are not communicated with practical implementation in the form of expert systems of occupational safety management, implemented in real enterprises.

The relevance of this study is determined by the fact that the reason for the high neuro-emotional stress of workers is the execution of works of high danger, which include work at height that is necessary in various areas of production. Work at height is included in the list of occupations and types of work, which are subject to increased requirements for compliance with safety rules during work [15,16].

The object of this study is to work at height in the construction. Official statistic shows that about 15% of fatal accidents and up to 23% of severe incidents are registered in construction. These data are higher in comparing with the level of industrial injuries in general in the Russian Federation [1,2,17].

Figure 1 shows the distribution of the causes of accidents at construction sites, which include [5,18]:

- falling of worker from height;
- accidents caused by the action of moving and rotating parts of machines and mechanisms;
- traffic accidents;
- collapse of materials, falling objects.

![Figure 1. The main types of accidents in construction, 2017.](image)

2. Results and discussion

At Belgorod State Technological University named after V.G. Shukhov the system of psychological testing has been developed (the module “Employee’s Psychological State Testing and Assessing” of the expert decision support system for the occupational safety management) based on brief and time-limited tests designed to establish quantitative and qualitative individual psychological differences between workers. The system of psychological testing was tested on the employees of the contracting organization of the BSTU named after V.G. Shukhov, who carried out the construction and installation work in the repair of the outer part of the 9-storey buildings of the university’s dormitory.

Evaluation of the results of the psychological state of statistical sample of 30 workers, among whom 83% are men, 17% are women showed that work at height – the “height factor” affects the change in the psycho-emotional state of workers. By conducting and analyzing the psychological testing of workers, the criteria for assessing the psychological state were established:
- age;
- floor;
- use of personal protective equipment;
- the height at which the work is performed;
- time of stay at height.

As a result of the study, it was revealed that workers aged 30–40 years most often have fear experience when working at height (Figure 2).

As you can see, at the age of 20–30 years, specialists are less susceptible to panic attacks when working at height. The explanation for this can be found in the professional immaturity and unawareness of all the seriousness and danger of doing this type of work; young workers do not know the hazards of technology and its possible consequences well enough, and also do not yet have sufficient technological operations.

In the period of 30–40 years, more than half admit that they experience discomfort and an increased level of fear when performing work at height. At this age, a person is established as a person and as a specialist, adapted to working conditions, more consciously approaches the task. Most workers of this age already have a family, and, consequently, the instinct of self-preservation, subconsciously, is supported by a sense of responsibility for their lives.

At the age of 50 years and above there is a decrease in the feeling of fear at the height. This can be explained by the fact that older people are much more stable than young people and it is more difficult to ruin them or bring them to panic. This is confirmed by studies carried out, including at Stanford University (California, USA) which show that workers aged 50 and over are more emotional and therefore less likely to experience psychological problems [19,20].

Susan Charles and Laura Carstensen of the Stanford University hypothesized that the social and emotional skills of an elderly person are improved by reducing the speed of information processing [20]. Consequently, the most stable employees are older age groups of 40 years and above. They are less susceptible to stress and, as a result, careless actions under the influence of negative stress factors when working at height, and therefore, such workers will be less exposed to the risk of falling from a height.

If we compare the manifestation of the fear of height in men and women, then here we can also observe a significant difference (Figure 3).
Based on Figure 3, we can see that more than half of the women surveyed are not prone to manifestation of panic fear when performing work at height, unlike men. This suggests that the female gender is more resistant to the negative effects of the “height factor”.

As a result of the study, the most comfortable height was also revealed during construction and installation works (Figure 4).

Most of the tested workers reported that the most comfortable height for them is 1–3 floors (30%), 23% are more accustomed to working with a stepladder at a height of 1.8 m, for 17% it doesn’t matter, 7% of respondents answered that work at a height of 3–6 floors was acceptable for them, 10% answered that they prefer to perform work at a height of 6–9 floors, and 7% of respondents reported that they feel quite comfortable doing construction work at a height of 9 floors and above (Figure 4).

Analysis of the most optimal time spent at height when performing construction work, revealed that for half of the respondents, time does not matter much 33% say that they feel discomfort after an hour of being at height (Figure 5).

The different degrees of human exposure to incidents can be explained by the concept of personality switch ability, which had been developed by Karl Marbet, a psychologist of the Würzburg School. According to this concept, individuals who have a good ability to change attitudes (psychomotor, perceptual, attention, affective) in the changed conditions of activity are relatively well protected from mistakes in their behavior and are rarely victims or culprits of accidents [19, 20]. Based on this theory and the results of testing, it is possible, when working at heights, to divide the working
day into blocks of 1–1.5 hours, after which it is possible to make small pauses or transfer the employee to a lower height.

The revealed study shows differences in the professional adaptation of workers of different age and gender, their psycho-emotional state. Consequently, to reduce injuries of workers working in conditions of increased danger, in particular when working at height, it is necessary to take into account not only the factors of working conditions, persistent adverse personality qualities, the degree of personnel competence that increase the likelihood of errors in production, but also the effect of production fatigue, monotony, stress, socio-psychological factors, etc. [19, 20].

Predicting the psychological and emotional state of an employee and his erroneous actions allows to use an automated information system for managing professional risks, to facilitate the processes of control and management of occupational safety, and develop the right solution in a specific problem situation.

The results of the survey of workers performing work at height showed that men aged 30–40 years who work at a height of 1–3 floors for 1 hour of work have the highest risk of injury, therefore, this category of workers should be given the most attention.

In accordance with the developed scale of Employee’s Psychological State Indicators (EPSI), this category of workers can be attributed to the “critical” EPSI with the following characteristic – the employee's condition may cause errors (Table 1).

| Indicator number | Indicator name | State characteristic | Indicator value          |
|------------------|----------------|----------------------|--------------------------|
| 1                | critical       | Regardless of age, gender, work experience, the state of the employee on that day (state of health, mood) contributes to a high probability of making a mistake; the employee feels the fear of work even when working at the height of the stepladder in the first hour of work; the employee may experience internal feelings, stiffness of movement, dizziness | More than 0.8 to 1 |
| 2                | high           | Fear of any height, regardless of the time of work | More than 0.6 to 0.8 |
| 3                | strong         | Fear of heights above floors 3-6 and the impact of work time | More than 0.4 to 0.6 |
| 4                | moderate       | Fear of heights above floor 3-6 | More than 0.2 to 0.4 |
| 5                | small          | The duration of work at height may affect only. | More than 0 to 0.2 |

3. Conclusion
Expert information and analytical decision support system in the field of occupational safety management, and in particular the module the “Employee’s Psychological State Testing and Assessing”, will allow to get real-time evaluation of the psychological state of workers, determine the level of risk of injury and perform effective measures to reduce the risk of injury.

According to the results of the EPSI assessment, measures were developed, taking into account the opinions of the workers themselves. The most effective measures, according to the workers themselves, are the following: mentoring and counseling (57% of respondents), a gradual increase in height (27%), familiarization with the specifics of work (27%), intimate acquaintance with the team, corporate culture norms, and the establishment of interpersonal and business communication (23%).

The analysis showed that the use of information systems to predict the risk of injury to workers on the basis of monitoring the psychological state of the worker is a promising method that will solve the problem of reducing industrial injuries.

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