

## REVIEW OF RISK ASSESSMENT METHODS AND THE PECULIARITIES OF THEIR APPLICATION AT CONSTRUCTION SITES

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**Abstract.** On average, workers at construction sites face double the chance of non-fatal accidents at work compared to workers from other EU sectors. The number of accidents and occupational illness cases is determined by exceptionally high risk faced by workers at construction sites. One of the methods used to reduce the number of accidents and occupational illness cases is risk assessment. In this article, What-If-Method, Failure Mode and Effects Analysis (FMEA) IEC 812, Method Organized for a Systematic Analysis of Risks, Fault Tree Analysis (FTA) IEC 1025, DELPHI-Method and Leitmerkmal-methode methods were analyzed. To assess the occupational risk assessment regulation requirements and the impact of their implementation at Lithuanian construction companies, an anonymous questionnaire-based survey was carried out. Questions were included in the questionnaires to determine the benefits of implementing the requirements set in the occupational risk assessment regulation as well as associated difficulties.

**Keywords:** workplace health and safety, accident, occupational illness, risk assessment, harmonious workplace, construction sector, construction company.

### Introduction

Much attention in developed countries is devoted to working conditions, i.e. making sure that the working conditions do not pose health threats or endanger human lives (Hallowell and Gambatese 2009; Hola 2009; Liaudanskiene *et al.* 2009; Kazlauskaite and Buciniene 2008; Babichenko and Babichenko 2008; Hernaus *et al.* 2008; Reinhold and Tint 2009; Reinhold *et al.* 2008). Employee safety and health conditions are regulated by the state. Laws and standard legal acts are passed, and funds are allocated for prevention of work safety and health threats. These measures reflect the state of work safety, and the concern of the state for preserving the health and life of every person.

On average, workers at construction sites face double the chance of non-fatal accidents at work compared to workers from other EU sectors (Dejus 2008). The number of accidents and occupational illness cases is determined by the exceptionally high risk faced by workers at construction sites. Conditions of work change constantly, various construction machines and devices are used, work is carried out by workers of various professions and of different professional levels (Giretti *et al.* 2009; Perera *et al.* 2009; Vaidogas and Juocevicius 2009; Zavadskas and Vaidogas 2009; Idoro 2008; Giretti *et al.* 2008;

Schabowicz and Hola 2008; Zavadskas and Vaidogas 2008; Vaidogas and Juocevicius 2008). Therefore, one of the main objectives of this study is to implement the necessary measures of work organization in order to eliminate dangers from construction sites, and ensure a safe and healthy, i.e. harmonious workplace.

One of the ways to reduce the number of accidents at work and occupational illnesses is risk assessment. The objective of workplace risk assessment is to empower the construction participants to effectively use the necessary measures required for ensuring the protection of worker health and safety. In order to create a harmonious workplace and ensure the reduction of real danger impact on workers at construction sites, it is important while assessing risk to anticipate all the possible dangerous situations and risks and to ensure that reducing one risk will not increase the other. Cases must be foreseen, where under changing circumstances, work conditions, and considering the already adopted (installed) protective measures, constant observation would be carried out to see if the current protective measures are enough, or additional ones should be introduced, maybe even new measures altogether.

Taking into account the currently existing problem in the construction sector and the analysis of scientific

publications, authors of this article have analyzed and structured the risk assessment methods, their possible practical application in the construction sector, and linked the solution of the problem to statistical processing of data.

### Objective of the study

The objective of this research is to review the legal regulation, analyze the methods of occupational risk assessment and their application possibilities. Another objective is to collect, by means of a survey, and to structure the information connected to risk assessment at construction sites.

### Work methods

In order to reach the objectives, statistical-analytical, analysis, mathematical modeling and other scientific research methods were applied. When evaluating the requirements set in the occupational risk assessment regulations, as well as the impact of implementing these requirements in Lithuanian construction companies, an anonymous questionnaire-based survey was carried out. The questionnaires contained questions which were aimed at clarifying the benefits and hardships arising from implementing the requirements set in the occupational risk assessment regulation. The main objective of the survey was to obtain the characterization of the population researched (general population). For that, selective observation, as a partial variant of non-continuous observation, i.e. when only the units analyzed are researched, was chosen. In this research, one of the random selection methods – block selection – was used. This kind of selection allows achieving meaningful results based on a comparatively small sample size. This is relevant when dealing with large general populations and completely matches the research objectives.

### The essence and methods of risk assessment

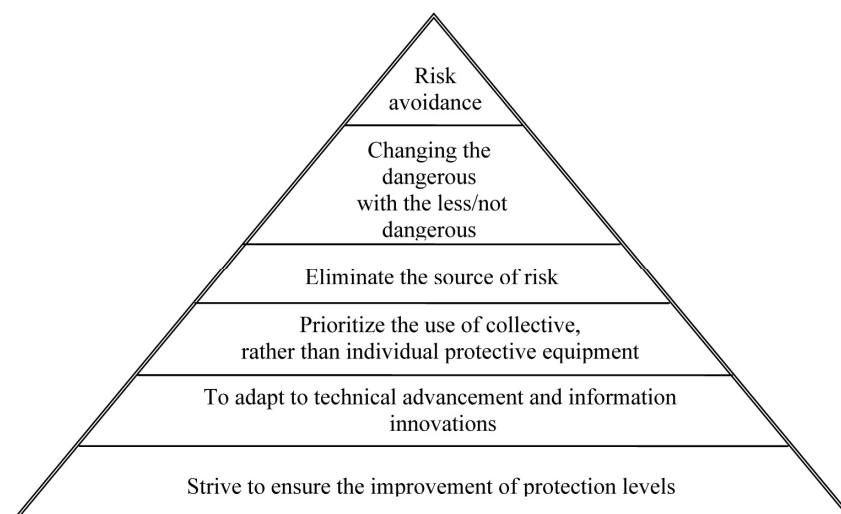
The words “danger” and “risk” in the various EU member states are not always understood in the same way, which is also the case in various scientific disciplines (Annual reports of the State Labour Inspectorate of the Republic of Lithuania). In order to avoid misunderstandings, these are the meanings of said words that are acceptable and advisable for use in the workplace context:

*Danger* – a feature or ability of a certain object (for example: work material, equipment, work method or practice) to cause harm.

*Risk* – a possibility that potential harm may be caused at certain conditions of usage and/or threat and a certain level of danger.

The main document that regulates risk assessment is the Council directive 89/391/EEC articles 6.3 (a) and 9.1 (a). In these articles, measures based on risk assessment requirements that encourage improvements in the area of worker safety and health at work are planned to implement. It is stated in the document that danger assessment and risk control strategies need to be based on the consulting and participation of persons that work at workplaces being assessed: employers, managers and workers or their representatives according to the local laws and practices.

Based on statistical data (Annual reports of the State Labour Inspectorate of the Republic of Lithuania), it may be stated, that the number of accidents at work and cases of occupational illnesses is higher in companies where risk assessment has not been carried out. The essence of risk assessment is to determine as exactly as possible the qualitative and quantitative impact on the Lithuanian construction companies that are implementing the EU Council directive 92/57/EEC “On the implementation of minimum safety and health requirements at temporary or mobile construction sites”, as well as to design and follow the hierarchy of principles of protection against risk (Fig 1).



**Fig 1.** Hierarchy of principles of protection against risk (scheme made by authors)

Risk assessment is a systematic check of all the aspects of work in order to decide the following: what may cause injury or damage, whether the dangers can be eliminated, and if not, what preventive or protective measures of risk control exist at the moment, as well as what measures should exist. Risk assessment is planned and implemented in a way that would help the employer or responsible persons controlling the work to:

- clarify the dangers at work and assess risk connected to these dangers in order to determine the measures for worker protection;
- assess risk in order to select the most suitable equipment for work, materials used and methods of carrying out work;
- check if the measures existing and being applied are suitable enough;
- ensure that the measures of protection and the necessary work and production methods that have been introduced according to the risk assessment results would improve the level of worker protection with respect to health and safety at work.

One of the most important tasks when assessing risk in order to ensure work place harmony in construction sites is a suitable choice of method (Table 1). The chosen risk assessment method should ensure that the occupational risk factors identified during risk assessment (chemical, physical, biological, psychological, ergonomic factors, internal control of the state of worker safety and health, and the work and rest times) would not be trans-

ferred, i.e. by solving one problem, a new problem should not be created.

A format of risk assessment most acceptable and suitable to construction companies would be that which assesses jobs or technological processes carried out by workers of different professions. Almost all dangers faced by workers of different professions during certain technological processes in construction are usually predictable and known. Unpredictable risk factors occur in all industries, not just in construction; in such cases, measures of prevention should be applied without delay. In anticipation of such situations due to risk assessment, organizational measures of prevention could be designed for solving emerging urgent problems. In this case it is most important to avoid the policy of drift towards these issues. In certain legal acts regulating the construction sector, interim prevention measures are foreseen, such as work safety coordinators, foremen, work execution projects, technological cards, load strapping, scaffold assembly and layout schemes, work execution account permits. This ensures safe organization and execution of current work; all there remains is to ensure effective implementation and application of aforementioned measures.

It is self explanatory that the workplaces in construction (construction sites) are not stable in terms of territory and change at a varying rhythm. Therefore it is important to select not only a suitable method for occupational risk assessment, but also a competent person or group of persons that are able to ensure a sound risk assessment at construction objects, and are very knowledgeable of the regulating standard legal acts.

**Table 1.** Risk assessment methods (Annual reports of the State Labour Inspectorate of the Republic of Lithuania)

Risk assessment methods	Form	Description
What-If-Method	Questionnaire assessment	A general method of identifying problem areas, which are later studied using more detailed methods.
Failure Mode and Effects Analysis (FMEA) IEC 812	Inductive method	Identification of system element failure frequency and their impact.
Method Organized for a Systematic Analysis of Risks	The connection of tables on · risks /dangers · amount of damage · actions to ensure safety to logic trees	A full 10-step method A system analyzed is an aggregate of changing subsystems Remaining risks/dangers are analyzed according to a special table.
Fault Tree Analysis (FTA) IEC 1025	Deductive method · Calculation of event frequency/probability · Combination of separate errors	Shows all critical paths leading to an unwanted event Analysis of alternative solution paths. Identification of reasons for the accident.
DELPHI-Method	Summary of expert opinions, Brain-Storming	Summary of separate concurring opinions and anonymous survey results.
NIOSH- Method (Leitmerkmalmethode)	Questionnaire assessment, observation/filming	Assessment of time/frequency, mass, body position.

## Scientific research results

After carrying out a company survey result analysis it has been established that construction sector companies, like companies from other industries that know work specifics well and apply the requirements set in regulations of occupational risk assessment can carry out risk assessment and fill the required documents (Regulations of occupational risk assessment). Despite that, risk assessment at construction sites is regarded as an exceptional case of applying the requirements set in regulations of occupational risk assessment. Following the analysis of results received, the main principles that need to be considered when carrying out risk assessment have been identified:

- identification of dangers and persons that may be affected;
- risk assessment and division of risk factors according to their importance;
- selection of prevention measures;
- implementation of prevention and safety measures;
- monitoring and selection of new prevention measures.

Scientific research results have revealed that when implementing the requirements set in the regulations of occupational risk assessment, the Lithuanian construction companies need additional funds, qualified workers and specialist consulting (Fig 2). Due to these reasons, the construction companies often carry out workplace risk assessment by hiring external companies.

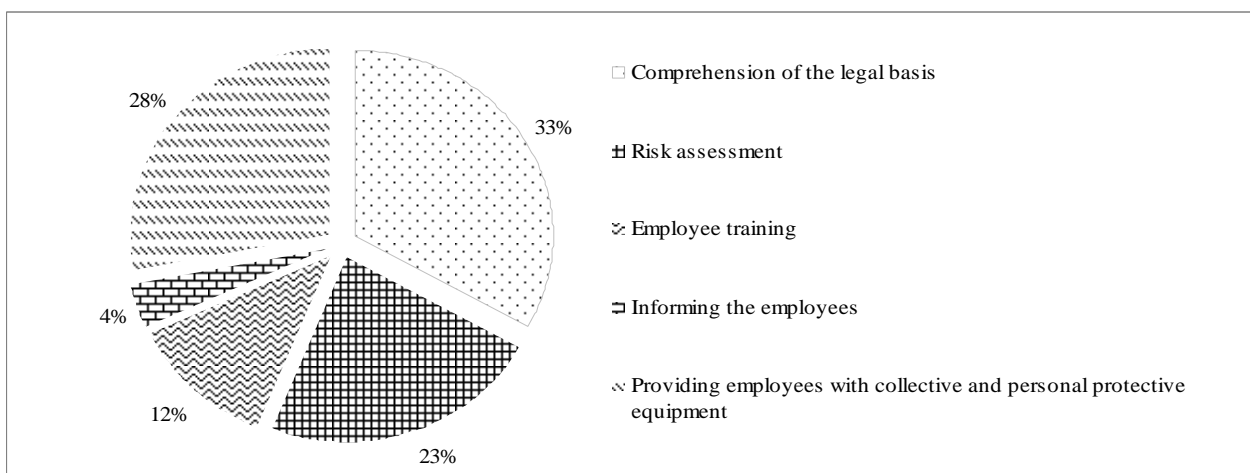
The survey showed that most of Lithuanian construction companies face problems in ensuring worker safety and health protection at construction sites. The key problematic areas are: apprehension of the legislative base, risk assessment, providing the workers with collective and personal protective equipment, as well as training and informing workers. Despite all the hardships that arise when striving to preserve worker health, life and efficiency, there are measures designed at construction companies to ensure a safe workplace:

- improvement of work safety and health as well as production daily life, and improvement of work places from the technical and organizational perspective;
- improvement of worker health;
- designing a work safety and health training system;
- designing a work safety and health management system.

During the research, the key measures for improving worker safety and health management systems in construction have been identified, according to the results of the analysis of the country's construction companies:

- acquisition of a competitive advantage by participating in tenders;
- ensuring the meeting of stakeholder expectations when implementing the strategic objectives;
- identifying the weaknesses of the organization that impact the continuity of operations with respect to worker safety;
- setting a desired and realistic level of worker safety and health;
- using the resources devoted to measures of worker safety and health protection in a rational way;
- increasing worker safety at work;
- reacting to incidents in a expedient manner, and assuring continuity of operations;
- faster adaptation to the rapidly changing legislative base that regulates worker safety and health.

The construction companies that took part in the survey appreciate the regulations of Directive 89/391/EEC regarding improvement of measures for worker safety and health protection at work and believe that these will further improve worker safety and health protection at construction sites, as well as have a positive impact on work results and working culture.



**Fig 2.** Problems faced by construction companies when meeting the requirements of occupational risk assessment regulation (Schema made by authors)

## Conclusions

1. One of the ways to reduce the number of accidents and occupational illness cases at construction sites is risk assessment.

2. One of the most important objectives of risk assessment is a suitable choice of method. The chosen risk assessment method should ensure that the occupational risk factors identified during risk assessment would not be transferred, i.e. by solving one problem, a new problem should not be created.

3. The research showed that the construction companies that took part in the survey appreciate the regulations of Directive 89/391/EEC regarding improvement of measures for worker safety and health protection at work and believe that these will further improve worker safety and health protection at construction sites, as well as have a positive impact on work results and working culture.

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