Assessment of an accident risk into an industrial building site

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Abstract. Starting from the concept that the industrial construction represents a work system with four defying components such as the executant, the workload, the means of productions and the work environment, the collective protection systems for the principal categories of activities, which are ongoing into the industrial building sites, must be analyses and evaluated. The work accidents risks and occupational illness are and they will be present all the time in the industrial building sites. The problem of prevention specialists consists in the way in which the organized and implemented measures are applied and made effective, in order to avoid the occurrence of events or, at least, to mitigate their consequences for the jobs in the industrial sites. Of the specific activities frequently encountered in temporary construction sites, the construction and assembly of metallic structures for the strength and elevation of buildings is highlighted, where there is a large and complex exposure to the risks of injury and also to professional illness. This paper presents a complex evaluation of accidents risks in a construction site for a mechanical locksmith stationary metal structures.

1. Introduction
In designing and building industrial construction, a major concern is given to the occupational safety and health management, which complements the responsibilities in the field of quality and the environment, aiming to prevent the occurrence of occupational injuries and illnesses on temporary and mobile construction sites [1, 2].

The organization and development of construction projects is carried out on several phases of execution, by the general contractor, designated by the beneficiary. The contractual and legal obligations, conduct, all the actors involved in the execution of the works on the site, to apply and observe the technical prescriptions for execution, as well as the health and safety at work, both through the Contractor's employees and those in the sub-contract [1, 3-7].

From the practice of coordinating the categories of activities for the execution of the works on the construction sites, but especially through the satirical reports issued by the accredited bodies, there is an alarming share at national level regarding the existence of risks related to the occurrence of technical events and accidents at work, as well as professional illnesses [7, 8].

According to the legal provisions, any activity scheduled to be carried out on site must be well documented technically and economically prior to execution [1].

Through health and safety management work implemented on the site, it is intended to carry out all the preventive measures necessary to ensure a safe environment for the workplaces and is carried out on several stages, applied to each execution activity, as follows [1, 3, 4, 8, 9]:
• Establishment of Working Procedures for the scheduled activity, with the specific phases of execution, describing the need for work equipment and work personnel, identifying and assessing the risks of injury, generated by the working conditions;
• Additional daily training of workers prior to commencing activities through so-called "toolboxes", which include the execution conditions and the specific health and safety measures required for each workstation;
• The proper organization of the workstation, with the production space being secured, securely signposted and protected from the interference of the other site activities, with the materials and work equipment necessary for the production, with the individual protective equipment (PPE) required by the workers and with ensuring the access and movement paths, with the necessary collective protections and signalling security;
• Production workflows site workstations, application and compliance with the measures of prevention and protection of the health and safety, set the stage for identifying and assessing risks;
• Concluding production activities at work stations, tightening work equipment, collecting and disposing of resulting waste, and securing the security conditions for the completed work by maintaining collective protections and security signatures.

As a working method in these assessments, an identification of the risks specific to each activity in an industrial construction site will be carried out, followed by the necessary prevention measures and the persons responsible for their construction and monitoring [2, 6].

Depending on the identified risk factors, a job assessment file, which is the centralizing document for all risk assessment work and / or professional illnesses, can be prepared and includes [5, 7]:
• job placement data;
• identification data of the team of evaluators;
• nominating the identified risk factors and presenting the concrete form of their manifestation;
• maximum foreseeable consequence for each risk factor; the severity and probability class for each risk factor;
• partial risk level, based on the combination of severity and probability of each risk factor; the level of risk at work, as a weighted average of the partial risk levels;
• the weighting factor shall be that of the risk factor that is equal to the level of risk.

In the study of this scientific paper, it was attempted to assess the level of risk of injury for the workplace mechanical locksmith, which mainly performs in the industrial construction sites.

Depending on the tasks assigned to the work load and the work processes carried out on the temporary site, the risk assessment method developed by the National Research and Development Institute for Environmental Protection Bucharest was chosen.

2. Paper content
In order to identify the risk factors that can lead to accidents at work, as well as the probability of their production, a series of documents from the company's history, employee job descriptions, processes of refurbishment and modernization of the production processes were requested and analysed, which were the basis for the evaluation.

In principle, the components of the work system must meet a minimum of requirements as follows:
A. The worker: be physically and mentally fit and have no infirmities that would hinder him / her in activity or which could lead to his / her injury or other persons; to have the necessary skills related to the complexity and level of mechanicalness of the technical equipment; to have professional qualifications; be authorized (nominated) to carry out the work entrusted to them.
B. Workload: be well-defined, with clear delineation of the work being done, through appropriate organizational measures; to have all the instructions necessary for the execution of all the operations specified by the workload; not to include operations which, in order to be carried out, are in breach of provisions of the legislation in force;
C. Production facilities: technological facilities (devices, devices, measuring kits, lifting means, means
of transport, etc.) and personal protective equipment to ensure safe working; they do not have conditions for causing accidents at work.

D. Working environment: do not offer professional illness conditions and not aggressive.

Following the assessment of the risks of injury and professional illness by the National Research and Development Institute for Environmental Protection Bucharest, resulted in a number of 96 risk factors for which the global risk level, \( N_r \), was determined with the following equation (1):

\[
N_r = \frac{\sum_{i=1}^{n} r_i R_i}{\sum_{i=1}^{n} r_i}
\]

Where: \( R_i \) = the weighted average of the risk levels; \( r_i \) = rank of the risk factor.

Applying the equation (1) for the evaluation of mechanical locksmith, it is obtained \( N_r = 3.21 \).

The job proposed to analyse and assess the risks of injury and professional illness was specifically chosen because it carries out the most complex activity and more exposed to hazards in an industrial construction site.

Next, we propose to analyse the identified and assessed risks according to the four components of the work system and the measures to be taken to reduce the risk values and reduce the residual risks leading to the 3 cases represented by the range colours of warning, respectively (see figure 1):

- Green, if the residual value of the risk falls under the "Acceptable" section and the activity can be carried out under controlled conditions;
- Yellow, if the residual value of the risk falls under the "Permanent surveillance" section, and the activity can only be carried out under the conditions in which it will be supervised health and safety at all times by a trained and competent person.
- Red, if the residual value of the risk falls under the "Unacceptable risk" section and the activity will not be executed under the assessed labour conditions.

![Figure 1. Representation of the range of residual risks through alert colours.](image)

By analysing the risks related to the means of production, it is represented the job evaluation sheet for the mechanical locksmith, which resulted in 29 risks. Partial risk values are shown in figure 2.

![Figure 2. Partial risk levels graph for risk factors related to the means of production.](image)

As can be seen in figure 2, a number of 9 hazards, assessed at the value "4" for the degree of severity, resulted; using the Method of the National Research and Development Institute for Environmental Protection Bucharest requires major preventive measures.

Similarly, risk reassessment is applied in order to reduce residual risk values under the following components of the work system and the work environment respectively.
First, the risks related to the work environment were assessed, which are assessed by the method of the National Research and Development Institute for Environmental Protection Bucharest, as can be seen in figure 3, and as a result, there were 17 risks, of which 2 risks were assessed at the "4" degree of severity, which requires major preventive measures.

![Figure 3. Partial risk levels graph for risk factors related to the work environment.](image)

In the case of the risk analysis related to the executor, also assessed by the method of the National Research and Development Institute for Environmental Protection Bucharest, it can be seen in figure 4, how a number of 37 risks were recorded, out of which 9 risks were assessed at grade "4" and one at "5" of severity, which requires major preventive measures.

![Figure 4. Partial risk levels graph for risk factors related to the worker.](image)

For the case of labour risk analysis, also assessed by the Method of the National Research and Development Institute for Environmental Protection Bucharest, one can see in figure 5, how a number of 9 risks have been recorded, none of which has been evaluated over the "3" degree of severity, which does not require major preventive measures.

![Figure 5. Partial risk levels graph for risk factors related to the workload.](image)

If we process these values through the health and safety management method, starting from the consideration that the risk is the product of probability and severity, and we restructure risk analysis based on the injury risk scale according to table 1.
Table 1. Risk grid.

| Probability | Legend |
|-------------|--------|
| Gravity     |        |
| 5           | 5      | 10 | 15 | 20 | 25 | Probability |
| 4           | 4      | 8  | 12 | 16 | 20 |
| 3           | 3      | 6  | 9  | 12 | 15 |
| 2           | 2      | 4  | 6  | 8  | 10 |
| 1           | 1      | 2  | 3  | 4  | 5  |

Note 1 = Very improbable
Note 2 = Unlikely
Note 3 = Probable
Note 4 = Very Affordable
Note 5 = Almost certainly

Note 1 = Negligible
Note 2 = Minor injury or illness
Note 3 = > 3 days or illness
Note 4 = Major injury or illness
Note 5 = Fatalities, Injury, Gr.I, etc.

The major goal of the health and safety coordinators and managers for temporary yards is to reduce the risks as much as possible by either lowering the probability value or gravity value or by reducing both of the reference factors: probability and gravity.

It is aware that workplace accident risk assessments depend on the level of knowledge and experience gained by the assessor, that is to say subjective, and therefore the results obtained can be processed because they are not absolute values.

Risk values identified and evaluated initially can be diminished by applying the necessary health and safety measures to the declared purpose of carrying out the activities specific to the analysed job under the safety conditions, the normative health and safety requirements at work.

Following the analysis of the presented graphs, a reassessment sheet for the residual risks for the workstation - mechanical locksmith for the production means components and the work and execution environment will be obtained. Within these sheets, reassess the risks with a degree of gravity \( \geq 4 \).

At the end of the review, the measures necessary to obtain the acceptable level for the risks of injury and professional illness, identified and evaluated, using the method developed by I.N.C.D.P. M. Bucharest, resulted in a number of 96 risk factors, broken down by the four components of the work system, presented in table 2.

Table 2. The share of risks through the work system.

| Reference | Risks related to the means of production | Risks related to work environment | Risks related to the worker | Risks related to work load | Total risks |
|-----------|----------------------------------------|---------------------------------|---------------------------|---------------------------|-------------|
| Number    | A                                      | B                               | C                          | D                         | GP          |
| %         | 29                                     | 18                              | 38                         | 11                        | 96          |

On the basis of these results, it is possible to graphically represent the share of risks through the work system for the mechanical locksmith, as in figure 6.
3. Conclusions
Risks of work injury and occupational disease exist and will always exist on temporary construction sites, and the issue of health and safety workers remains the way in which the implemented and implemented measures are implemented and effective, in order to avoid the occurrence of events or mitigation of their consequences for workstations.

Through the process of identifying and assessing the risks for the workstation engineer on industrial construction sites, it was attempted to highlight the importance of the managerial organization of health and safety at work, in the production activities, as well as the estimation of situations in which, the higher the risk, the higher the risk of an accident, at the work stations on the site.

Preventive measures on production activities have led to reassessing risks and obtaining residual values that allow passage from unacceptable risks to acceptable risks and / or requiring ongoing supervision of works.

4. References
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