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ANALYSIS OF RISK FACTORS IN CONSTRUCTION INDUSTRY

BY

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Abstract. The construction sector is associated with a complex succession of operations, all of them being accompanied by a wide diversity of risks. The starting point of the current research was the idea that in construction sector the percentage of work accidents is more extended as compared with other areas. In this context it might be considered as necessary and useful an extended analysis of risk factors, even more identification of risk factors in constructions is highly important as related to work safety on sites. As a result, the analysis of risk factors can be translated in a plan containing prevention and protection measures for a significant reduction of risks. In this context, the present paper objective was to identify main risk factors in construction sector, based on activity peculiarities and to provide a strategic approach on risks management policy. The analysis process consisted in identification of risk classes, their probability and severity level associated with different construction work types. Based on the results obtained during the analysis, the purpose was to adopt specific measures, useful for risks management and to diminish the fatalities in construction sector.

Keywords: risk; accident; evaluation; prevention, analysis.

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1. Introduction

The constructions sector is provider for a significant number of jobs, all around the World. Accordingly to statistics in the area show (Inspecția Muncii, 2017) this area has associated a large number of risks corresponding to the working activity and also with professional diseases.

In this context is absolutely necessary to identify and fight these risks. Due to construction sector peculiarity, it is important to continuously monitor the risk factors, since there is a great potential to develop new, associated ones.

Based on the consideration of work safety in constructions, the present paper details this topic using a case study for several job types from a construction site, more exactly for 8 occupations. The working system under consideration contains several components namely, human factor, work task, means of production and work environment each with its proper level of risk. It has been considered for analysis a scale for the risk level between 1 and 5, based on indications from NIRDEP experts (National Institute for Research and Development in Environmental Protection) (INCDPM) evaluation method. Using Excel software mathematical correlations, can be obtained the risks percentage for every particular job and component of the working system. The software can show, in every moment of the analysis, the risks situation in the organization, allowing the responsible personnel to establish due preventive measures for risks control. The final results refer to determination of the general risk level of the organization and creation of a plan with prevention and protection measures for diminishing the identified risks.

The management policy in work safety for construction sector must be consistent, so that a responsible awareness of all the elements involved in the working process could contribute to the improvement of the prevention process for the entire organization. This implies caring not only for workers safety but also financial economies for the organization since work accidents imply significant financial losses and creation of an unsafe, unstable environment for the other participants to the production process. Shortly, the conclusion would be “is cheaper to prevent that to treat”.

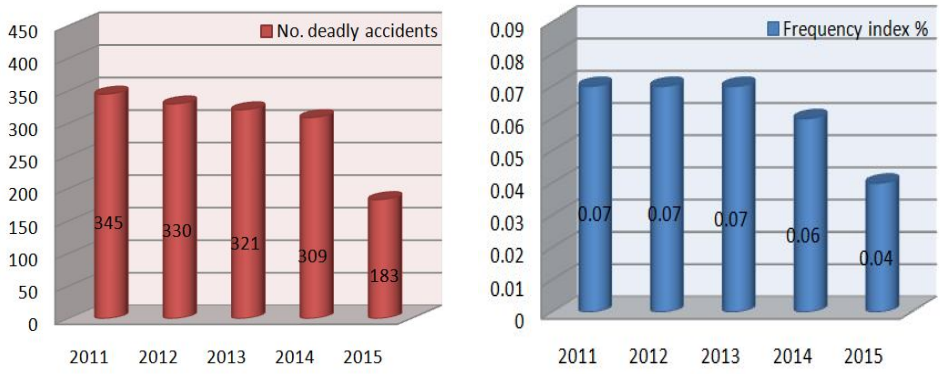
Romania experience and involvement in work safety processes has a low profile, mostly for small construction companies. The main cause of this situation is the decision makers which due to a proper education on the topic or the desire to gain a larger profit, they tend to ignore the expenses for work safety leading to all sorts of accidents.

The current paper analysis the work safety and risk management in constructions sector with the clear purpose of preventing and reducing incidents in the area.

2. Work Safety in Constructions

The constructions area, unlike other sectors of economy is characterized by peculiarities, the most important being the workers mobility on site. In the activity specific to the area operate over 40,000 estimate articles or over 10,000 merged specification articles, almost 150,000 material types, 150 jobs and over 200 classes of equipment (Şerbănoiu, 2009). The jobs can be identified by different codes in Romanian Labor Code (RLC). This diversity of occupations makes of the constructions sector the largest occupational sector.

Constructions represent a complex area characterized by process particularities and the production diversity. These characteristics induce also a high level of associated injury risks. National statistics in the field (Inspecția Muncii, 2017) of working accidents, for 2011-2015 periods, show that constructions area is classified as first, from the point of view of deadly accidents percentage, of all economic sectors. Fig. 1 below presents the evolution of deadly work accidents in the construction field for the envisaged period of 2011,...,2015 in numbers, point A, and as a percentage, point B. As can be observed, the trend is descendent, reaching in 2015 a significant decrease in the number of deadly accidents, of almost 50% as compared to reference year, 2011. This decrease is also envisaged in the frequency index from point B.



A B

Fig. 1 – Evolution of deadly work accidents (2011 – 2015).

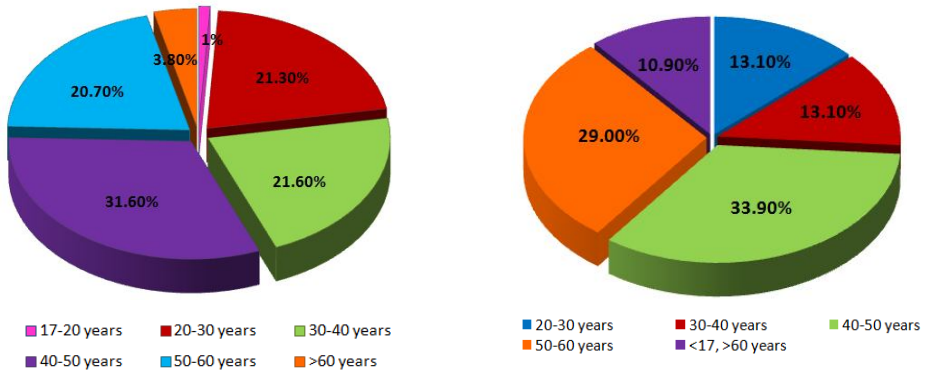
Statistics on work accidents for all economic sectors, evaluated at national level (Inspecția Muncii, 2017) in 2015, show a significant decrease of 11.2% for construction sector as compared with 2014 results. In conclusion, in 2015, the deadly accidents in constructions sector represent 11.5% of total

deadly accidents in national economic sectors, with 41.7% less than year 2014, when the number of deadly accidents reached 36.

In statistics related to (Inspecția Muncii, 2017) the time table with the highest number of work accidents registrations, can be observed that on Wednesday, in between hours 13 – 14, the probability of producing an accident is mostly significant.

The index of average duration for work disablement (average number of working days lost by an injured person), considered for year 2015, was 61.4 days, with 3.1% smaller than 2014, when it was 63.4 days. Evaluated from the point of view of severity index (total number of working days disablement, reported to 1000 employees) it was registered a percentage of 48% for 2015, with 3.4% larger than 2014, when it was registered 46.4% (Inspecția Muncii, 2017).

The accidents at workplace can be also analyzed from the point of view of age category incidence but also from the years of service point of view. Figure 2 and 3 below take a grasp on these issues. Fig. 2 presents a statistics on work accidents percentage for 2015 distributed by group age, part A containing the injured people percentage, while part B presents the percentage of deadly accidents. As observed in the chart, part A the lowest percentage of injures belong to 17 – 20 years group age, while the highest percentage of injures belong to 40,...,50 years group age category. A similar conclusion can be drawn for part B graph, the highest percentage of deadly accidents belonging to 40,...,50 years group age (Alexandru, 2013).



A. Total number of injured people B. Deadly accidents

Fig. 2 – Work accidents in 2015 distributed by group age.

Fig. 3 below presents an evaluation of work accidents from the point of view of injures at workplace, classified by years in service criteria.

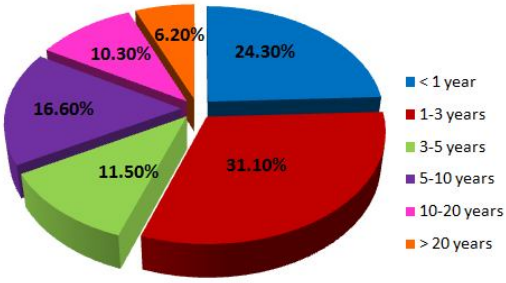


Fig. 3 – Work accidents in 2015 devided by age group.

As it can be observed, from the figure, 66.9%, meaning a total of 2,877 workers from the total of injured people, are people with seniority at workplace up to 5 years. Of these, 31.1%, meaning 1,337 injured workers, have years in service in between 1,...,3 years, while for years in service below 1 year, there is a percentage of 24.3% of total injured people (Şerbănoiu, 2016).

The conclusion of this analysis is that, the years of experience at workplace bring a decrease of accidents, while in the first years of activity the workers are more subjected to all types of injuries at workplace.

3. Risk Analysis in Civil Engineering

Construction projects are associated with a significant number and variety of risks, due to the specificity of the area activity. Working with natural components, significant mobility of production process, extended execution time table, a large number of activities that must be leaded and coordinated, various production processes and contractual relationships between processes partners are arguments that talk about the construction sector complexity.

Each process has an associated risk with a correspondent level of uncertainty. This uncertainty refers to the probability like a hazard event might take place.

The risks are associated to an event when:

a) the event takes place but the result is uncertain;

b) the effect of an event is known, the event occurrence is uncertain;

c) both the event and its consequence are uncertain.

Risks evaluation, in every sector, must take into consideration three components, namely (Şerbănoiu, 2016):

a) risk identification;

b) risk analysis;

c) risk reaction.

A first section in the evaluation of risks process consists in their **identification** which implies:

i) analysis of working process components that might be considered as destructive;

ii) identification of the ways to eliminate the dangers specific to each operation;

iii) establishing preventive measures.

The principles that guide the risks protection measures (Hola, 2014) refer to:

a) risks avoidance;

b) replacement of dangerous elements;

c) risk control at source;

d) priority for collective protection measures;

e) consideration of technical–scientifically evolution;

f) continuous improvement of work security level.

Identification of risk factors represents a priority for each working organization. If this process is being realized with maximum responsibility by the liability factors it could mean improvement of working conditions and a significant decrease in the number of injured people at workplace, of working days disablement and also of associated costs. Acknowledging all the factors involved in the working process, implies awareness on working accidents control policy and professional behavior on site.

The evaluation methods of risks at workplace analyze the working systems based on safety criteria, with the main purpose of preventing the working accidents. (Liao, 2016)

The second section in risks approach refers to **risks analysis**. Based on the first section of risks identification, at this point the information is focused mainly on the quantification process and prioritization related to severity degree and frequency.

In order to identify the risk factors in the area of civil engineering, the current study focused on the analysis of a general construction company in Romania. The risk factors have been customized based on several job profiles. The analysis was performed for a number of 8 types of jobs specific to construction sites, namely:

1. Manager and administrative personnel;
2. Carpenter;
3. Steel fixer;
4. Craner;
5. Welder;
6. Painter;
7. Plumber;
8. Driver.

According to "INCDPM Risks Evaluation Method" (y) for each job have been associated 4 evaluative components namely, human factor, work task, means of production and work environment. The analysis consisted in the consideration and association of a number of customized risk factors for each of the above mentioned components.

In order to perform a risk analysis it was necessary to consider all potential risks associated and to perform a thorough quantification of them. Risks quantification implies consideration of risk tolerance, risk sources, estimations on activities duration and costs (Carisso, 2015).

Using Excel Computer software was performed a risk analysis for the eight jobs types, mentioned above, specific to a typical construction company.

The evaluation process consisted in the centralization of risk level for each job type based on several analysis criteria, namely: **human factor, work task, means of production and work environment**.

Each job type under consideration received a classification of risk factors associated with each analysis criteria. For example, the position of "Manager and administrative personnel" has associated a number of 11 risk factors for the criteria of human factor, 2 for work task, 11 for means of production and 8 for work environment. Similarly, each job type considered for analysis received associated risk factors.

In order to perform the analysis was considered a quantification of risk level with values from 1 to 5, with 1 as neglect able risks level and 5 maximum risk level. For every evaluation category, human factor, work task, means of production and work environment, have been considered all potential risks reaching a number of:

- 62 types of risks for human factor,
- 22 types of risks for work task,
- 43 types of risks for means of production and
- 39 types of risks for work environment.

Once identified all types of risks associated with a specific category, the analysis continued with the identification of specific risks and their severity level for each of the 8 job types under consideration. In order to quantify as percentage the risk level value, was used Excel computer software.

Based on the analysis results on risk level, Table 1, "Centralization of Risk Level" provides the percentage values for each job type and risk category criteria.

Fig. 4 above, titled "Risk level associated to job type" is the graphical representation of the analysis results, pointing out the general risk level for all 8 job types. As seen in the graph, the highest percentage value of risk belongs to the welder with 65% and the lowest belongs to the manager, with 59.4%.

Table 1
Centralization of Risk Level

Job code	Job type	Risk level				General risk level
		Human factor	Work task	Means of production	Work environment	
1	Welder	63.8%	62.6%	69.8%	61%	65%
2	Plumber	64.8%	66.4%	65.6%	62.6%	64.8%
3	Driver	66.2%	60%	64.6%	58.2%	64%
4	Craner	68.6%	60%	64.2%	57.4%	64.2%
5	Steel fixer	67.6%	72%	60.8%	57.4%	64.2%
6	Carpenter	66.8%	72%	60.8%	56.8%	64%
7	Manager	60%	60%	60%	57.2%	59.4%
8	Painter	65.2%	72%	60%	56.4%	63%
General risk level		65.8%	65.8%	63.6%	59.2%	64%

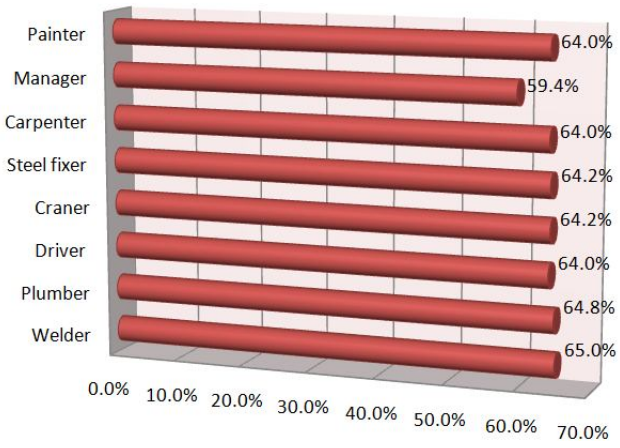


Fig. 4 – Risk level associated to job type.

Presented in more detail, the analysis results take the form observed in Fig. 5 that contains a percentage representation of risk level for every criterion specific to each job type.

Looking at the analysis results presented in Fig. 5 can be observed that the highest risk level percentage value is registered for the work task criteria. A value of 72% belongs to painter, carpenter and steel fixer. At the other side, the lowest risk level belongs to work environment section, where the painter and the carpenter register the lowest values of 56.4% and 56.8% (Şerbănoiu, 2015).

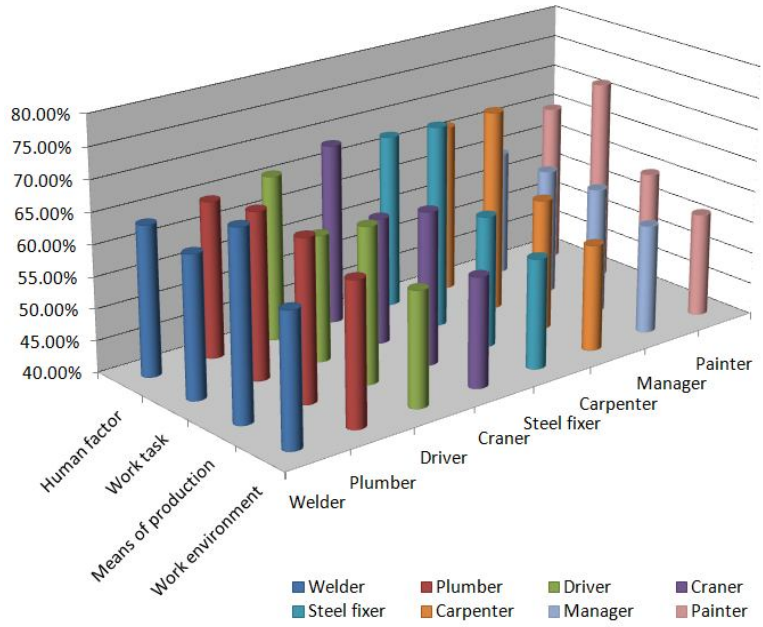


Fig. 5 – Percentage of risk factors for main jobs in constructions.

The analysis results can be used to establish measures for risk reduction in constructions area.

A third component of risk evaluation refers to reaction to risk, which can be considered as the action phase of risk management process. This section reffers to, if not eliminating, at least reducing the risk level and value.

Generally, the actions are based on a risk management plan that includes procedures for risk control, social engagement and responsibility in actions associated to different risk levels, associating resources to this purpose and pozitive feedback for risk management procedures.

In the construction sector, reducing the risk level implies taking the necessary measures for every phase of the construction process. In this sense, it is important to create a strategy to approach the risks issue in the complex area of constructions, strategy that starts from the very beginning of the project phase. Reactions to risks could integrate:

- Shift towards new and developed technology. It is important not to forget the the fact that any new technological equipment has associated new risks, that must be forseen.
- Awareness of work security for all participants in the working process.
- Supervizing and control.

- Ergonomic work and protection equipments so that they don't overstrain the workers.
- Identification of new risks and taking associated measures.
- Policies for commitments towards safe working procedures.

4. Conclusions

Constructions sector holds the first place in the statistics related to deadly working accidents in Romania. Unlike other sectors of economy, constructions are characterized by particularities like size and volume for materials, equipment and work force, workers mobility on site, diversity of job categories and vulnerability towards minor and major work accidents.

Reducing the risks level and value consists of taking the right measures at every phase of the construction process. In order to do this, it is necessary to identify the risk factors associated with every project phase, so that to establish associated prevention and protection measures for the analyzed risks.

Analyzing the risks factors and their percentage interference value in civil engineering provides an overview for specific prevention measures consisting of significant awareness on the work security for all employees, frequent surveillance and control, norming at the right level the workers capacity, ergonomic usage of work and protection equipment, policies for workers commitment towards safety procedures.

Shifting towards new and developed technologies might be considered as an optimum measure, but mustn't be forgotten that every chance in equipment comes with associated new risks.

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ANALIZA FACTORILOR DE RISC ÎN INDUSTRIA CONSTRUCŢIILOR

(Rezumat)

Sectorul construcţiilor este o succesiune complexă de operaţiuni, fiecare dintre acestea având asociată o diversitate de riscuri. Cercetarea curentă a pornit de la idea conform căreia, în construcţii, procentul accidentelor de muncă este semnificativ mai ridicat comparativ cu alte domenii de activitate. Acest context a indus ca necesară şi utilă analiza a factorilor de risc asociaţi activităţilor din domeniul construcţiilor. S-a dovedit ca fiind extrem de importantă identificarea factorilor de risc specifici diferitelor activităţi inginereşti în corelaţie cu siguranţa muncii pe amplasamente. Ca rezultat, analiza factorilor de risc poate fi transpusă într-un plan care să cuprindă măsuri de prevenţie şi protecţie în vederea reducerii semnificative a riscurilor.

Pentru atingerea obiectivului de cercetare propus, s-a procedat la identificarea principalilor factori de risc din domeniul constructorilor, pe baza specificităţilor la nivel de activitate şi asigurării unei abordări strategice a politicii de management a riscurilor. Procesul de analiză a constat în identificarea claselor de risc, a probabilităţii manifestării lor şi a nivelului de severitate asociat diferitor tipuri de activităţi în construcţii. Rezultatele analizei au condus către stabilirea unor măsuri specifice, necesare în managerierea riscurilor şi pentru reducerea numărului de accidente în sectorul construcţiilor.