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IDENTIFICATION OF INJURY RISK IN BUILDING CONSTRUCTION – EDUCATION, EXPERIENCE AND TYPE OF WORKS

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Original scientific paper
This paper presents an overview of research in the frequency of injuries at work among construction workers, from the aspect of education, experience and professional training in the realization of different types of construction works. The research included 719 injuries without fatal outcome in the field of building construction in the Republic of Serbia, within the Autonomous Province of Vojvodina. The analysis of construction workers structure, realized according to the data provided by Statistical Office of the Republic of Serbia, showed that the great majority of construction workers (over 89 %) have elementary or high school education levels, as well as that 17 % of workers in Vojvodina have less than five years of experience in construction. By analyzing the injury base, a conclusion was drawn that the highest number of injured workers has elementary or high school education level, as well as that longer working experience of workers imply smaller number of injuries. In addition, a conclusion was drawn that the injuries were caused to the largest extent owing to workers' unsafe act, and less owing to unsafe conditions of work.

Keywords*: construction works, education, experience, injury risk, professional training, unsafe act, unsafe condition*

Identifikacija rizika povreda u građevinarstvu – obrazovanje, iskustvo i vrsta radova

Izvorni znanstveni članak
Rad prikazuje istraživanje učestalosti povreda na radu građevinskih radnika sa aspekta obrazovanja, iskustva i stručne obučenosti prilikom realizacije različitih vrsta građevinskih radova. Istraživanje je obuhvatilo 719 povreda bez smrtnih posljedica u oblasti građevinarstva u Republici Srbiji u okviru Autonomne pokrajine Vojvodina. Analiza strukture građevinskih radnika, realizirana na osnovu podataka Zavoda za statistiku Republike Srbije, pokazala je da je većina građevinskih radnika (preko 89 %) završila osnovnu ili srednju školu kao i da 17 % radnika u Vojvodini ima manje od pet godina iskustva u građevinarstvu. Na osnovu analize baze podataka o povredama zaključeno je da najveći broj povređenih radnika ima osnovno ili srednje obrazovanje kao i da radnici s većim iskustvom impliciraju manji broj povreda. Također, zaključeno je da je veći dio povreda nastao uslijed nemara radnika na radu, a manji dio uslijed nesigurnih uvjeta rada.

Ključne riječi*: iskustvo, građevinski radovi, nemaran rad, nesigurni uvjeti, obrazovanje, rizik od povreda, stručna obuka*

1 Introduction

In the majority of industrial countries, construction industry presents one of the most significant branches of industry, from the aspect of its influence on the gross national product. Despite being one of the most significant branches, construction industry features the highest injury rate [1 ÷ 6]. The causes of such condition have been linked with the very characteristics of construction industry, which are considerably different from the characteristics of stationary industries. The terms "stationary" and, "non-stationary" in themselves, indicate the mobility of processes which is typical of building construction. Construction industry is project-oriented, where the goals are set individually for each project, contrary to the stationary industry, which is oriented towards the continuity in production [1]. Uniqueness of projects is reflected through differences in their input parameters and construction sites, limitations on construction processes and different project goals, which are often mutually exclusive. In a large number of cases at least one of the listed parameters will differ if two projects are compared. For that reason, when estimating the risk in safety at work, it is necessary to consider each construction process separately [7 ÷ 10]. Construction site production presents realization of processes on different locations, where a complete process gets relocated to a new location and modified, i.e. adjusted to new conditions within which it has to function. At the same time, construction works are realized in the open air, which has a negative impact on working conditions. In addition, a significant impact on the frequency of injuries at work has the size of a construction company. The research in the impact of company size on the number of injuries in the European Union, conducted by Mucenski, Pesko and Matic [11] showed that micro and small companies (up to 50 employees) feature 4 times higher rate of injuries at work compared to large companies, whereas medium-size companies (up to 250 employees) feature 3 times higher rate of injuries compared to large companies (over 250 employees). High rate of injuries at work presents a result which requires a systematic approach and record-keeping of all potential risks which can result from badly organized building processes and work technology [12].
Within the realization of construction processes, all levels of workers are included, from the company's management, to the lowest level of working force on the construction site. For that reason, implementation and providing of safe working conditions is a duty of all the workers in the process, according to their position in the company's hierarchy. It is a mistake to link workers only to their activities and attitudes, since working discipline along with workers' attitudes from the aspect of safety can be conditioned by safety procedures, i.e. company's attitude [13 ÷ 15]. Heinrich [16] came to a conclusion through his research that 88 % of all accidents and injuries at work have a human error as a cause. Health and Safety Executive of Great Britain concluded that approximately 80 % of accidents can one way or another be linked with the behaviour of employees [17]. Research carried out in Hong Kong [5] encompassed injuries which occurred on construction sites, where the causes of injuries were analyzed in order to determine their link with attitude of workers or the management. The authors

drew a conclusion that there are eleven factors which influence safety at work: *experience, education and training,* management, safety procedures, psychological features, economic features, self-respect, required performances, understanding of risks, working environment. Torner and Pousette [15] came to a conclusion that one of four categories of characteristics of high safety standards in construction work is the category of individual competence and attitudes. Workers individual competence is defined by knowledge, ability and experience.

For that reason, it is necessary to analyze the influence of working force characteristics (education, experience and training) on the frequency of injuries at work in building construction.

2 Construction workers structure from the aspect of education and experience

With the aim of better understanding and consideration of construction production features, the features of working force within construction industry of Serbia, for the Autonomous Province of Vojvodina, between the years 2008 and 2010 were analyzed. In realizing the research, data provided by the Statistical Office of Serbia were used, encompassing all the construction companies, where the two observed parameters were education and experience. In classifying workers' education, the following education levels were adopted: incomplete elementary school (a worker either had not started or completely finished elementary school), elementary school (only elementary school was finished), high school (high school lasting 3 or 4 years was finished), college (a particular college was finished) and faculty degree, masters, PhDs (a worker completed some of the highest levels of education). Tab. 1 shows the number and percent proportion of workers in the construction industry of Vojvodina according to their level of education.

According to data presented in Tab. 1, a conclusion can be drawn that the proportion of workers who finished elementary and high school amounts to an average of 87,48 %, whereas the proportion of workers with college and faculty education amounts to an average of 6,86 %. Elementary school was not finished by 3,66 % of workers on average.

Tab. 2 shows the number of workers and the percent proportion based on the levels of experience (i.e. the length of employment). The subject of observation was the experience in jobs on which a worker was employed at the time of data gathering.

It is important to note that the proportion of workers with less than 4 years of experience amounts to 17,39 %, which indicates the significance of workers education and training from the aspect of safety at work.

3 Structure of injured construction workers from the aspect of education and experience

Within the research of risk identification, data were gathered about injuries of workers that occurred while realizing construction works in the field of building construction on the territory of Vojvodina. The data were gathered based on the reports on injuries at work to institutions in charge of the occupational health service. Based on these reports, a data base of 719 injuries at work with no fatal outcome was created.

Within this data base, the following data were defined:

- data on acquired education of workers,
- data on the experience of workers in jobs at which the injuries occurred,
- data relating to the type of work
- data relating to causes of injuries.

The listed data were mutually compared in order to determine their interdependence. In Fig. 1, the impact of education level and experience of workers on the injuries percent proportion is shown.

Considering a rather small number of injuries of workers with incomplete elementary school, college or academic education, a conclusion can be drawn that the highest risk group is made of workers with elementary school and high school with 0 to 9 years of experience (see Fig. 1). It should be noted that these education levels (elementary and high school) at the same time present the most common education levels of workers in construction industry (taking into consideration not only building construction, see Tab. 1).

Based on Fig. 1 it can be concluded that injury risk is decreasing with increasing of experience. Workers with less than five years of experience at positions at which injuries occurred have the highest rate of injuries (over 30 %).

It can be concluded that higher levels of education implie reduction of risk of injuries only for workers with college, faculty, masters and PhD degree (total percent of injuries is 1,11 %). The reason is not a higher level of knowledge but lower risk exposure. Total proportion of injuries of workers with high school education accounts for 57,3 % of injuries in total, which corresponds to the proportion of these workers in the construction industry, whereas injuries of workers with elementary school education account for 39,92 %. The proportion of injuries of workers without elementary school education accounts for 1,67 %, which approximately corresponds to their proportion in the construction industry of Vojvodina.

Table 1 Number and percent proportion of workers according to education level in the period between 2008 and 2010

Education level	Year						Average value for the observed period	
	2008		2009		2010			
Incomplete elementary school	2 746	5,19 %	1 612	3,80 %	400	1,15 %	1 586	3,66 %
Elementary school	16 680	31,55 %	11 269	26,59 %	7 771	22,35 %	11 907	27,48 %
High school	30 497	57,69 %	26 784	63,20 %	23 324	67,09 %	26 868	62,00 %
College	564	1,07 %	843	1,99 %	1 711	4,92 %	1 039	2,40 %
Faculty, Masters, PhDs	2 374	4,49 %	1 872	4,42 %	1 558	4,48 %	1 935	4,46 %
Total	52 861	100,00 %	42 380	100,00 %	34 764	100,00 %	43 335	100,00 %

Table 2 Number and percent proportion of workers according to experience for the period between 2008 and 2010

Experience of workers in jobs at which injuries occurred	Year						Average value for the observed period	
	2008		2009		2010			
0 ÷ 4 years	9 531	18,03 %	8 231	19,42 %	4 842	13,93 %	7 535	17,39 %
5 ÷ 9 years	5 351	10,12 %	4 726	11,15 %	3 779	10,87 %	4 619	10,66 %
10 ÷ 19 years	14 549	27,52 %	13 460	31,76 %	9 105	26,19 %	12 371	28,55 %
20 ÷ 29 years	15 462	29,25 %	8 808	20,78 %	9 760	28,07 %	11 343	26,18 %
30 ÷ 39 years	7 057	13,35 %	5 923	13,98 %	6 165	17,73 %	6 382	14,73 %
40 years and more	910	1,72 %	1 231	2,91 %	1 113	3,20 %	1 085	2,50 %
Total	52 861	100,00 %	42 380	100,00 %	34 763	100,00 %	43 335	100,00 %

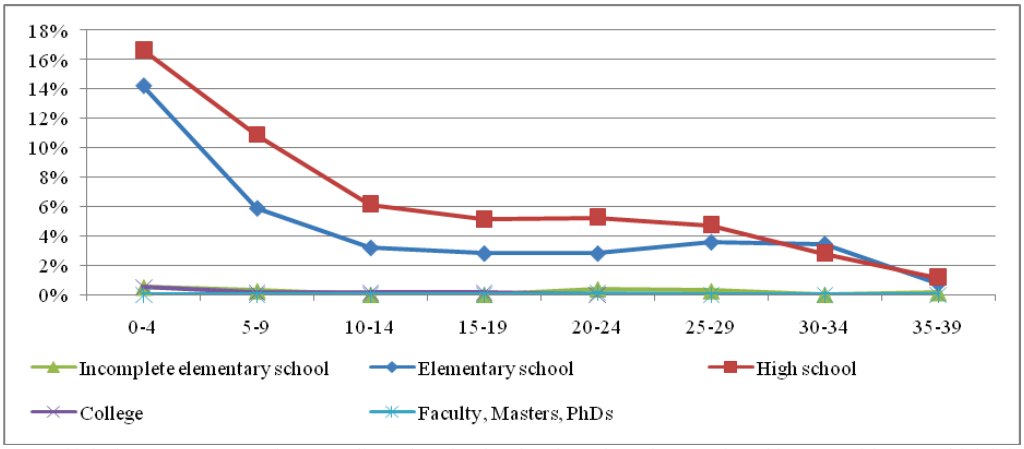

Figure 1 Diagram of injuries percent proportion regarding education level and number of years of working at positions at which injuries occurred

4 Influence of experience in realizing various types of construction works

Apart from the analysis of education level related to the experience, this research also analyzed the influence of construction work types on the frequency of injuries related to the experience of a worker who suffered an injury. The same intervals of years of experience were observed over the five year period. The types of construction works at which injuries occurred are shown in Tab. 3 and are divided into two groups, according to whether they require a certain level of training (expertise) or not. The act of moving around the construction site (walking without handling) was set apart, due to a high rate of injury occurrence, in order to give it particular attention, since it is not directly influenced by training or the position of a worker.

Tab. 3 provides the comparison between the percent proportions of injuries in work types relating to the average proportion for all types of works. If the frequency for the observed type of works is higher than the average, the field is painted red. If not, it is green. According to this, it is possible to conclude that the frequency of injuries of workers with 0 ÷ 4 years of experience for those works that require relevant training is lower than the average, whereas it is the other way round for the works performed mainly by unqualified workers. This implies a positive influence of workers training on the reduced frequency of injuries within the first five years at work.

An interesting piece of information is that the exception to this rule occurs in the case of workers that operate construction mechanization, who are also supposed to be highly skilled for it. It implies that being highly skilled does not necessarily have to be related with training for operating construction machinery safely.

Since the data indicate an increased risk of injuries for the second group of works that require no professional training, a conclusion can be drawn that training is necessary for safe working after all. Moreover, it can be seen that after first five years at work this regularity does not apply any longer (for all kinds of observed works), which indicates the significance of continuous training and work control, in order to provide safe working operations.

By analyzing the number of injuries, the types of works which are seen as being of highest risk are Carpentry works, Finishing works, Walking without handling, working on material transfer, Material transfer – manual. The increased injury risk in finishing works should be considered with care, due to a high number of different types of finishing works.

4.1 The cause of injury occurrence (unsafe act or unsafe condition)

Considering the fact that in 11 types of works (out of 13 in total) the frequency of injury occurrence is the highest with workers having 0 ÷ 4 years of experience in works at which they happened, the analysis of causes of injuries was carried out. It was observed whether the injury occurred owing to the unsafe act or the unsafe condition according to OSHA methodology (Tab. 4). [18] It is necessary to note that the causes related to the unsafe act are the responsibility of a worker himself, whereas the causes related to the unsafe condition are the responsibility of a construction company.

Results of the analysis are shown in Figs. 2, 3, 4 and 5. At the same time, Figs. 2 and 3 refer to works which require certain level of training, whereas Figs. 4 and 5 refer to works which do not require training (manual work). Values shown in diagrams refer to the average

number of injuries in the year in which they occurred within the first five years at work and after that. In addition, the total number of injuries for the observed works was divided by five years (for the period of 0 ÷ 4) and 36 years (for the period of over full 5 years of experience).

Table 3 Overview of number and percent frequency of injuries relating to workers' experience in all types of works.

Type of construction work		Experience of workers in jobs at which injuries occurred								Total
		0 ÷ 4	5 ÷ 9	10 ÷ 14	15 ÷ 19	20 ÷ 24	25 ÷ 29	30 ÷ 34	35 ÷ 39	
Group 1 Construction works that require some level of training	Reinforcing	10	11	5	4	5	4	0	0	39
		25,6 %	28,2 %	12,8 %	10,3 %	12,8 %	10,3 %	0,0 %	0,0 %	100 %
	Concreting	11	9	3	4	2	3	3	0	35
		31,4 %	25,7 %	8,6 %	11,4 %	5,7 %	8,6 %	8,6 %	0,0 %	100 %
	Machinery handling	18	6	6	4	7	6	2	1	50
		36,0 %	12,0 %	12,0 %	8,0 %	14,0 %	12,0 %	4,0 %	2,0 %	100 %
	Carpentry	28	18	19	9	11	7	7	4	103
		27,2 %	17,5 %	18,4 %	8,7 %	10,7 %	6,8 %	6,8 %	3,9 %	100 %
	Masonry	16	7	5	6	4	4	5	2	49
		32,7 %	14,3 %	10,2 %	12,2 %	8,2 %	8,2 %	10,2 %	4,1 %	100 %
	Finishing	29	23	14	10	12	5	6	4	103
		28,2 %	22,3 %	13,6 %	9,7 %	11,7 %	4,9 %	5,8 %	3,9 %	100 %
	Machinery maintenance	4	5	0	6	4	6	3	1	29
		13,8 %	17,2 %	0,0 %	20,7 %	13,8 %	20,7 %	10,3 %	3,4 %	100 %
Performed by all workers	Walking without handling, working or material transfer	37	17	4	7	7	11	6	2	91
		40,7 %	18,7 %	4,4 %	7,7 %	7,7 %	12,1 %	6,6 %	2,2 %	100 %
Group 2 Construction works that do not require any level of training	Material transfer - manual	46	25	9	4	4	9	13	1	111
		41,4 %	22,5 %	8,1 %	3,6 %	3,6 %	8,1 %	11,7 %	0,9 %	100 %
	Loading and unloading - manual	25	8	3	7	9	8	4	0	64
		39,1 %	12,5 %	4,7 %	10,9 %	14,1 %	12,5 %	6,3 %	0,0 %	100 %
	Earth works - manual	7	3	2	1	1	2	0	0	16
		43,8 %	18,8 %	12,5 %	6,3 %	6,3 %	12,5 %	0,0 %	0,0 %	100 %
	Demolition and removal - manual	12	1	2	1	1	2	0	0	19
		63,2 %	5,3 %	10,5 %	5,3 %	5,3 %	10,5 %	0,0 %	0,0 %	100 %
	Preparation works and site cleanup - manual	6	1	2	0	0	0	0	1	10
		60,0 %	10,0 %	20,0 %	0,0 %	0,0 %	0,0 %	0,0 %	10,0 %	100 %
Average		19,15	10,31	5,69	4,85	5,15	5,15	3,77	1,23	55,31
		34,6 %	18,6 %	10,3 %	8,8 %	9,3 %	9,3 %	6,8 %	2,2 %	100 %
									Total	719

Table 4 Overview of number and percent frequency of injuries related to workers experience in all types of works

Unsafe Acts	Unsafe Conditions
1. Failure to wear PPE	1. Congested work areas
2. Failure to warn co-workers or to secure equipment	2. Defective machinery/tools
3. Ignoring equipment/tool defects	3. Improperly stored explosive or hazardous materials
4. Improper lifting	4. Poor illumination
5. Improper working position	5. Poor ventilation
6. Improper use of equipment	6. Inadequate supports/guards
7. Operating equipment without authority	7. Poor housekeeping
8. Horseplay	8. Radiation exposure
9. Making safety devices inoperable	9. Excessive noise
10. Drug misuse	10. Hazardous atmospheric conditions
11. Alcohol use	11. Dangerous soil conditions
12. Violation of safety and health rules	12. No firefighting equipment
	13. Unstable work areas/platforms

According to the analysis, it is possible to conclude that the frequency of injuries occurring within the first five years at work is dominantly related to the unsafe act. This rule applies to all types of works. By comparing the relationship between frequencies of injuries, it was noticed that the frequency of injuries is higher 2,5 times (for Reinforcing) and up to 12 times (for Demolition and removal - manual) in the period of 0 ÷ 4 years of

experience compared to the period after it. A curious fact is that the difference in frequency of injuries of workers with 0 ÷ 4 years of experience compared with workers having more than 5 years of experience is lower for the unsafe condition than for the unsafe act, which indicates a certain level of adjustment of workers to unsafe conditions with increasing level of experience.

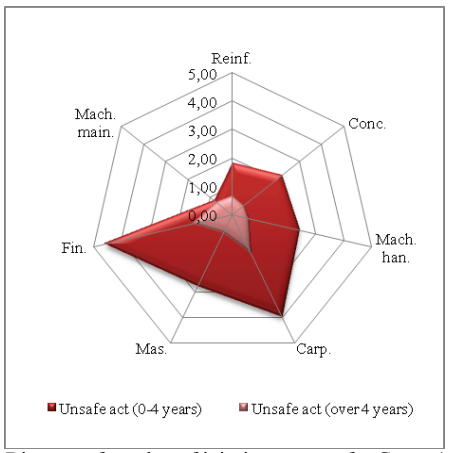

Figure 2 Diagram of number of injuries per year for Group 1 – unsafe act

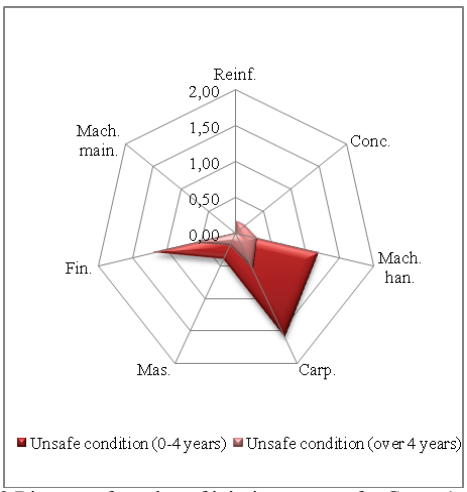

Figure 3 Diagram of number of injuries per year for Group 1 – unsafe condition

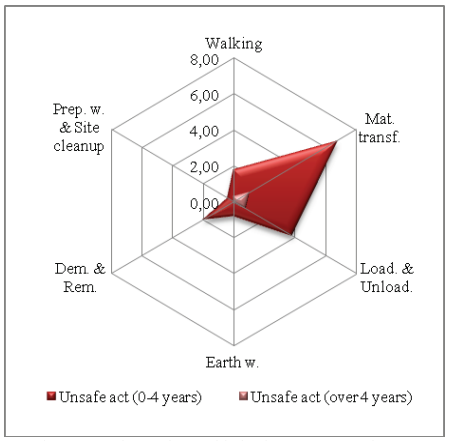

Figure 4 Diagram of number of injuries per year for Group 2 and walking without handling, working or material transfer – unsafe act

If Figs. 2 and 3 are observed, a conclusion can be drawn that all types of works from group 1 have a dominant source of injury risks related to the unsafe act, which indicates the need for additional and/or better quality training of workers throughout their working life, particularly at the beginning of their career.

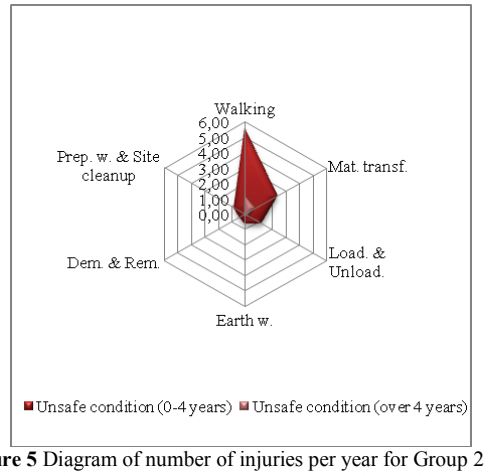

Figure 5 Diagram of number of injuries per year for Group 2 and walking without handling, working or material transfer – unsafe condition

If Figs. 4 and 5 are observed, it can be seen that the unsafe act presents a dominant source of risk in all types of works in group 2, except for Preparation works and Site cleanup, as well as the separated operation walking without handling, working or material transfer. Such data highlight the necessity of higher engagement of mechanization and equipment in order to minimize the amount of manual work. It is also essential to maintain construction sites and organize work better, in order to reduce the injury rate occurring when walking around the site, since these two causes make the most common ones for this working operation.

5 Conclusions

The paper provided an overview of the structure of construction workers in the Autonomous Province of Vojvodina (Republic of Serbia) from the aspect of experience and education level, as well as the impact of experience and education level on the frequency of injuries in realization of construction works. The research comprised 719 injuries without fatalities, which occurred within the field of building construction.

By analyzing the education structure and experience of construction workers, a conclusion was drawn that in the observed period, the largest portion in the total of workers is made of those with elementary and high school education (87,48 %). There are 17,39 % of workers with less than 4 years of experience. This data confirms the significance of planning education of workers in the field of safety at work, which should be realized immediately after hiring them.

In analyzing the relationship between the type of works and experience, construction works are divided into two groups depending on whether they require a certain level of professional training (Reinforcing, Concreting, Machinery handling, Carpentry, Masonry, Finishing works and Machinery maintenance) or do not require professional training (Material transfer - manual, Loading and unloading - manual, Earth works - manual, Demolition and Removal - manual, Preparation works and

site cleanup - manual). It should be noted that the operation of Walking without handling, working or material transfer was set apart, owing to its high importance as well as the fact that it is performed in realizing all kinds of works.

Within the analysis of frequency of injuries for the observed groups of works and also depending on the years of experience in work at which an injury occurred, it was concluded that all works which require a certain level of training are less risky within the first five years of working, whereas those works which require no training feature a higher rate of injury occurrence within the first five years compared to the average frequency of injuries in all kinds of works. This rule does not apply after the mentioned period, which highlights high significance of training for proper and safe realization of all types of works in this period. After the first five years of working, the importance of experience increases, but it can be concluded that it is essential to continue with workers' training and work control.

In order to consider the causes of injuries within the first five years of working at positions at which an injury occurred as well as in the period following it, the sample analysis according to the OSHA methodology was carried out, identifying whether the cause of injury was related to the unsafe act or the unsafe condition. In this way, it was possible to consider responsibility of workers and companies for the injuries that occurred. A conclusion was reached that the injuries occurring within the first five years of working are dominantly related to workers' unsafe act. This rule applies to all types of observed works, except for Walking without handling, working or material transfer and Preparation works and site cleanup – which indicate the existence of certain shortcomings in the training of workers for proper and safe work. Sources of injuries which are related to the unsafe condition are significant in works which do not require training, within which working environment and work position are emphasized. Also, it was concluded that with increasing experience workers get more efficient in avoiding risks related to the unsafe condition.

Future research will be based upon the analysis of influence of workers' training processes from the aspect of safety at work in the field of building construction, as well as the link between education, experience and quality of construction workers' safety training. In addition, the causes of injury occurrence will be analyzed into more detail, according to the OSHA methodology for the observed works.

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