International Scientific Conference *People, Buildings and Environment 2014* (PBE2014)
15-17 October, 2014, Kroměříž, Czech Republic, www.fce.vutbr.cz/ekr/PBE

INJURIES IN CONSTRUCTION INDUSTRY OF SERBIA – SOURCE, TYPE AND SEVERITY OF INJURY

Vladimir Mucenski[1]*, Igor Pesko[1], Jasmina Drazic[1], Milos Seslija[1], Milan Trivunic[1], Dragana Djordjevic[1]

[1] University of Novi Sad, Faculty of Technical Sciences, Department of Civil Engineering and Geodesy, Trg Dositeja Obradovica 6, Novi Sad 21000, Republic of Serbia

Abstract

In most industrialized countries, the construction industry is one of the most important branches of industry, and one of the main drivers of employment. The construction industry is the riskiest branch with the highest death rate in Serbia. The paper presents a part of research of safety at work in the construction industry of Serbia, which refers to the analysis of impact of source and type of injury on injury severity. Research was conducted in Autonomous Province of Vojvodina through the creation of an injury database and an analysis of injuries with identification of type of construction works and operations, injury sources, cause of injury, way that injury occurred, injury severity, body parts injured, data on the injured worker and data on the time of the injury. During identification of the possible causes of the injuries it was determined 66.34% of injuries were caused due to unsafe act of workers while 33.66% of injuries occurred due to unsafe working conditions. Most of the injuries were caused by improper realization of work operations. Through analysis of way in which injury have occurred, it was found that more than 30% of injuries were caused due to a fall (at the same level or at a level below), while more than 38% of injuries are caused due to struck by an object and struck against an object. Observing the severity of the injuries, most injuries are rated as medium (42.56%). Most frequently injured body parts are the foot-feet (32.41%) and hand-arm (31.99%).

Key words

Construction; database; injury; severity; source; type

To cite this paper: *Mucenski, V., Pesko, I., Drazic, J., Seslija, M., Trivunic, M., Djordjevic, D. (2014). Injuries in Construction Industry of Serbia – Source, Type and Severity of Injury, In conference proceedings of People, Buildings and Environment 2014, an international scientific conference, Kroměříž, Czech Republic, pp. 337-348, ISSN: 1805-6784.*

*Corresponding author: Tel.: +381-64-2-369-782
E-mail address: mucenskiv@gmail.com

1 INTRODUCTION

Every branch of industry generates specific risks of occupational safety that are arising from the work environment, the workplace and the necessary resources for the work operation. The number of hazardous situations depends on how the work process is organized to provide a safe work and how much the workers are trained to work in a safe manner. Increasing complexity of work processes requires more time and resources for organization of the same in a safe way. The building process has all the characteristics of a very complex process: each object that is being built is specific, the process requires a large number of participants and stakeholders, the problem of design and construction is present, a large number of different types of materials, tools and machinery is needed, the building process is exposed to weather conditions, the movement of workers, materials and machinery is present in one or more buildings, education of the workforce is low, and so on. Despite its large complexity, the building process can be fully determined (defined), but only if all elements of processes and their interconnections are identified in a systematic way. The process of observing the relationship between the elements of process and characteristic of their relations is applicable for the risk management of occupational safety as well.

Given that the construction industry is facing huge losses, especially human life, and then the working hours and financial resources, it is necessary to manage risks of occupational safety in a proactive manner. If a risk is not detected, it is reasonable to expect that it will not be given any importance and control mechanisms, which leads to various hazards. Basis of risks identification is in the historical databases, members of the management team, all members of the project (company employees who perform works, subcontractors, suppliers, etc.), external experts, and so on. Each of these members is a potential source of knowledge and experience for risk identification. However, if the knowledge arising from the project participants and previously implemented building process is not preserved in written or electronic form, the likelihood that it will be lost or unused increases. For this reason, quality databases are the most important resource in the process of safety at work risk control.

2 METHODOLOGY

Given that the existing knowledge about injuries is extremely important for a preliminary risk assessment it is necessary to easily and quickly generate them in the risk assessment process. For this reason, main research objective was to establish a database of sufficient quality in order to efficiently and accurately perform a preliminary risk assessment i.e. risk assessment at the design stage. Research that is partially shown in the paper was done on the basis of data on injuries occurred on construction sites of Autonomous Province of Vojvodina.

In order to form high-quality database, it must contain the data on an injured worker, data on the timescale of injury, data on the type of work and work operations that were realizing at the moment of injury, data on the source of injury, cause of injury, way that injury occurred and data relating to consequences of an injury (severity and injured body parts).

All the above-mentioned data sets are specially formed for the purpose of this research and proposed as the basis for risk quantification process. In order to form the best possible subdivision quality an extensive research of the existing divisions was performed. Data resulting from the research combined with the data available from the injury reports are used for forming of new divisions and subdivisions for each group of data listed in the previous paragraph.

After forming new database according to adopted structure analysis of data was performed. Analysis included impact of construction works and operations, labour force characteristics, injuries sources, causes and way in which injury occurred on the injuries frequency, severity and injured body parts.

3 CREATING OF INJURIES DATABASE – MODEL BAZA

Application of data bases has been intensified over the past 15 years, along with the development of computers and computer applications. The trend of their frequent application is present in the field of safety at work in construction industry. A group of experts from the Netherlands, Great Britain and Greece [1] has formed a data base with 10000 analysed events which resulted in injuries. The created data base is used when identifying and quantifying various types of risks, such as fall at a level below. [2] Marhavilas and Koulouriotis in [3] have presented a hybrid model of risk quantification based upon data on injuries which occurred over the period of 19 years. Based on the research carried out in China, Tam et al. in [4] have analysed a data base on 1000 accidents which resulted in the death of workers, in order to define the causes of these accidents. Data provided by the National Bureau of Statistics of China were used in this case. Hadikusumo and Rowlinson in [5] used the data base for identifying potential dangers of safety at work and planning of corrective measures. The data base is connected with an application which provides a 3D view of a building during the construction process. Chua i Goh in [6] have presented a model of causal relations with aim of identifying the risk of safety at work. They did so by using the reports on 140 injuries which occurred in building construction. Kartam et al. in [7] came to a conclusion that the creation of a national data base about events which resulted in injuries would provide better management of risks of safety at work in construction industry. Levitt and Samelson in [8] recommend creating of a data base within each construction company, in order to be able to identify the most problematic segments of the construction process.

For research purposes, a database of workplace injuries that occurred during the realization of the construction works was formed. The database was formed in order to define potential sources of risk, their connection with different types of works (earth works, concrete works, carpentry works, etc.), materials, tools, machinery and labour force characteristics. In addition, injuries data provide information about the significance of these parameters and facilitate the quantification of risk parameters (probability and consequences). The data were gathered based on work injuries reports addressed to Occupational health services of Autonomous Province of Vojvodina and are related to construction companies in Vojvodina. Analysis of injury reports has shown that a certain part of the reports relates to injuries that are incurred on building sites as well as that some of the reports do not contain all the required information. The structure of the analysed injury reports is shown in the Table 1.

Tab. 1: The structure of the analysed injuries reports

<table>
<tr><th colspan="2">Area of construction sector</th><th colspan="2">Number of analysed reports</th></tr>
<tr><td colspan="2">All areas - inside and outside the site</td><td>1158</td><td>100%</td></tr>
<tr><td colspan="2">All areas - inside the site</td><td>990</td><td>85,49%</td></tr>
<tr><td rowspan="3">Building construction – inside the site</td><td>Total</td><td>736</td><td>63,56%</td></tr>
<tr><td>Do not include key data</td><td>17</td><td>1,47%</td></tr>
<tr><td>Included in the database</td><td>719</td><td>62,09%</td></tr>
</table>

4 STRUCTURE OF DATABASE FOR INJURIES

The database is structured to provide information on as many parameters that are relevant for the occupational health and safety risk identification and quantification. At the same time the final database structure depended on the data available within the injury reports. The database consists of five groups of data: data on an injured worker, data on the time of injuries occurred, data on the type of work and work operations realized at the moment of injury, data on the source of injury, cause of injury and way that injury occurred and data relating to consequences of an injury (severity and injured body parts). Each of the data groups consists of a number of sub-groups that provide more accurate information about the parameters of the observed injuries.

4.1 Data on the source of injury, cause of injury and way that injury occurred

Information about the works and operations that were performed at the moment of injury do not provide insight into the causes of injuries. Data on the way in which injury occurred and source of injury in more detail define the risk of the type of work and working operations. Some types of works are more exposed to certain risks. For this reason it is necessary to determine which machinery, tools and materials generate risks and which are the most common ways of causing injures for observed types of works and working operations. Considering the above, the group of data on injuries causes and way in which injury occurred is formed by the following data:

- source of injury,
- causes of injury and
- way in which injury occurred.

Internal and external physical injuries of the human body can be a consequence of energy released or direct impact of hazardous materials. Considering the above, the sources of injury according to Reese and Eidson [9] can be: energy (mechanical, electrical, thermal, chemical and radiation) and hazardous materials (liquefied petroleum gas, compressed gas, corrosive materials, combustible substances, poisons, oxidizing materials and dust). In order to determine what the direct source of injury is, the following parameters were identified based on the description of reported injuries: machinery that was the source of injuries, tools that were the source of injuries, materials which were the source of injuries and equipment that was the source of injuries.

At the same time, it has been analysed:

- if these resources are direct source of an injury (breakdown of machinery, tools)
- whether an injury occurred during their improper use or
- if the injury is a consequence of the operation which was only associated to the observed resources, i.e. injury would not have occurred if the resource had not been used (for example, material takeover at the edge of the building during the use of tower crane).

Data on the source of injury in combination with data on the type of work and the working operations (which were realized at the moment of injury) precisely define the technical aspects of an injury, which enables more precise risks identification and simplifies its quantification.

Many authors have carried out research on the possible ways in which injuries have occurred and formed different classifications. In this research an analysis of several classifications was carried out, four of which were analysed in detail. Analysed classifications were formed specifically for the needs of the building process or can be easily applied for the same. Classifications analysed are: Classification according to Hallowell [10], classification made by Conte et al. [11], classification according to the Guidelines of the Administration of Occupational Safety and Health of the United States (OSHA) that is related to the safety and health in the construction industry [9] and classification according Arandjelovic and Jovanovic [12]. Analysing classification of specified authors and information from injury reports, it was concluded that the basic structure of classification of the way the injury occurred consists of eight groups:

- struck by,
- struck against,
- caught in, under, or between,
- fall,
- excessive physical strain and exhaustion of the organism,
- exposure to harmful substances and harmful environments,
- accidents occurred during transport within and outside the construction site and
- none of the above.

Determination of the cause of injury is very important for the risk identification and quantification process. If the cause of the injury is not specified, it is impossible to fully perceive all the factors of injury. Combining all the data (data about the injured worker, data on the time, data on the type of work and work operations realized at the time of the injury, data on way in which injury occurred and causes of injuries and data on the consequences of the injury) the prerequisites are established for better understanding the reasons of injury, and creates opportunities for better prevention of future injuries and changes to the building process in order to improve safety at work.

Observing the characteristics of any work process can be concluded that the causes of injury can be divided into two levels. The first level of the injury is related to the characteristics of certain work operation that caused the injury whether injured worker was realizing operation or the worker was injured by another worker (i.e. incorrect realization of the working operation or malfunction of tools). The first level is called the indirect cause of the injury. (table 2 and table 3) The second level considers the essence of the injury (basic causes) i.e., what are the reasons that led to the incorrect realization of the working operation or malfunction of tools. Two level classification was adopted pursuant to the Handbook of Occupational Safety and Health Administration of USA (OSHA) for construction industry [9] and the detailed classification was formed based on an injuries analysis according to literature [9-15] improved by using information available from the injury reports. For purpose of risk quantification, information about the indirect causes are more important whereby for the purpose of corrective measures information about both, indirect and root causes should be considered.

4.2 Severity of injury and injured body part

Within the literature, numerous classifications of severity of injuries have been defined. According to Great Britain’s Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, RIDDOR [16] , it is necessary to report two types of injuries: serious injuries which require medical treatment of the injured person, i.e. hospitalization of an injury which caused the worker to be absent from work more than 7 days without the day on which the injury occurred. Singh et al. in [17] adopt the classification according to BIFSA, Building Industries Federation of South Africa, where the consequences of injuries are divided into four categories of injuries: those requiring only the first aid, injuries which require hospitalization of a worker, injuries resulting in disabilities and fatal outcomes. Hallowell in [10] suggests a more detailed classification of severity of injuries, with the aim of a more accurate quantification of risk, dividing them into eleven categories. European Occupational Safety and Health Administration (OSHA) [18] suggests a four-level division of injuries, as follows: injuries which prevented a worker from coming to work for less than 4 days, between 4 and 14 days, between 14 days up to 3 months, and injuries which prevented a worker from coming to work longer than 3 months or resulted in the permanent loss of working ability. According to the modified AUVA method presented in [19], severity of injuries is determined according to a five-level scale. Injuries are divided into: extremely small (negligible damages, requiring only first aid), small (minor, temporary damage, maximum 15 days of absence from work), medium (temporary damage, temporary loss of ability to work, lasting from 16 to 40 days) and heavy (serious or permanent damage, inability to work longer than 40 days or permanent) and death or collective (an injury resulting in death or injuries of several persons).

Relying upon the ways of classifying injuries from the research works mentioned above and taking into consideration the requirements of the valid legislation of the Republic of Serbia, the new division of injuries was created, encompassing six categories of injuries:

- small injuries (injuries which required first aid and/or hospital treatment and absence from work of up to 4 days),
- medium injuries (injuries which required hospital treatment and / or absence from work of between 4 and 13 days),
- large (injuries which required hospital treatment and/or absence from work of 14 days minimum),
- very large (injuries resulting in the total loss of ability to work),
- death (occurring instantly or later on as the consequence of an injury) and
- multiple death (an incident resulting in death of more than one worker).

On the other hand, data on injured body parts provide more precise insight into the features of an injury and at the same time of risk as well. For particular types of works, certain body parts will be more prone to suffer an injury, whereas for some other ones this will not be the case. Which body parts will be more at risk of getting injured primarily depends on the movements carried out within certain work operations (compliance with ergonomics, incorrect realization), physical load (lifting of heavy load), application of tools (technical accuracy, accuracy of elements of protection), materials (hazardous substances), etc. By identifying those body parts which are more at risk, more efficient prevention of injuries is provided, making it easier to identify and eliminate or possibly modify certain elements of work (if possible), to diminish the risk of injuries.

Classification of an injured body part, adopted in the research, was specified after the analysis of classifications adopted by international institutions and certain authors who analysed classifications particularly for the needs of construction processes, or whose classifications could easily be applied for that purpose. These classifications are presented in [12], [18] and [20]. According to the analysis of the listed classifications and the analysis of information on injuries gathered from the reports on injuries at work, for the purpose of this research a new classification was created and applied within he observed data base. The adopted classification is shown in tables 4 and 5.

5 RESULTS AND DISCUSSION

Table 2 and Table 3 present the 42 indirect causes of injuries that are defined on the basis of newly created database and injury reports. Indirect causes were divided into three groups according to whether they are associated with unsafe act and / or behaviour of workers, unsafe working conditions or unknown. Most existing theories that define the process of injuries occurrence, such as two-factor theory, "domino" theory and the "Swiss cheese" theory presented in [10], [21] and [22] are based on two basic types of injury causes: unsafe condition and unsafe act.

When determining the cause of the injury, which was based on data from injuries reports, all relevant information such as information about the work that was performed, information on whether the worker was properly trained, whether it was subjected to medical examination, whether the worker was properly protected as well as data available from injury reports were considered. Injuries which were defined to be caused by unsafe act are the sole responsibility of the workers since there are no identified reasons for which it could be argued that injury is the responsibility of the employer. Injuries which are defined to be caused due to unsafe conditions are the sole responsibility of the employer because the employer has not fulfilled all the obligations premised in the current legislation. Injuries caused by unsafe act are a direct consequence of one of 12 indirect causes shown in Table 2.

Tab. 2: Number and percentage frequency of injuries for indirect causes of unsafe act

Code of cause	Indirect cause	Num. of injuries	
IU-RP-1	alcohol	2	0,28%
IU-RP-2	**poor housekeeping of workplace**	**42**	**5,84%**
IU-RP-3	**failure to wear PPE**	**66**	**9,18%**
IU-RP-4	horseplay	2	0,28%
IU-RP-5	incorrect movement, turning, blackouts	11	1,53%
IU-RP-6	**improper realization of work operation**	**247**	**34,35%**
IU-RP-7	**improper use of tools and equipment**	**50**	**6,95%**
IU-RP-8	improper use of ladders	6	0,83%
IU-RP-9	incorrect entry and exit from the machine	25	3,48%
IU-RP-10	improper handling of machinery	9	1,25%
IU-RP-11	overturning of vehicle	5	0,70%
IU-RP-12	improperly build material	12	1,67%
	Total	**477**	**66,34%**

Common characteristic of indirect causes presented in table 2 is that all of them can be avoided by better quality of practical trainings of workers, better safety trainings and better quality of working process control. Safety trainings are required by the Law on Safety and Health at Work presented in [23] but they are usually carried out in order to meet the statutory provisions and not to improve the quality of safety of work. As can be seen from Table 2, most of the injuries are caused by improper realization of work operations (34.35% of all injuries). This cause of the injury implied that the worker is injured due to improper realization of the operation from a practical aspect or the safety aspect. As a result of not wearing personal protective equipment (PPE), unclean workplace and improper use of tools and equipment 158 injuries occurred which makes 21.97% of the total of the number of injuries.

On the other hand, the analysis of indirect causes of unsafe conditions (presented in Table 3) showed that the highest number of injuries was due to poor housekeeping (corridors and access points) and due to the failure to ensure hazardous places such as openings, edges, working scaffolds and scaffolds. The frequency of injuries caused by failure of tools, machinery and equipment as well as due to unsafe environments is significantly lower than the previously mentioned.

Tab. 3: Number and percentage frequency of injuries for indirect causes of unsafe conditions

Code of cause	Indirect cause	Num. of injuries		Code of cause	Indirect cause	Num. of injuries	
IU-PP-1	malfunction of tools	9	1,25%	IU-PP-16	cracking of built-in materials	4	0,56%
IU-PP-2	use of defective or unsafe tools	14	1,95%	IU-PP-17	inadequate PPE	8	1,11%
IU-PP-3	malfunction of auxiliary equipment	1	0,14%	**IU-PP-18**	**poor housekeeping of corridors**	**61**	**8,48%**
IU-PP-4	use of defective or unsafe equipment	0	0,00%	IU-PP-19	poor housekeeping of access points	16	2,23%
IU-PP-5	malfunction of machinery	15	2,09%	IU-PP-20	improper control of internal traffic	2	0,28%
IU-PP-6	unsafe access ramp	4	0,56%	IU-PP-21	electrocution	3	0,42%
IU-PP-7	improper edge safety	17	2,36%	IU-PP-101	improper design of internal traffic	0	0,00%
IU-PP-8	improper pit safety	1	0,14%	IU-PP-102	excessive noise	0	0,00%
IU-PP-9	improper safety of openings	20	2,78%	IU-PP-103	exposure to radiation	0	0,00%
IU-PP-10	improper safety of trench	7	0,97%	IU-PP-104	insufficient ventilation	3	0,42%
IU-PP-11	improper safety of working scaffolds	4	0,56%	IU-PP-105	insufficient illumination	1	0,14%
IU-PP-12	improper safety of scaffolds	20	2,78%	IU-PP-106	confined spaces	0	0,00%
IU-PP-13	improper marking of hazardous places	4	0,56%	IU-PP-107	improperly stored explosive or hazardous materials	0	0,00%
IU-PP-14	improper ladder instalation	12	1,67%	IU-PP-108	lack of fire protection	0	0,00%
IU-PP-15	improper storage of materials	15	2,09%	IU-PP-109	weather conditions	1	0,14%
Total						**242**	**33,66%**

The results indicate the importance of procedures and rules in providing safe site and housekeeping. Both groups of causes are the responsibility of the company that must provide fundings for securing of hazardous places and must organize workers for regular site cleaning. The fact that 10.71% of injuries are caused by congested corridors and access points is devastating. It should be noted that site housekeeping requires a minimum investment in the form of few working hours. Also 10.71% injuries were caused due to failure in securing hazardous places (from IU-PP-6 to IU-PP-13), which unlike the previous ones require greater financial investment by the employer. Previous researches have shown that experience has a significant impact on reducing number of workplace injuries whether caused by unsafe work or unsafe conditions. [24]

Tab. 4: Number and percentage frequency of injuries by indirect causes and severity

Code of cause	Indirect cause	Severity				Total	
		small	medium	large	very large	num. of injuries	frequency
IU-RP-2	poor housekeeping of workplace	16	22	4	0	42	5,84%
IU-RP-3	failure to wear PPE	13	35	18	0	66	9,18%
IU-RP-6	improper realization of work operation	115	94	38	0	247	34,35%
IU-RP-7	improper use of tools and equipment	25	18	6	1	50	6,95%
IU-PP-18	poor housekeeping of corridors	20	37	4	0	61	8,48%
	Total	**189**	**206**	**70**	**1**	**466**	**64,80%**

If the indirect causes which lead to more than 5% of injuries and their impact on the severity of an injury are observed (Table 4), a conclusion can be drawn that in the majority of cases injuries are characterized as medium, where there are most medium, then small, then large and finally very large injuries. Such trend is not present only in the case of ‘’improper realization of work operation” and “improper use of tools and equipment”.

Tab. 5: Number and percentage frequency of injuries by way in which injury occurred, injuried body part and severity

Way in which injury occurred	**Severity**				**Total**	
	small	**medium**	**large**	**very large**	**num. of injuries**	**frequency**
dropping of object	17	17	3	0	37	5,15%
exposure to harmful substances	0	6	8	0	14	1,95%
exposure to harmful environment	0	4	7	0	11	1,53%
accidents occurred in traffic or transportation	0	0	5	0	5	0,70%
fragments, parts of materials	7	22	14	0	43	5,98%
falls at same level	55	33	5	0	93	12,93%
falls at level below	14	50	61	0	125	17,39%
excessive physical strain and exhaustion of the organism	13	27	10	0	50	6,95%
caught in, under, or between	21	25	11	1	58	8,07%
struck by machinery	2	2	5	0	9	1,25%
struck by	75	53	20	1	149	20,72%
struck against	42	67	16	0	125	17,39%
Injured body part	**small**	**medium**	**large**	**very large**	**num. of injuries**	**frequency**
head	19	19	12	0	50	6,95%
face	4	1	4	0	9	1,25%
eyes	5	25	18	0	48	6,68%
respiratory system	0	3	0	0	3	0,42%
foot – legs	81	121	31	0	233	32,41%
hands – arms	111	84	34	1	230	31,99%
body – skin	2	1	2	0	5	0,70%
body - torso	14	27	26	1	68	9,46%
multiple injuries	10	25	38	0	73	10,15%
Total	**246**	**306**	**165**	**2**	**719**	**100,00%**
	34,21%	**42,56%**	**22,95%**	**0,28%**		

Based on an analysis of ways in which injuries occurred (Table 5) it can be concluded that more than 30% of injuries are caused by a fall (at the same level or at a level below), while more than 38% of injuries are caused by “struck by” or “struck against” which indicates the most common risks that occur during the realization of building process.

Observing the severity of the injuries, most injuries are e as the medium (42.56%) while the frequencies of small and large injuries are 34.21% and 22.95% respectively. Most frequently injured body parts are the foot-legs (32.41%) and hands-arms (31.99%) which are in line with the manner of realization of work in the building processes. It should be noted that no injuries of hearing organs were reported, which can be linked with the case that this injury usually occurs spontaneously, i.e. over a certain period, and is often the consequence of partial damage usually not even reported to the employer by workers.

In order to consider in a more detailed way of impact of ways in which injury occurred on the body part affected, Table 6 was created. It can be seen that feet-legs are most commonly injured body parts, due to “falls at same level” and “struck against”, then hands-arms due to “caught in, under, or between”, “struck by” and “struck against” Head is by far the most frequently injured as a result of “struck by”, eyes due to “fragments, parts of materials”, whereas torso gets most frequently injured as a result of "falls at level below" and "excessive physical strain and exhaustion of the organism". Multiple injuries are usually caused by „falls at level below".

Tab. 6: Number of injuries by way in which injury occurred and injuried body part

Way in which injury occurred	Injured body part									
	foot – legs	hands – arms	face	head	eyes	ears-hearing	respirat. system	body – skin	body - torso	multiple injuries
dropping of object	28	9	0	0	0	0	0	0	0	0
exposure to harmful substances	2	2	3	0	4	0	3	0	0	0
exposure to harmful environment	0	3	1	0	0	0	0	2	1	4
accidents occurred in traffic or transportation	0	0	0	0	0	0	0	0	0	5
fragments, parts of materials	0	3	0	0	39	0	0	0	0	1
falls at same level	58	17	0	3	0	0	0	1	9	5
falls at level below	36	23	0	5	1	0	0	1	17	42
excessive physical strain and exhaustion of the organism	6	19	0	1	0	0	0	0	23	1
caught in, under, or between	6	42	0	0	0	0	0	0	4	6
struck by machinery	1	3	0	1	0	0	0	0	0	4
struck by	33	57	5	34	3	0	0	0	13	4
struck against	63	52	0	6	1	0	0	1	1	1
Total	**233**	**230**	**9**	**50**	**48**	**0**	**3**	**5**	**68**	**73**
	32,41%	**31,99%**	**1,25%**	**6,95%**	**6,68%**	**0,00%**	**0,42%**	**0,70%**	**9,46%**	**10,15%**

6 CONCLUSIONS

Databases represent contemporary way of risk identification and the basis for the risk management. They are a source of relevant information that must be carefully interpreted in order to avoid wrong managerial actions. The data must be comprehensive and include all relevant information about the injury.

During identification of the possible causes of the injuries it was determined that there are 42 indirect causes of injury. It can be concluded that 12 indirect causes can be associated with unsafe act of workers while 30 causes can be associated with unsafe working conditions. 66.34% of injuries were caused due to unsafe act of workers while 33.66% of injuries occurred due to unsafe working conditions.

Most of the injuries were caused by improper realization of work operations (34.35% of all injuries). 21.97% of all of injuries are result of failure to wear PPE, poor housekeeping of the workplace and improper use of tools and equipment. 10.71% of injuries were caused due to poor housekeeping of corridors and poor housekeeping of access points to work places. Also, 10.71% of injuries occurred due to improper marking of hazardous places on the site.

Through analysis of way in which injury have occurred, it was found that more than 30% of injuries were caused due to a fall (at the same level or at a level below), while more than 38% of injuries are caused due to struck by an object and struck against an object. Observing the severity of the injuries, most injuries are rated as medium (42.56%) and the frequencies of small and large injuries are 34.21% and 22.95% respectively. Most frequently injured body parts are the foot-feet (32.41%) and hand-arm (31.99%) which is consistent with the way of working in the building processes.

ACKNOWLEDGEMENT

The work was done within the scientific research project TR 36043 "Development and application of a comprehensive approach to the design of new and safety assessment of existing structures for seismic risk reduction in Serbia", supported by the Ministry for Education, Science and Technology, Republic of Serbia. This support is gratefully acknowledged.

REFERENCES

[1] Bellamy, L.J., Ale, B.J.M., Geyer, T.A.W., Goossens, L.H.J., Hale, A.R., Oh, J., Mud, M., Bloemhof, A., Papazoglou, I.A., Whiston, J.Y. (2007). Storybuilder—A tool for the analysis of accident reports. *Reliability Engineering and System Safety*, **92**, pp. 735–744. http://dx.doi.org/10.1016/j.ress.2006.02.010

[2] Aneziris, O.N., Papazoglou, I.A., Baksteen, H.M., Mud, M., Ale, B.J., Bellamy, L.J., Hale, A.R., Bloemhoff, A., Post, J., Oh, J. (2008). Quantified risk assessment for fall from height. *Safety Science*, **46**, pp. 198–220. http://dx.doi.org/10.1016/j.ssci.2007.06.034

[3] Marhavilas, P.K., Koulouriotis, D.E. (2012). Developing a new alternative risk assessment framework in the work sites by including a stochastic and a deterministic process: A case study for the Greek Public Electric Power Provider. *Safety Science*, **50**, pp. 448–462 http://dx.doi.org/10.1016/j.ssci.2011.10.006

[4] Tam, C., M., Zeng, S., X., Deng, Z., M. (2004). Identifiying elements of poor construction safety management in China. *Safety Science*, **42**, pp. 569-586 http://dx.doi.org/10.1016/j.ssci.2003.09.001

[5] Hadikusumo, B.H.W., Rowlinson, S. (2002). Integration of virtually real construction model and design-for-safety-process database. *Automation in Construction*, **11**, pp. 501– 509 http://dx.doi.org/10.1016/S0926-5805(01)00061-9

[6] Chua, D.K.H., Goh Y., M. (2004). Incident Causation Model for Improving Feedback of Safety Knowledge. *Journal of Construction Engineering and Management ASCE*, July- August, pp. 542-551.

[7] Kartam, N.A., Flood, I., Koushki, P. (2000). Construction safety in Kuwait: issues, procedures, problems, and recommendations. *Safety Science*, **36**, pp. 163-184 http://dx.doi.org/10.1016/S0925-7535(00)00041-2

[8] Levitt, R., Samelson, M.N. (1993). *Construction Safety Management*. John Wiley & Sons, Inc. ISBN 0-471-59933-6.

[9] Reese, C.D., Eidson, J.V. (2006). *Handbook of OSHA Construction Safety and Health*. Taylor & Francis Group, LLC. ISBN 0-8493-6546-5.

[10] Hallowell R.M. (2011). *A Formal Model for Construction Safety and Health Risk Management*. ProQuest, UMI Dissertation Publishing. ISBN 978-1243973634.

[11] Conte, J.C., Rubio, E., García, A.I., Cano, F. (2011). Occupational accidents model based on risk–injury affinity groups. *Safety Science*, **49**, pp. 306–314 http://dx.doi.org/10.1016/j.ssci.2010.09.005

[12] Aranđelović, M., Jovanović, J. (2009). *Occupational medicine - the first electronic edition for students of integrated academic and basic vocational studies*. Medical Faculty, University of Nis, Serbian.

[13] CHSM (2003). *Construction Health and Safety Manual*, Construction Safety Association of Ontario. ISBN 0-919465-54-4.

[14] Holt, A.St.J. (2006). *Principles of Construction Safety*, Blackwell Science Ltd. ISBN 978-14051-3446-0.

[15] Fahlbruch, B., Schöbel, M., (2011). SOL – Safety through organizational learning: A method for event analysis. *Safety Science*, **49**, pp. 27–31. http://dx.doi.org/10.1016/j.ssci.2010.05.004

[16] RIDDOR - Reporting of Injuries (2012). *Diseases and Dangerous Occurrences Regulations*. Health and Safety Executive, United Kingdom, Available at: http://www.hse.gov.uk/pubns/indg453.pdf (accessed 13 April 2014).

[17] Singh, A., Hinze, J., Coble, J.R. (1999). *Implementation of Safety and Health on Construction Sites*. A.A. Balkema Publishers, Roterdam, Holand. ISBN 978-9058090362.

[18] OSHA (2004). *Work and health in the EU - A statistical portrait*. Office for Official Publications of the European Communities. Available at: https://osha.europa.eu/fop/latvia/en/news/news_archive/work_health_eu.pdf (accessed 14 February 2013).

[19] Radonjić, B., Jelić, M., Paunović-Pfaf, J., Kovačević, Lj., Rajaković, R., Radojević, S. (2007). *Practicum for risk assessment and risk management of the workplace and work environment*. Belgrade, Serbia. ISBN 9788690911912.

[20] Lipscomb, H.J., Schoenfisch, A.L., Shishlov, K.S. (2010). Non-fatal contact injuries among workers in the construction industry treated in U.S. Emergency departments. 1998-2005. *Journal of Safety Research*, **41**, pp. 191–195.

[21] Heinrich, H.W. (1959). *Industrial Accident Prevention. A Scientific Approach*. New York, McGraw-Hill.

[22] Hinze, J., Parker, H.W. (1978). Safety, productivity and job pressures. *Journal of the Construction Division*, ASCE, **104**(1), pp. 27−35.

[23] Law on Safety and Health at Work. Official Gazette of RS", no. 101/05, 2005. Available at: http://www.minrzs.gov.rs/files/doc/bezbednost/zakon%20o%20bezbednosti%20i%20zdravlju%20na%20radu.pdf (accessed 1 June 2014).

[24] Mučenski, V., Peško, I., Trivunić, M., Ćirović, G., Dražić, J. (2013). Identification of Injury Risk in Building Construction – Education, Experience and Type of Works. *Technical Gazette*, **20**(6), pp. 1011-1017. Available at: http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=165749