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Analysis of Occupational Accidents in Construction Sector in Turkey

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***Abstract*— Due to the inadequacy in measures at many construction sites in Turkey, approximately 400 workers died and hundreds of workers become permanently disabled in occupational accidents. Occupational accidents cause serious financial loss for both the company and the country economies. This study is conducted to analyze causes and results of occupational accidents at a construction site in Istanbul-Turkey. Research data consists of the occupational accident statistics of 2012-2013 time period of a construction site in Istanbul, which is obtained by using 'Retrospective Cohort' method. In this study, causes and results of occupational accidents, which occurred in the construction site, are investigated.**

The main reasons for accident occurrence are being hit by dashing and flitting objects', 'being hit by objects', 'falling objects' and 'being stung by something'. As a result of occupational accidents, injuries occurred in the form of incision, exposure to metal burrs, contusion, transient loss of vision, trauma and perforation. Eye, finger, foot and hand injuries are the most common accidents. The majority of occupational accidents occur on Mondays, in summer months and between the hours 16.00-18.00. The most important reason of occupational accidents is 'unsafe behaviours' with a rate of 67 %, which is defined as not to obey the rules although the necessary occupational safety measures are provided. Due to occupational accident statistics is not kept enough in Turkey, "accident incidence rates" is lower than the actual rate. According to the survey results, construction occupational accidents incidence rate is at least 6.5%. This rate is 6-10 times more to other sectors in Turkey and all European countries. In Turkey, construction safety performance is much worse than developed countries.

Keywords— safety, construction, accident analysis, preventive methods

I. INTRODUCTION

Occupational accidents cause serious social and economical problems due to physical injuries and loss of life. In every year, 60.000 fatal accidents occur worldwide in construction sector and one worker dies because of an occupational accident in every 10 minutes. Construction sector involves high risks due to its production processes and labor intensive characteristic and the sector is faced with financial loss in large scale because of occupational accidents. Occupational accidents have a significant importance for sustainability of enterprises due to their costs and environmental impacts [1, 2, 3].

Construction is referred as heavy industry due to the equipment used and the complexity of the total production processes. Construction industry uses and produces a wide variety of manufactured components in addition to basic construction materials. There is a major manpower requirement to maintain production in a construction site under hard working conditions with hazardous materials and machines. Construction is an extremely complex business, which means quite complicated tasks have to be performed simultaneously [4, 5, 6].

Construction sector, which has a great contribution to economic development with its employment capacity and added-value to the economy, is one of the most important sectors in developing countries. On the other hand, occupational accidents frequently occur, due to the lack of preventive measures.

According to Turkish Social Security Institution statistics, the number related with occupational accidents is at an alarming level (see Table 1). 6,000-9,000 occupational accidents occur and approximately 400 workers die and another 400 workers become permanently disabled in these accidents, annually. 34 % of the deaths related with occupational accidents occur in construction sector. It is also observed that occupational accidents and deaths tend to increase in recent years.

Studies show that occupational accidents and diseases in construction sector cause serious financial losses in Turkey. In a study published in 2008, it was indicated that the occupational accident related added-value losses are 1.6 % of the total added-value in construction sector. In a study conducted in 1995, it was calculated that the death rate was 730 for 10 million working hours in whole sectors while the rate is 1430 in construction sector. One worker becomes 'disabled' for every 10 million $ gross national product contribution to the economy [7, 8, 9].

Table 1. The Number of Occupational Accidents, Occupational Diseases, Fatalities and Permanent Disabilities in Turkish Construction Sector (Turkish Statistical Institute)

Years	2005	2006	2007	2008	2009	2010	2011	2012
Accidents	6480	7143	7615	5574	6877	6437	7749	9209
Diseases	3	5	16	6	9	31	16	30
Permanent Disability	324	428	364	377	2188	319	406	568
Fatality	290	397	359	297	156	475	570	256
Ratio in Total Fatality	26%	25%	34%	34%	13%	33%	33%	34%

Occupational accidents in construction sector are investigated in many different studies. Main reasons of these accidents are; inadequacy of trainings and personal protective equipment that provided to employees, not implementing “working at height” methods, not carrying out periodic maintenance and systematic environment measurements, working with subcontractors and inadequacy of inspections. In addition, managerial faults stand out during analyzing the reasons of accidents. It was observed that some major and minor occupational accidents were not recorded, reasons of these accidents were not analyzed, risk assessments were not prepared well enough and precautions were not managed and thus, it is asserted that accidents occur due to these lacknesses [3, 10, 11, 12, 13, 14, 15, 16, 17, 18].

There are limited studies related with causes and results of occupational accidents in Turkish construction sector. The main causes of accidents are as follows; being unprepared for the rapidly increasing demand; the subcontractor system that cannot work regularly; the lack of qualified intermediate staff; the lack of education of employees in the construction sites and the lack of audit.

Based on the evaluation of past accidents, the risk of possible accidents in construction sites depend on five different reasons; falling from height, falling objects and being hit by objects, machinery and crane accidents, electric shock, and explosion. In Turkey, 90% of workers are subcontracted from third party companies in construction sector. Subcontractor system, which is commonly used in construction sector, limit the organization and to take measures for workers’ health and safety [19, 20, 21].

Analyzing occupational accidents occurred in construction sites is important for identifying risks correctly, preparing occupational safety plans in workplaces, conducting occupational safety works systematically and avoiding from accidents that might occur in the future.

The aim of this study, which is based on result of a research conducted in a construction site in Turkey, is to classify occupational accidents in construction sites, to specify dangerous behaviours of workers and the results derived from these behaviours, which can cause accidents. The study aims to determine the results of occupational accidents in terms of workers and enterprises.

On the other hand, due to occupational accident statistics is not kept enough in Turkey, “accident incidence rates” is lower than the actual rate. General occupational accident incidence rate for all sectors is calculated and published in Turkey; however, sectoral occupational accident incidence rates are not calculated, separately. The study is also aimed to determine a realistic incidence rate of accidents in construction sector by using accidents and insured workers data in construction site and compare with the overall country incidence rate. Thus, the real socio-economic results of occupational accidents will be presented in construction sector in Turkey.

II. MATERIAL AND METHOD

Research data is obtained from 2012-2013 occupational accidents statistics of with “Retrospective Cohort’ method in a construction site in Istanbul-Turkey. In this study, 200 occupational accidents, which occurred in the site between February 2012 - November 2013, are investigated. Data is collected from the occupational physicians and safety experts’ accident reports for registered occupational accidents. The process of obtaining data with cohort method was monitored by occupational safety consultant of the construction site.

Retrospective Cohort Method is widely used in medical research and monitoring. In these types of studies, cohort is created in a previous time. Exposure and diseases are observed based on records collected during that time. At the planning stage of studies, it is determined how to create cohort and how long it is monitored by researchers. In the next step, the exposure conditions of patients in the cohort and the results are analyzed. It is determined how to define criteria for exposure at the planning stage. At the end of monitoring time, cause-effect relationships between accident and exposured risk factors are investigated. Retrospective cohort method is widely used in the investigation of workplace accidents [17, 22, 23, 24, 25, 26, 27, 28].

Data collection was carried out with the permission of the construction enterprise. Firstly, the software is designed to make data collection easier. Then, occupational health and safety personnel (site safety experts, occupational physician and occupational health nurse) were informed about the program. Data collection process was followed by weekly periods; occupational accidents and exposure information were recorded in detail during 22-month period.

Visual Basic based software (Accidents Analysis and Management System) is developed for analyzing detailed occupational accidents easier and faster. This software offers obtaining large amount of data about occupational accidents from the chosen site. In the light of the collected data by means of the computational software, 200 major and minor

accidents in construction site were determined and classified by types, the causes and demographic characteristics of exposed workers by analyzing all of the factors that cause occupational accidents. The victim's age, gender, education level, department, cause of accident, accident date, type of the injury and accident, workday losses and other related information were collected. The findings of 'accident investigation reports' must be considered in order to determine the causes of the occupational accidents.

The total of workdays was 290; monthly average number of workers was 302; the total working hours was 700,640 for the construction project in 2013. 2 serious occupational accidents, a 'falling from height' and a 'falling object', occurred during the project and both of them resulted with disability more than 30 days.

Occupational accident incidence rate is calculated for all sectors and published by the Turkish Social Security Institution. Based on Turkish Social Security Institution insured workers and occupational accident records, the annual incidence rate of occupational accident is calculated by the following formula:

* Occupational Accident Incidence Rate (OAIR) = NOA / (NDPA x 8) / 225,000

NOA = *Total number of occupational accidents in a year*

NDPA = *Total number of days worked by all insured persons during calendar year (multiplied by 8 hours per day)*

225,000 = *Base for 100 equivalent full time insured person (working 45 hours per week, 50 weeks per year)*

Occupational accident incidence rate at the site is also calculated in same way. Including the full-time and temporary employees, total occupational accidents number occurred in site in 1-year period between February 2012 January 2013 was divided by total working hour and 225000, respectively. In this way, occupational accident incidence rate was calculated at the site. The accident incidence rate calculated on the construction site was compared with the overall incidence rate in Turkey and EU countries.

III. RESULTS

29 %, 21 % and 13 % of workers who exposed to occupational accident in construction site are unqualified workers, molders and plumber, respectively. Because the monitoring period is rough construction stage, occupational accidents occurred for these occupational groups more. Besides, the great number of unskilled workers in the construction site causes more occupational accidents for these occupational groups.

Young workers are highly employed due to the heavy duty conditions in construction sites, age groups of 18-24 and 25-39 are exposed to 44 % and 52 % of occupational accidents, respectively. In consideration of the age group of 18-39 is exposed to 96 % occupational accidents, it can be understood that young workers sustain injuries more (see Table 2).

Table 2. Duties and Age Groups of Workers Exposed to Occupational Accidents

	Age of Workers (%)				
Duty of Workers (%)	18 - 24	25 - 39	40 - 54	40-54	**Total**
Watchman				1	**1**
Painter	1	4			**5**
Smith	5				**5**
Mason	3	1			**4**
Unskilled Worker	12	17			**29**
Ganger		1			**1**
Electrician	1	6			**7**
Foreman		1	1		**2**
Administrative Personnel		1			**1**
Molder	11	10			**21**
Welder		1	1		**2**
Fitter	3	1			**4**
Operator			1		**1**
Plasterer	1	3			**4**
Plumber	7	6			**13**
Total	**44**	**52**	**3**	**1**	**100**

'Dashing or flitting object' is the most common reason for occupational accidents in the construction site with a rate of 23 %. All of these types of accidents are exposed by young workers, who belong to 18-39 age group. 'Being hit by objects' (18 %) is the second most common type of accident. After these, 'falling objects' (15 %), 'being stung by something' (11 %) are the most common reasons, respectively. Besides, workers who are in the age group of 25-39 and 18-24 are mostly exposed to 'being hit by object' (12 %) and 'being hit by dashing and flitting object' (12 %), respectively (see Table 3). 'Falling objects' accidents are also affected noteworthily to the workers in the age group of 25-39. Due to power and strength requirements, manual handling or handling with the aid of some equipment, are performed by young workers more, it can be deduced that young workers expose to 'falling objects' accidents more.

Worker, who are above 40, generally don't work on active duties. Skilled workers, foremen, chiefs, technicians and administrative personnel expose to occupational accidents less.

In addition, it is observed that unskilled worker exposure to 'being stung by an object' with the rate of 7 %; plumbers and unskilled workers exposure to 'being hit by dashing or flitting objects' with the rate of 6 %. Also, molders expose to 'falling objects' by 5 % and electricians, molder and plumbers expose to 'being hit by an object' by 4 %.

Table 2 presents the 63 % of all occupational accidents are exposed by unskilled workers, molder or plumbers. These workers, who are uneducated and

even illiterate, are faced with difficulties in adapting to the rules of occupational safety, they pay no attention to the rules, disuse the equipment and it result in fatal accidents. Some of these workers are employed for a brief and temporary period and thus, they have difficulties in adapting to physical and working conditions. Besides, because the workers are employed for a temporary period; they are forced to work rapidly since they are undeclared worker. It is obviously seen that these conditions invite the accidents.

Construction includes processes that require working at height during the project. Falling from height accidents mostly cause death or severe injuries, unless the necessary measures aren't applied. Strict measures are taken in the construction site in which this research is prepared. Equipments for working at height are determined and supplied in consequence of appropriate risk assessments. Workers are educated on working at height and monitored strictly for applying the rules. Nevertheless, a falling from height accidents occurred that resulted with severe injury. This accident isn't counted in the table. 3 falling from low-height accidents, which resulted with minor injuries, are assessed.

The most common result of injuries from occupational accidents is 'incision' (29 %). Incision is followed by exposure to metal burr (14 %), contusion, transient loss of vision and trauma (11 %) and perforation (10 %). Eye, finger, foot and hand are the most common injured body parts with ratios of 25 %, 19 %, 12 % and 11 %, respectively (see also Table 4). Eyes are effected most (14 %) by the metal burrs that are produced as a result of hot working such as metal cutting and welding processes; fingers (11 %), hands (8 %) and face (5 %) are effected most by frequent use of drilling and cutting tools; feet are effected most by falling objects with a result of perforation. Due to exposure to chemical vapor, hot weather and intense beam; transient loss of vision may occur (11 %).

Table 3. Distribution of Types of Accidents with Respect to Age Groups

	Age of the Worker (%)				
Type of Accident (%)	18-24	25-39	40-54	40-54	**Total**
Falling from the same level	3	3			**6**
Hit to an object	2	6	1	1	**10**
Being stung by an object	6	4	1		**11**
Being hit by an object	6	12			**18**
Dashing or flitting object	12	11			**23**
Being squeezed between or under two people	5	1			**6**
Fight		1			**1**
Exposure to welding beam	1				**1**
Exposure to chemicals	1				**1**
Falling object	4	10	1		**15**
Drifting or rubbing	1	1			**2**
Falling from height	1	2			**3**
Being forced	2	1			**3**
Total	**44**	**52**	**3**	**1**	**100**

Several processes are performed with an intense usage of labor force. Thus, these processes include accident risks that may cause not only partial injuries for different organs but also major injuries to the whole body and can result in even death. Because the necessary measures are taken, personnel protective equipment (PPE) and educations are provided completely in the construction site in which this study was applied, most of the accidents are got off lightly. On the other hand, because these measures aren't taken in many construction sites in Turkey, a great number of deadly occupational accidents occur.

In addition, most of the occupational accidents in the construction site occur on Monday (23 %). Tuesday (17 %), Wednesday and Saturday (15 %) are the other days on which accidents occur commonly. Due to the lack of motivation after weekend holiday, it is meaningful that Mondays are the days on which accidents occur most. While occupational accidents occur more frequently in summer months, they occur less in winter months due to the cold weather and slow process. Besides, it is determined that 40 %, 50 % and 10 % of the occupational accidents occur during first 3, during 4^{th}-6^{th} and during 7^{th}-8^{th} working hours, respectively.

Dangerous behaviors that may cause an accident and the places at which an accident occur are investigated within the scope of the research. According to the results, the main reason of the accidents is 'unsafe behaviours' (67 %) which can be defined as not to obey the rules despite the safety measures are taken. The second most common cause of accident is not to use the personal protective equipments (12 %). Using the equipment and tools in a dangerous way is the third most common reason (8 %). 'Working dangerously fast' and 'unsuitable stowing and loading' are also important reasons of accidents.

While the majority of the accidents (62 %) occur in the building which is constructed, 28 % of the accidents occur at open fields in the construction site (see Table 5). The remarkable fact in the data is determining that a significant amount of accidents occur not only in the buildings that are constructed but also at outdoor environments as open construction fields. Especially the number of accidents, which occur as a result of falling objects that carried by heavy duty vehicles, must be less. These results show that the measures taken in the outdoor environment are inadequate and neglected.

Table 4. Effected Organs and Type of Injury as a Result of Occupational Accident

	Type of Injury (%)											
Effected Part of the Body (%)	Bruise	Sprain	Exposure to metal burn	Perforation	Contusion	Transient loss of vision	Trauma	İncision	Fracture	Ambustion or Scalding	Torn	**Total (%)**
Foot		1		7			3		1			**12**
Leg	4	2			1		2					**9**
Waist					1							**1**
Wrist							1	1				**2**
Hand					2		1	8				**11**
Chest					1							**1**
Eye			14			11						**25**
Skull								2	1			**3**
Arm	1			1			1	1		1	1	**6**
Ear								1				**1**
Shoulder	1				1		1					**3**
Finger				2	5		1	11				**19**
Back							1					**1**
Face	1							5				**6**
Total (%)	**7**	**3**	**14**	**10**	**11**	**11**	**11**	**29**	**2**	**1**	**1**	**100**

Table 5. Distribution of the Reason of Accidents According to the Departments

	Place of the Accident (%)					
Dangerous Behaviours of Workers that Cause Accident (%)	Open field in the construction site	Workshops	Indoor	Offices	Roads in the construction site	**Total**
Working for other than its own duty			1			**1**
Unsafe behaviour	15	2	44	1	5	**67**
Disobey the work discipline			1			**1**
Not to use personal protective equipment	5		6		1	**12**
Using dangerous tools and equipment	3		5			**8**
Working dangerously fast	3		2			**5**
Carrying or loading dangerous loads	2	1	1			**4**
Not to use suitable personal protective equipment			1			**1**
Tiredness and lack of sleep			1			**1**
Total	**28**	**3**	**62**	**1**	**6**	**100**

IV. DISCUSSION

In this study, 200 accidents are defined to the software for examination. The result of this study shows the facts about the ages, occupation and education level of the victims, injured parts of the body, severity of injury, unsafe behavior that cause accidents and types of accidents. There have been no fatal accidents in the site during the research period. Only 2 severe injuries occurred. Nevertheless, it is known that minor occupational accidents, which are not considered sufficiently and even not registered, cause great financial loss in workplaces.

According to the results of the study, 29 % and 21 % of workers, who are exposed to occupational accident, are unskilled workers and molders, respectively. 44 % and 52 % of the accidents affected workers in 18-24 and 25-39 age groups, respectively. Majority of the accidents caused by 'dashing and flitting objects', 'being hit by an object', 'falling objects' and 'being stung by an object'. The injuries as a result of accidents are 'incision', 'exposure to metal burr', 'transient loss of vision', 'trauma' and 'perforation', respectively. Eye, finger, foot and hand injuries are the most common areas that affected from the injury. Most of the accidents occur on Mondays, in summer months and during 4^{th}-6^{th} working hours.

According to the results of this research, 'unsafe behaviours', which is defined as not to obey the rules despite the necessary measures are taken, is the most important reason for accidents with a rate of 67 %. Not using the 'personal protective equipment' and 'using the tools and equipment in a dangerous way' are the other important causes of accidents. In spite of all warnings, measures and trainings, personal protective equipments aren't used effectively and regularly. Especially hand tools and lifting machines such as crane and forklift are used in dangerous way and for the wrong purposes.

The physical, mechanical and personal protective measures are taken at a good level in the construction site. Risk analyses are prepared and updated regularly. There are occupational safety specialist, occupational physician and site control officers in the construction site. The equipments are maintained and controlled periodically, personal protective equipments are provided and and workers are trained, regularly.

Working hours are arranged in accordance with legal limitations. Therefore, except the 2 severe accidents, which resulted with disability for more than 30 days, no accidents occurred that may result with permanent disability or death during the duration of the project.

On the other hand, despite all of the measures and controls, dangerous behaviours of the workers can't be prevented. Workers avoid obeying the rules and are poor in terms of occupational safety culture. Workers have a low general and vocational education level. In general, they are young, brave and excited. Fatalistic beliefs prevail among the workers in accordance with the national traditions of Turkish people. Therefore, the managers and engineers remain incapable to prevent the dangerous behaviours despite all efforts and measures.

Hundreds of serious accidents occur in Turkey due to lack of attention, dangerous behaviours, disregarding the occupational safety rules, disapplying the rules of working at height, disusing of the lifting vehicles and hand tools, which have a high potential for accidents, lack of maintenance and control of the equipment, lack of experts, technical staffs, inspections and trainings. While 400 workers dies in every year in construction sector, approximately 400 workers become permanently disable also. 35 % of these deaths occur as a result of 'falling from height'.

However, occupational accident statistics in Turkey are far from the truth due to sweeping the events under the carpet, informality, unregistered worker. Besides, public officers working in construction sites are not taken into account in the statistics since they are not considered as workers. Moreover, the enterprises aren't attentive to keep proper records and being a part of statistics analysis. Thus, the total financial losses can't be calculated in many enterprises.

127 accidents were occurred in 1 year period from February 2012-January 2013 at the construction site which conducted the survey. Including full-time and temporary workers, workers have done 869760 working hours totally in site. Occupational accidents incidence rate is calculated as 6.5 per 100 worker (or 6500 per 100000 worker) in site by using Social Security Institute calculation method (127 / 869760 / 225.000). The occupational accident incidence rate is 0.55 for all sectors in Turkey in 2012. According to the survey results, construction occupational accidents incidence rate is more than 10 times to other sectors in Turkey.

Occupational accidents incidence rate is 1614 per 100 000 worker in EU. Incidence rate calculated as 2085 in Germany, 2807 in Portugal, 2373 in France, 1851 in Holland, 1810 in Austria and 891 in UK, respectively [29, 30]. Occupational accident frequency rates are high in the construction sector in all countries relatively. However, Turkey's situation is much worse than the all European countries.

In addition, the majority of occupational accidents occurred in the construction industry are not reported to the social security institution. Thus, the official data not reliable. Although the safety measures taken at a good level, occupational accidents incidence rate was 6.5 in site. In many small-scale construction worked in poor conditions, thus, hundreds of workers die from occupational accidents or seriously injured. In this case, it makes difficult to take the adequate preventive measures and calculation of financial loss caused by accidents.

V. CONCLUSION

Keeping the statistics, investigating the causes and results of all accidents and taking measures according to these data are crucial requirments. Financial and moral losses of occupational accidents cause important socio-economic problems for sustainable developing enterprises, environment and society.

Although the main reason of the accidents is determined as 'dangerous behaviours of the workers', it is also well known that 'managerial faults' have an important effect on the accidents. In brief, ignorance, disregarding and lack of equipment, which are the main reasons of dangerous behaviours, must be investigated and thus, the necessary measures must be taken in order to minimize these reasons. At this point, systematic trainings of occupational safety play a key role.

Besides, the workers must report the improper practices, obey the occupational safety rules and demand from administration to take measures. All employees have to pay attention to use PPE. Educational, instructional and informative occupational safety seminars, which cover all topics and risks, should be conducted. Necessary interventions should be done to avoid mistakes after examining the occupational safety reports that are prepared by both company and whole sector. Trainings should be given regularly until the workers interiorize the usage of personal protective equipment as an obligation.

Duties shouldn't be given to a person who doesn't have enough expertise. Alerts and warning signs must be prepared and placed in accordance with the work type and all workers must pay attention to these signs. Necessary controls should be applied permanently in all electricity areas. Permanent measures for environment should be taken for work performed in closed areas. PPE should be defined and classified according to the work and material.

A majority of accidents occurred in the construction industry are not reported to the authorities. Occupational accidents incidence rate is very high in the construction sector in Turkey. Occupational accidents records should be kept and be reported to the Ministry of Labour including types, causes, and demographic characteristics of the affected employees. Despite legal sanctions brought by OH&S

Act, enterprises are not supervised enough on this issue.

It is well understood that occupational safety related studies in construction sites should be carried out within the frame of a management system and detailed report of occupational accidents occurred in the sites should be kept. Risk assessment studies should be focused and revised in the light of examination of causes and results of accidents in detail. In order to minimize the occupational accidents and protect the workers in a long term, traditional production methods should be replaced with developed production technologies.

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