Industrial Health 2013, **51**, 581–595

Original Article

Analysis of Construction Accidents in Turkey and Responsible Parties

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Received August 24, 2012 and accepted August 22, 2013
Published online in J-STAGE September 27, 2013

Abstract: Construction is one of the world's biggest industry that includes jobs as diverse as building, civil engineering, demolition, renovation, repair and maintenance. Construction workers are exposed to a wide variety of hazards. This study analyzes 1,117 expert witness reports which were submitted to criminal and labour courts. These reports are from all regions of the country and cover the period 1972–2008. Accidents were classified by the consequence of the incident, time and main causes of the accident, construction type, occupation of the victim, activity at time of the accident and party responsible for the accident. Falls (54.1%), struck by thrown/falling object (12.9%), structural collapses (9.9%) and electrocutions (7.5%) rank first four places. The accidents were most likely between the hours 15:00 and 17:00 (22.6%), 10:00–12:00 (18.7%) and just after the lunchtime (9.9%). Additionally, the most common accidents were further divided into sub-types. Expert-witness assessments were used to identify the parties at fault and what acts of negligence typically lead to accidents. Nearly two thirds of the faulty and negligent acts are carried out by the employers and employees are responsible for almost one third of all cases.

Key words: Industrial accidents, Occupational health and safety management system, Risk management, Work environments, Work hours

Introduction

Construction is one of the world's biggest industries that includes jobs as diverse as building, civil engineering, demolition, renovation, repair and maintenance. It accounts for a large proportion of GDP − for example, 10% in the U.K. and 17% in Japan. Despite improvement in safety management[1, 2], fatalities are still frequent. Construction workers are exposed to a wide variety of hazards on the job. All around the world, at least 108,000 workers are killed on sites every year, this figure represents about 30% of all fatal occupational injuries. In China, there were an estimated 3,000 construction industry fatalities in 2003 alone[3]. In Korea, the construction industry was responsible for greatest number of fatalities among all industries[4]. Data from a number of industrialized countries show that construction workers are 3 to 4 times more likely than other workers to die from accidents at work[5]. In the developing world, the risks associated with construction work may be 3 to 6 times greater than other industries. The data from National Safety Council of the U.S. showed that the construction industry accounted for 5% of all workers, but 20% of all fatalities and 9% of all serious injuries and disabilities[6]. Similarly, in the U.K. construction industry accounted for five times more fatalities than the average of other industries, and twice the number of injuries[7, 8].

In Turkey, the 2011 official statistics reveal that construction accounts for 6.3% of the labour force and 33.5% (570 in 1700) of total fatalities for all industries. The high rate of fatalities in the construction industry is consistently

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observed in the years between 2000 and 2011[9]. In 2011, the construction industry accounted for 6% of the GNP with and 8.5% growth from previous year and 1.581 million individuals were employed by the construction industry. Construction Industry Employment Index for Buildings has increased from 69.2 to 75.0 (that is 75 percent of construction workforce easily find jobs) and for Other Structures has increased from 98.9 to 104.6. As these figures show, the construction industry is playing a significant role in the economic development of Turkey[10]. However, the industry has the reputation of being one of the most unsafe industries in Turkey and compared with other industries.

Literature Review on Accident Analyses in the Construction Industry

Previous research on construction fatalities has focused on general causes or causal relationships on sites. It is shown that project features and different design preferences have effects on multi-causal and complex nature of the construction accidents[11, 12]. Researchers have also investigated and analyzed historical data for construction accidents as well as near misses from different countries, to shed light on underlying causes of fatal construction accidents and provide proper information for mitigation and abatement techniques on sites[13–19]. There is also great deal of research that focuses on the specific causes of construction accidents, such as research on heavy equipment activities, related risks and accidents[2, 20–25]. It is striking that an overwhelming portion of fatal construction industry accidents resulted from falls from height, therefore, these accidents have received a great deal of attention for years. Falls from roofs, slips or trips, scaffold safety, protective equipments, modern prevention techniques have been a research field for different practitioners as well as academicians[26–36]. Although, accidents due to being struck by or against falling objects and/or equipment generally rank second or third in total accidents, they are usually analyzed in general studies that seek to understand the causes of construction accidents as a whole. However, some research mainly focused on those types of accidents[37, 38]. Ranking second or third in terms of fatalities, electrocutions are also an important class of accidents in the industry. Research performed to investigate electrical fatalities among construction workers as well as to establish scenarios and flow diagram analysis of the electrical fatalities in the industry[39–44]. Accident analyses for different work sites with different sizes within the construction industry are crucial for investigating fatalities and establishing a risk assessment models. It is also worth mentioning to cite some recent studies for building, tunneling and highway work zones, because of the fact that they reveal not only characteristics of accidents on those projects but also the causal relationship between the accidents and size of construction sites[45–50].

In Turkey, both the number of fatalities and the share of total work-site deaths, which the construction industry is responsible for, reflect poor conditions on construction sites. However, research on the causes of construction accidents in Turkey is very limited. Müngen[51] provided the first attempt to classify the construction injuries in the Turkish construction industry. This study resulted in higher number of visits to the Social Insurance Institution (SII) General Directory archives and insurance claim records for construction injuries were separated from other accidents. The analysis of these records has facilitated a better understanding of the nature of safety in the Turkish construction industry. Müngen and Gurcanli[52] and Gurcanli *et al.*[25] analyzed equipment and motor vehicle accidents from the archives of the Social Insurance Institution. Gunay *et al.*[53] analyzed hospital records and evaluated occupational injuries and mortalities from the point of view of forensic medicine. Medical researchers have conducted a retrospective study of industry fatalities by investigating the records of occupational deaths between 1990 and 2001 in the Kocaeli District of Turkey. Fatal occupational injuries in the construction sector were investigated in detail by evaluating the records based on data from 153 deaths[54]. Unsar and Sut[55] presented a general assessment of occupational accidents between 2000 and 2005 including the construction industry. In addition, Gurcanli[56] investigated 956 expert witness reports and analyzed third party and child deaths on sites in order to determine the responsible parties for the accidents. Ceylan[57] compares mining, metal and construction industries between the years of 2004 and 2010, by the aid of official statistics. Baradan[58] evaluates the occupational safety and health regulations and standards in Turkey and in developed countries by addressing regulations, related institutions and applied practices. Additionally, Arslan and Kıvrak[59] performed investigations among construction workers to assess the level of safety training and culture and Cecen and Sertyesilisik[60] recommends a practical, economical and functional fall protection system in their study by giving technical details. Unfortunately, published international literature is very limited for occupational accidents in Turkish construction industry, but research have been performing since the

beginning of 2013, in other words after the publication of new Occupational Safety and Health Law (No: 6331, 29.12. 2012). A detailed and comprehensive analysis of occupational accidents in Turkish industry has yet to be carried out. This study is designed to fill this hole in the literature, addressing the needs of researchers, academics and safety professionals, not only from Turkey, but any individuals who would like to understand the characteristics and specific risks in the construction industry for employers and related parties. Since the progress in construction safety has only happened very recently and detailed and satisfactory data have not collected for recent years yet, analyses of the historical data become very important also to compare before and after new Occupational Health and Safety Law. This study will be beneficiary for academicians as well as practitioners who will implement new law and related very new regulations on construction sites.

Materials and Methods

Data collection from the expert witness reports

The source of data is the expert witness reports, which are more reliable and comprehensive than official statistics and records archived in Social Insurance Institution of Turkey (SII). Because SII only stores the cases whose legal procedures are completed and lacks a proper classification or documentation system for the causes of construction accidents. This study analyzes 1,117 expert witness reports submitted to criminal and labour courts collected, accounting for 1,149 fatal and non-fatal injuries. These reports are from all regions of the country covering the years between 1972 and 2008. The time span may seem excessive to derive meaningful conclusions. However, until 2012 (the issue date of new Occupational Safety and Health Law is 20.06.2012, Law Number 6331) construction industry has used the regulations of Health and Safety (in general) issued in 1973 and Construction issued in 1974. Therefore substantial governmental safety policy changes have been observed recently since the government efforts for preparing a new occupational health and safety law began in 2007. Moreover, substantial technical advances regarding occupational safety in construction is very new in Turkey and future studies may compare accident statistics before and after the new Law and related regulations revealed. It should also be noted that, since in insurance claims judicial action and law suit may take many years, in many cases, the authors and their colleagues wrote expert witness reports for incidents that occurred 15 years prior. In the Turkish legislative system, judges of the criminal and labour courts demand expert witness, primarily academics, in most occupational accident cases. In Turkey, when an accident occurs, an investigation is executed by the public prosecutor. If the public prosecutor decides that someone is at fault or that there had been an act of negligence, then documents are sent to criminal court and an official investigation assigns fault in the accident. This final verdict is regularly based on an expert witness report that provides information about responsible parties, technical deficiencies and negligent acts. Labour courts are responsible for the issue of compensation and in those cases the final verdict again is reached with the aid of expert witness reports. Below we discuss the procedures of an expert witness investigation to better understand the data from expert witness reports. The preparation of an expert witness report typically involves an investigation of the premises of the accident and the judicial documents (if they exist) such as statements made by witnesses and defendant, preliminary official record and drawing of the location which the accident occurred, accident report written by employer, statements made by the victim of the accident and his/her relatives, statements made by the employees responsible for safety in the company, investigation record and photos, contracts between prime and subcontractors, technical specifications of the work done and equipments being used, previous expert witness report (s)[52]. Many of the expert witness reports prepared by the authors and information from those reports have broader information. Authors created a codification system to enter the information from the reports and/or court files into spreadsheets for analyses.

Classification of accidents

From the expert witness reports, we recorded the consequence of the incident (fatal or non-fatal), the date and hour (time of day, day of the week, month, year), the main causes of the accident (falls, electrocutions, etc.), the type of construction site, the occupation (trade), the job or activity at time of the accident and responsible parties. We further divided construction accidents into sub-types, for instance the major accident class "fall" was further divided into falls from a ladder, falls from scaffolding or falls due to a collapse of a structure, etc. These classifications were designed to address the questions of "how," "who," "when," "where," and "with what" for accidents with serious or fatal consequences. While other details may be relevant for our analyses, some critical information, like the ages of the victims, typically goes unreported, and is unavailable from the sources. The results of these analyses are shown in Tables below. Though both fatal and non-fatal cases are

Table 1. Economic figures and occupational accident statistics for Turkey, 2000–2011

Years	GNP change for all sectors	Construction industry GNP change	Employment of construction industry and its share (%) in total workforce	Total permanent disabilities due to occupational accidents	Permanent disabilities in construction industry and their share (%) in total	Total fatal accidents for all industries	Fatal construction accidents and their share (%) in total
2000	6.8	4.9	761,452 (3.5)	1,818	399 (21.9)	1,173	379 (32.3)
2001	–5.7	–17.4	681,882 (3.2)	2,183	517 (23.7)	1,008	341 (33.8)
2002	6.2	13.9	713,629 (3.3)	1,820	439 (24.1)	872	319 (36.6)
2003	5.3	7.8	685,902 (3.2)	1,421	354 (24.9)	810	274 (33.8)
2004	9.4	14.1	752,136 (3.8)	1,693	345 (20.4)	841	263 (31.3)
2005	8.4	9.3	933,498 (4.7)	1,639	322 (19.6)	1,072	290 (27.1)
2006	6.9	18.5	1,185,723 (5.8)	2,267	425 (18.7)	1,592	397 (24.9)
2007	4.7	5.7	1,247,970 (6.0)	1,550	361 (23.3)	1,043	359 (34.4)
2008	–0.7	–8.1	1,238,888 (5.8)	1,452	373 (25.8)	865	297 (34.3)
2009	–4.8	–16.1	1,227,698 (5.8)	1,668	282 (16.9)	1,171	156 (13.3)
2010	8.9	17.1	1,431,000 (6.3)	1,976	319 (16.1)	1,434	475 (33.1)
2011	8.5	11.2	1,581,000 (6.3)	2,093	405 (19.4)	1,700	570 (33.5)

Source: Social Insurance Institution General Directory and Statistical Institution of Turkey Statistics.

Table 2. Comparison of employment, fatal accidents and fatal incidents rates between Turkey, Japan, USA and P.R of China, 2000–2010

Years	Employment of construction and its share (%) in total workforce, Fatal construction accidents and share (%) in total, Fatal incidence rate											
	Turkey[1]			Japan[2]			USA[3]			P.R of China[4]		
2000	761,452 (3.5)	379 (32.3)	49.8	6,530,000 (10.1)	731 (38.7)	11.2	6,884,000 (4.68)	1,154 (19.5)	16.8	7,440,000 (6.6)	3,778 (32.3)	50.8
2001	681,882 (3.2)	341 (33.8)	50.0	6,320,000 (9.9)	644 (36.0)	10.2	7,043,000 (4.75)	1225 (20.8)	17.4	7,330,000 (6.8)	4,056 (32.3)	55.3
2002	713,629 (3.3)	319 (36.6)	44.7	6,180,000 (9.8)	607 (36.6)	9.8	6,991,000 (4.68)	1121 (20.3)	16.0	7,560,000 (7.2)	4,538 (30.4)	60.0
2003	685,902 (3.2)	274 (33.8)	39.9	6,040,000 (9.6)	548 (33.7)	9.1	7,013,000 (4.68)	1131 (20.4)	16.1	7,735,000 (7.4)	4,522 (30.1)	58.5
2004	752,136 (3.8)	263 (31.3)	35.0	5,840,000 (9.2)	594 (36.7)	10.2	7,282,000 (4.82)	1234 (21.4)	16.9	7,777,000 (7.4)	4,274 (30.5)	55.0
2005	933,498 (4.7)	290 (27.1)	31.1	5,680,000 (8.9)	497 (32.8)	8.8	7,606,000 (4.97)	1186 (20.8)	15.6	8,543,000 (7.9)	4,202 (30.1)	49.2
2006	1,185,723 (5.8)	397 (24.9)	33.5	5,590,000 (8.8)	508 (34.5)	9.1	7,951,000 (5.13)	1239 (21.2)	15.6	9,098,000 (8.2)	4,157 (29.8)	45.7
2007	1,247,970 (6.0)	359 (34.4)	28.8	5,520,000 (8.6)	461 (34.0)	8.4	7,893,000 (5.05)	1204 (20.9)	15.3	9,616,000 (8.4)	4,121 (29.7)	42.9
2008	1,238,888 (5.8)	297 (34.3)	24.0	5,370,000 (8.4)	430 (33.9)	8.0	7,438,000 (4.71)	969 (19.1)	13.0	9,712,000 (8.4)	4,055 (29.4)	41.8
2009	1,227,698 (5.8)	156 (13.3)	12.7	5,170,000 (8.2)	375 (34.9)	7.3	6,247,000 (3.96)	834 (18.3)	13.4	9,917,000 (8.5)	4,017 (29.1)	40.5
2010	1,431,000 (6.3)	475 (33.1)	33.2	4,980,000 (8.0)	394 (33.5)	7.9	5,767,000 (3.66)	774 (16.5)	13.4	10,052,000(8.5)	3,945 (28.4)	39.2

[1]Source: Social Insurance Institution General Directory and Statistical Institution of Turkey Statistics. [2]Sources: http://www.stat.go.jp ; http://laborsta.ilo.org/. [3]Sources: http://www.bls.gov/iif/oshwc/cfoi/worker_memorial_data.htm#fatal_injuries.xls, http://www.bls.gov/iif/oshcfoiarchive.htm#rates (calculated as the number of new cases of injury (fatal) during the calendar year divided by the number of workers in the reference group during the year, multiplied by 100,000. US figures were converted). [4]Source: http://laborsta.ilo.org/, http://www.stats.gov.cn/english.

presented in the Tables, it should be noted that because many non-fatal accidents are go unreported, the fatal cases provide a more reliable sample for identifying the characteristics of construction accidents in Turkey.

Accident causes were classified according to International Classification of Diseases current version of ICD-10 (International Statistical Classification of Diseases and Health Related Problems). There are some limitations to this classification system. First, the specification of heavy equipment accidents in ICD-10, unfortunately falls short to explain these occurrences. In the second version of ICD-10, heavy equipment accidents are under W24 and V09 classifications. W24 is defined as "Contact with lifting and transmission devices, not elsewhere classified code, including chain hoist, drive belt, pulley (block), rope, transmission belt or cable, winch, wire" while V09 class includes accidents of "special construction vehicle which is a motor vehicle designed specifically for use in the construction (and demolition) of roads, buildings and other structures, such as bulldozer, digger, dumper truck, earth-leveler, mechanical shovel" (WHO, 2012). Heavy equipment accidents can be differentiated from traffic accidents on the basis of their cause and this difference has a clear consequence for risk assessment. Table 2 combines W24 and V09 classifications into a single accident type. Second, it is important to distinguish the accident catego-

Table 3. Causes of construction accidents in expert witness reports

Causes	Deaths	%	Non-fatal injuries	%	Total	%
Falls (W00–W19)	426	54.1	191	52.9	617	53.7
Struck by thrown, projected or falling object (W20) exluding cave-in, or building collapse	102	12.9	50	13.9	152	13.2
Building/Structure Collapse (W20)	78	9.9	43	11.9	121	10.5
Exposure to electricity (W85–87)	59	7.5	15	4.2	74	6.4
Cave-ins (while or after excavation), (W20)	36	4.6	10	2.8	46	4.0
Other types (W25–31, W68–70, W73–74, X40–40)*	26	3.3	11	3.0	37	3.2
Heavy equipment accidents (W24 and V09.0)**	21	2.7	5	1.4	26	2.3
Heavy equipment fall over (W24 and V09)	13	1.6	2	0.6	15	1.3
Exposure to smoke, fire and flames (X00–X09) and Explosion (W36, 40)	12	1.5	11	3.0	23	2.0
W23 Crushed, jammed or pinched in or between objects	11	1.4	4	1.1	15	1.3
Transport accidents on site (W01–09)	3	0.4	4	1.1	7	0.6
Caught between machinery part (W23)***	1	0.1	15	4.2	16	1.4
Total	788		361		1,149	

*Other Types include W25 Contact with sharp glass, W26 Contact with knife, sword or dagger, W27 Contact with nonpowered hand tool, W28 Contact with powered lawnmower, W29 Contact with other powered hand tools and household machinery, W31 Contact with other and unspecified machinery, W68 Drowning and submersion following fall into swimming-pool, W69 Drowning and submersion while in natural water, W70 Drowning and submersion following fall into natural water, W73 Other specified drowning and submersion, W74 Unspecified drowning and submersion, X40–X49 Accidental poisoning by and exposure to noxious substances. **Incl. Collision with pedestrian, struck by moving equipment part, caught b/w equipment part. *** Excl. Caught b/w heavy equipment part.

ries of building and structure collapse, cave-ins and struck by thrown, projected or falling object. However, the World Health Organization's classification system combines these different accidents into one classification, W20. These difference accident types are separately analyzed in Table 3.

Results and Discussions

Overview of construction industry of Turkey

Table 1 reports the role of the construction industry in Turkey's economy and the prevalence of construction accidents between 2000 and 2010. While the construction industry accounts for only 3–6% of the total workforce, it accounts for nearly one third of all occupation-related fatalities and 20% of occupation-related permanent disabilities. These patterns support a recent study by Gurcanli *et al.*[25] which showed that construction workers had a fatal occupational injury rate nearly twice that of all workers in Turkey (56.4 per 100,000 full-time equivalent construction workers vs. 28.8 for all workers between 1992 and 2003). These figures have stayed relatively constant across the years studied. The main resource for the injury data in Turkey is Social Insurance Institution. Although the SII archives are the broadest data source of information about occupational accidents in Turkey, there are limitations to the analyses that can be carried out using these files due to insufficient information in the reports and a lack of proper classification. The SII only stores the cases whose legal procedures are completed and lacks a proper classification or documentation system for the causes of construction accidents. Since the Institution is only interested in employee-employer relationships and labour compensations and not accident analysis and classification, a large number of files have been waiting to be stored in the archives for the final verdict of the courts compensation claims. Besides, since the official statistics for occupational accidents are only based on SII, annual accident statistics do not reflect the accidents that occurred in the previous year, instead reporting only those accidents whose files (i.e. official procedures) were completed.

Additionally, in the Turkish construction industry, data collection is insufficient due to a high number of unregistered workers. As Ergör *et al.*[61] stated, accident surveillance system and inspections of accidents are restricted to serious accidents which result in death, loss of an organ or a long period of hospitalization. Large enterprises which operate in the formal sector are responsible for most of the reporting with many of the injuries in small and medium enterprises going undocumented. Briefly, it can be stated that the official statistics just give an overall view for occupational accidents in Turkey, because of the fact that they just reflect the accidents whose official procedures were completed. Unfortunately International Labour Organization or other international organizations have been

taking these statistics into account.

Table 1 reveals the boom and bust cycles in the industry and its effects to employment and number of accidents. There is a positive correlation between growth of the industry and increase in injuries. Moreover, the importance of the economy especially after 2006 could be noticed, in terms of growth as well as rapid shrinkage and its share in the total workforce. If we focus on the fatal construction accidents, the tendency of going downward has changed after 2005 (except big busts in 2008 and 2009) and it seems to increase in 2012 and following years. Another interesting fact that, though the share of the industry in total workforce has been 3–6.3%, the share of the permanent disabilities changes between 19 and 25 percent and that of fatal cases almost one third of all fatal accidents, between the years 2000 and 2010. Briefly, it can be stated that the industry's share in fatalities is almost six times bigger than its share in workforce. Construction industry has importance in Turkish economy especially due to its contribution to total gross national product growth. However, the growth of the industry has not influenced the conditions of construction workers on sites yet.

Injury trends, disparities and similarities between Turkey and other countries

International Labour Organization online statistics and some certain governmental organizations which publish statistical data about employment, occupational injuries and related topics are good source for deriving data. However, statistical figures of many countries are not being currently updated. Here, for the reference years of 2000 and 2010, employment of construction industry and its share in total workforce, fatal construction accidents and their share in total and fatal incidence rates of Turkey, Japan, USA and China are compared in Table 2. For each country, first columns (A) show the total number of construction workers and its percentage (in parenthesis). Number of construction workers has been increasing in Turkey and China since 2000 and decreasing in Japan and USA. The share of the industry in the economy in terms of percentage of total workforce has been slightly decreasing in Japan and USA, but almost 80% increased in Turkey and 30% increased in China between the years of 2000 and 2010. In those countries, it can be stated that the importance and role of the construction economy have been increasing. If we focus on the share of construction industry in total fatalities, it is observed that in Turkey, Japan and China, almost one third of the fatalities occur in the industry. Huge difference between percentage of construction workforce and share of fatalities in total accidents for all countries shows that the construction industry is very hazardous industry when compared with other sectors. Moreover, fatal occupational injury rates nearly three times that of all workers, for instance as the Center for Disease Control and Prevention[62] states for US or governmental bodies reveal for Turkey[9], Japan[63, 64] and China[63–65]. However, it is especially worth mentioning that average 5% share in total workforce creates 6 or 7 times greater share in fatalities for Turkey.

Third columns for each country show injury rates per 100,000 workers. At this point it should be noted that the calculation methods of injury rates differ among the countries. Incidence rates are calculated as the number of new cases of injury (fatal and non-fatal) during the calendar year divided by the number of workers in the reference group during the year, multiplied by 100,000. It can be also calculated as (in USA for example) number of injuries per 100 full time workers, that is, number of injuries divided by total hours worked by all employees during the calendar year, multiplied by 200,000 that represents base for 100 equivalent full time workers, working 40 h per week 50 wk per year. In Table 2, the figures in third column for USA were calculated as the former definition and the data from US Bureau of Labour Statistics Database transformed into that formula to compare incidence rates of the countries easier. Fatal incidence rates provide a good view to compare different industrial branches of the countries. In Table 2, fatal incidence rates of Turkey and China are very close to each other. For China they have tendency to decrease, but for Turkey after 2005 figures have been fluctuating and in 2011 (from the figures of Table 1) it reached 36 per 100,000 workers, i.e turned back again the figures of 2004. Table 2 reveals that countries, except Turkey, have succeeded in decreasing incidence rates. However, the growth of the construction industry in Turkey has not reflected its success to the workers in terms of decrease in incidence rates or better conditions on work sites yet.

Characteristics of construction accidents in Turkey

Expert witness reports provided an opportunity for in-depth analyses of construction accidents. As mentioned above, we analyzed 1,117 expert witness reports submitted to criminal and labour courts, consisting of 1,149 fatal and non-fatal injuries. These reports provide detailed analysis of causes as well as sub-causes, trades, activity at time of accident and especially faulty and negligent acts of the parties. Table 3 reports the causes of construction accidents for this sample. Falls account for the greatest number

Table 4. Distribution of fatalities according to trades

Trades vs. fatal accidents	Falls	Struck by thrown, projected or falling object	Building/ Structure collapse	Exp. to electricity	Cave-ins	H. equip-ment accidents	Other types	Exp. to smoke, fire flames, or explosion	Crushed, jammed or pinched in or between objects	Trans. acc. on site	Caught btw. mach. part	Total
Unskilled workers	175	55	42	38	30	14	1	5		2	1	363
Painters and plasterers	66	4	1	4			1					76
Scaffolder/formwork crafts	37	9	3	2	1							52
Other craftsmen*	32	1	7	4			3	3	2			52
Concretor	12	6	2	1	1							22
H. equipment operator	4	3		1		6	1					15
Bricklayers	11		2									13
Site supervisory staff	8	1	2			1		1				13
Plumbers and pipefitters	6		1				1					8
Driver	2		1			4						7
Co-operator, co-driver						6						6
Technical staff	2	1		1			1					5
Electrician	3			1				1				5
Pipe layers working in channels		1			3	1						5
Apprentices		2		2								4
Stonemasons	1	2	1									4
3rd person (children)	28	7	10	2	1	2	10					60
3rd person	30	7	6	2			4	1		1		51
Other staff	9	3		1			4	1	5			23
Undefined									4			4
Total	426	102	78	59	36	34	26	12	11	3	1	788

*Welders, steel fixers, survey levelers, mechanics and cited in expert witness reports only as “craftsman”.

of accidents (54.7%), with struck by thrown, projected or falling object (13.2%), building/structure collapse (10.5%) and exposure to electricity (6.4%) as the 2nd, 3rd and 4th most frequent causes of accidents.

The data from the reports give us information on types of accidents which different trades are exposed to. Table 4 gives this kind of information in a cross tabulated form. The high rate of accidents among unskilled workers is unsurprising due to high share of unskilled workers in total workforce. Other than unskilled workers, the three occupations with the highest fatal injury numbers were: painters and plasterers (9.6%), carpenters and wooden scaffolders (6.6%) and other craftsmen include welders, steel fixers, survey levelers and mechanics (6.6%). Third party and child fatalities are also common in construction, and these have been analyzed comprehensively elsewhere[53]. Since unskilled workers have tasks in everywhere, they exposed almost every type of accidents. However, almost all of the fatalities of painters and plasterers caused by falls and co-operators caused by heavy equipment accidents, due to their tasks and related working conditions on site.

To better understanding the nature of the accidents, we recorded the activity of the victims at the time of accident, shown in Table 5. The proportion of fatalities by event differed for each trade. For supervisors, technical staff and apprentices, falls and transportation accidents accounted for all fatalities. For unskilled workers, carpenters, painters, unskilled workers on roof and structural steel workers, falls were most common. Main construction activities required for constructing the structural core of a building or civil engineering structure construction such as scaffold or formwork mantling/dismantling, roof works, concrete slab and platform re-bar placement accounted 30.2% of all fatalities. “Other activities” includes inspecting and small jobs with hand tools. It also include irrelevant activities such as swimming (observed in third party related accidents), entering a well by the aid of a rope, or playing at or very near to the site (observed in incidents whose victims were children) accounted for 29.2% of all fatalities and 26.7% of total cases.

Fatalities during roof works and painting/plastering on scaffold each accounted for 56 and 7.1% of all fatalities, and if formwork mantling/dismantling is added to these figures these three activities are responsible for almost one fifth of all fatalities. Almost all fatalities during these ac-

Table 5. Activity of the victims at the time of accident

Main activity	Activity of the victims at time of incident	Deaths	%	Non-fatal injuries	%	Total	%
Main construction activities	Scaffold mantling/dismantling and repair	22	2.8	8	2.2	30	2.6
	Formwork mantling/dismantling and repair	53	6.7	34	9.4	87	7.6
	Roof works	56	7.1	21	5.8	77	6.7
	Concrete slab and platform re-bar placement	46	5.8	23	6.4	69	6.0
	Masonry	14	1.8	7	1.9	21	1.8
	Joinery works	8	1.0	4	1.1	12	1.0
	Plumbing (assemble, install, repair pipes, fittings etc.)	4	0.5	6	1.7	10	0.9
	Welding	7	0.9	2	0.6	9	0.8
	Culvert, concrete pipe installation and placement, trench support placement (screw props, wedges etc.)	10	1.3	5	1.4	15	1.3
	Plaster and soil mixture preparation (without equipment)	4	0.5	3	0.8	7	0.6
	Other	17	2.2	9	2.5	26	2.3
Painting and plastering	Painting and plastering on scaffold	56	7.1	32	8.9	88	7.7
	Painting and plastering on ladders	9	1.1	7	1.9	16	1.4
	Painting and plastering near slabs or openings	12	1.5	2	0.6	14	1.2
	Painting and plastering at other locations	4	0.5	1	0.3	5	0.4
Excavation with hand	Trench and channel excavation	16	2.0	4	1.1	20	1.7
	Foundation and footing excavation	6	0.8	3	0.8	9	0.8
	Excavation in quarries	7	0.9	3	0.8	10	0.9
	Well excavation	7	0.9	2	0.6	9	0.8
	Other	12	1.5	4	1.1	16	1.4
Material handling, loading, storage	Material handling, carrying on same level	3	0.4	1	0.3	4	0.3
	Material handling, carrying on scaffolding platform	4	0.5	1	0.3	5	0.4
	Material handling, carrying on ladders	7	0.9	5	1.4	12	1.0
	Material handling, carrying on roofs	6	0.8	2	0.6	8	0.7
	Material handling, carrying on slabs, platforms	8	1.0	10	2.8	18	1.6
	Material handling, carrying on other hazardous places	9	1.1	5	1.4	14	1.2
	Storage or taking material from storage (stack)	4	0.5	5	1.4	9	0.8
	Loading and unloading on/from motor vehicle	2	0.3	7	1.9	9	0.8
	Loading and unloading on/from simple hoists	42	5.3	19	5.3	61	5.3
	Heavy material handling, loading, storage	9	1.1	2	0.6	11	1.0
	Other	3	0.4	3	0.8	6	0.5
Equipment usage	Using simple equipment (trolley, wheelbarrow etc.)	9	1.1	1	0.3	10	0.9
	Driving a motor vehicle	4	0.5	0	0.0	4	0.3
	Operating hoist	7	0.9	8	2.2	15	1.3
	Operating simple wire rope hoist	8	1.0	4	1.1	12	1.0
	Operating driller	5	0.6	0	0.0	5	0.4
	Operation aggregate preparation machinery and equipment, concrete pump, bench clamp, woodworking machine etc.	2	0.2	7	2.0	9	0.8
	Repair and maintenance of equipment	7	0.9	6	1.7	13	1.1
	Other activities related with equipment and machinery	5	0.6	4	1.1	9	0.8
Demolition works	Demolition of roof and slab	3	0.4	2	0.6	5	0.4
	Demolition of walls	16	2.0	8	2.2	24	2.1
	Demolition of structural elements such as column and beam	9	1.1	4	1.1	13	1.1
	Other demolition works	2	0.3	0	0.0	2	0.2
Explosive usage	Mining for explosives	2	0.3	0	0.0	2	0.2
	Preparation of explosives, firing, handling	3	0.4	3	0.9	6	0.6
	Other activities related with explosives	5	0.6	1	0.3	6	0.5
Others	Inspecting, checking	18	2.3	6	1.7	24	2.1
	Standing without move	28	3.6	6	1.7	34	3.0
	Small jobs with hand tools	6	0.8	3	0.8	9	0.8
	Swimming	3	0.4	0	0.0	3	0.3
	Playing on or near construction site (children)	24	3.0	4	1.1	28	2.4
	Walking on same level	58	7.4	23	6.4	81	7.0
	Entering a well by the aid of a rope	55	7.0	11	3.0	66	5.7
	Other	29	3.7	14	3.9	43	3.7
	Undefined	13	1.6	6	1.7	19	1.7
	Total	788		361		1149	

tivities are caused by fall from height. Simply focusing on the proper prevention of falls during those three activities could lower the number of fatalities at Turkish construction sites by up to 20%. However there are other three activities worth to mention, walking on same level, entering a well by the aid of a rope and loading and unloading on/from simple hoists, account for 7.4, 7.0 and 5.3% of all fatalities respectively. Fatalities during "walking on same level" are very high, because many of these fatalities are falls from a slab or elevator openings due to a lack of fall protection on and around these openings (as well as the carelessness of the workers). Wells are confined spaces and may contain hazardous atmospheres, including insufficient oxygen, poisonous air, or an explosive atmosphere. These spaces may also have physical hazards that result, for example, in workers falling, being crushed or buried, or drowning. These hazards may not be obvious. All confined spaces must be carefully assessed to identify any hazards before workers are entered. On the other hand, use of simple and primitive hoists can cause materials to fall fatally striking those below. These six activities, along with excavation (For operators and co-operators includes flaggers, fatalities from improperly sloped or shored trenches continue to be a major cause of fatalities on sites), are responsible almost half of fatal construction accidents in Turkey. This information is very important to force construction companies to implement urgent abatement and mitigation methods on sites that could save many lives.

Analysis of most frequent construction accidents

Results from expert witness reports show that four most frequent accidents; falls, struck by thrown/projected/falling object, building/structure collapse and exposure to electricity are responsible for the 84.4% of all fatalities in Turkey, with cave-ins raising this number to 89%. A closer analysis of the four most common causes of construction-related fatalities can provide critical information for preventing fatalities on Turkish construction sites. Table 6 divides the "fall" category into separate types of falls. Most falls are falls from scaffolds, floor slab/platform edges and floor openings. Previous research on fall related accidents on sites[66] has tried to decipher accident patterns and related prevention measures. They found that falls from scaffold staging were associated with a lack of complying scaffolds and bodily action while falls through existing floor openings were associated with unguarded openings, inappropriate protections, or the removal of protections. Falls from roof edges were associated with bodily actions and being pulled down by a hoist, object or tool. Falls through roof surfaces were associated with a lack of complying scaffolds. Falls from ladders were associated with overexertion and unusual control and the use of unsafe ladders and tools. Primary prevention measures would include fixed barriers, such as handrails, guardrails, surface opening protections (hole coverings), crawling boards/planks, and strong roofing materials. Secondary protection measures would include travel restraint systems (safety belt), fall arrest systems (safety harness), and fall containment systems (safety nets).

Sub-causes of being struck by falling/thrown/projected objects, which is the second most common hazardous accident at construction sites need to be attention. The primitive installation of hoists resulted in 39 deaths, making it a leading cause of fatalities cause be being struck by falling/thrown/projected objects. Material bouncing ranks second and includes stone, nail, hand tool, material from air pressure equipment, wood shavings and so on. However, in many cases the exact cause of accident (24 in 102) was not reported in the court files, instead they were simply classified as "material fall".

According to Turkish legislation, "demolition" is considered "construction work" and the number of fatalities during demolition is the leading cause of structure/collapse deaths. Collapses during construction are most often caused by improper formwork installation and the early dismantling of scaffolds under slab or beam formworks before the concrete hardens. Formwork is a temporary structure which moulds concrete into the desired shape, and holds it in the correct position until it has hardened sufficiently and/or is able to support the loads imposed on it. Therefore formwork should have sufficient strength to resist the pressure of the fluid concrete without damage or excessive deflection. The data reveals that 86 of 121 building/structure collapses caused by collapse during construction and demolition. It is worth mentioning that 32 of 121 accidents occurred due to sudden collapses of old buildings before restoration or maintainance and collapse of garden or retaining walls.

The principal hazards associated with electricity include electric shock, electric burns, electrical fires and explosions, arcing, portable electrical equipment and secondary hazards, that is the flow of current through the human body or an electrostatic discharge from/to man may provoke uncontrolled movement or a muscle reaction that leads to tripping, slipping, falling and the like[62]. Here it should be noted that arcing from transmission lines to heavy equipments cause serious injuries or deaths on sites. A worker holding metal material who is standing on the

Table 6. Detailed analysis of falls

Type of falls	Deaths	Non-fatal injuries	Total
Falls from scaffolds			
Loss of balance (while working on the scaffold)	43	26	69
Breaking of planks	17	16	33
Collapse of scaffold	15	5	20
Other or undefined falls from scaffold	10	9	19
Scaffold mantling	9	1	10
Scaffold dismantling and breaking of horse scaffold component	4	4	8
Loss of balance (while working on horse scaffold)	3	0	3
	101	61	162
Falls from floor slab or platform edges			
Loss of balance	37	12	49
Falls from slab edges while formwork assembling	19	11	30
Loading or unloading simple wire rope hoist	16	13	29
Falls from window or door openings (near the edges)	10	1	11
Falls from slab edges while formwork assembling	6	10	16
Falls from the edge of slabs while demolition facility	4	1	5
Operating simple wire rope hoist	4	1	5
Mantling-dismantling simple wire rope hoist	3	2	5
	99	51	150
Falls from floor and elevator openings	75	28	103
Falls from roofs			
Breaking of roof covering materials or skylights	36	6	42
Loss of balance while roof construction	20	9	29
Other or undefined falls from roofs	8	4	12
Loss of balance from angled roofs	3	2	5
	67	21	88
Falls into excavated trenches, holes, pits	35	7	42
Falls from stairways and ladders	8	9	17
Fall from hoist	6	1	7
Falls into cliffs	4	1	5
Other or undefined falls*	31	12	43
Total	426	191	617

*Categories less than three and undefined.

ground, and sometimes even on a roof or floor slab too close to a high voltage conductor may suffer flash burns as a result of arc formation. Although Hughes and Ferret[67] states that almost 25% of all reportable electrical accidents involve portable electrical equipment, our results reveal that the percentage of those accidents very low on Turkish construction sites. The majority of fatal electrocutions are caused by contact or arcing from transmission lines near construction sites, 36 in 59 (48 in 74 in total accidents).

Table 7 categorizes construction accidents according to the time of day at which they occurred. These analyses are based on the 533 of 1,149 victims and expert witness reports that included an exact time. In a previous study, investigating fatal accidents in Illinois highway work zones in the period from 1996 to 2001, found that accidents were most frequent between 10:00 and noon when lighting and weather conditions were controlled[68]. In our study, the accidents were most likely between the hours 15:00 and 17:00 (close to finishing time at site), 10:00–12:00 (before lunch break) and just after the lunchtime (almost ten percent of accidents occurred between 13:00 and 14:00). Further research is required to determine the causal role that hunger, after meal lightheadedness and fatigue play in construction site accidents.

This study is designed to fill this hole in the literature, addressing the needs of researchers and safety profession-

Table 7. Distribution of construction accidents by time of day

Time interval	Fatalities	%	Non-fatal accidents	%	Total	%
07:00<t≤08:00	11	3.1	3	1.7	14	2.6
08:00<t≤09:00	28	7.9	18	10.1	46	8.6
09:00<t≤10:00	25	7.1	20	11.2	45	8.4
10:00<t≤11:00	41	11.6	20	11.2	61	11.4
11:00<t≤12:00	25	7.1	29	16.2	54	10.1
12:00<t≤13:00	22	6.2	7	3.9	29	5.4
13:00<t≤14:00	35	9.9	15	8.4	50	9.4
14:00<t≤15:00	27	7.6	14	7.8	41	7.7
15:00<t≤16:00	39	11.0	14	7.8	53	9.9
16:00<t≤17:00	41	11.6	21	11.7	62	11.6
17:00<t≤18:00	23	6.5	5	2.8	28	5.3
18:00<t≤19:00	18	5.1	8	4.5	26	4.9
19:00<t≤20:00	7	2.0	3	1.7	10	1.9
20.00<t<07:00	12	3.4	2	1.1	12	2.7
Total	354		179		533	

als, not only from Turkey, but any individuals who would like to understand the characteristics and specific risks in the construction industry for employers and related parties. At this point some implications for how to use the study findings should be stated:

- Since the progress in construction safety has only happened very recently and detailed and satisfactory data have not collected for recent years yet, analyses of the historical data become very important also to compare before and after new Occupational Health and Safety Law.
- Construction industry should focus on falls, because 54.1% of fatalities related with falls and regulations in Turkey related with fall protection are very inadequate. In-depth analysis of falls will be beneficiary not only for practitioners who must implement new Occupational Health and Safety Law and new regulations about construction but also academicians and governmental bodies who should improve current regulations.
- According to the results, 77.4% of all accidents occur because of falls, struck by thrown/projected/falling objects and building/structure collapse in Turkey. Although number of collapses during demolition works have important share in fatalities, Turkey has no specific safety regulation for demolition works.
- The accidents were most likely between the hours 15.00 and 17.00 (22.6%), 10:00–12:00 (18.7) and just after the lunchtime (9.9%) and this result points a requirement a further research to determine the causal role that hunger, after meal lightheadedness and fatigue play in construction site accidents. Moreover, safety is not a body of knowledge that includes only prevention techniques but also managerial efforts to regulate working hours, site conditions, nutrition and productivity.

Discussion on liable parties and faulty/negligent acts

It is also important to address "who is at fault in the construction accidents?" and "what primary faulty and negligent acts" cause these construction accidents. If the negligence of an individual leads to a preventable construction accident, that person may be liable for the victim's injuries. Safety professionals must be aware of the ins and outs of construction accident litigation in order to determine whether or not there is a case against the employer, general contractor, or subcontractors at the site. Injury victims are entitled to compensation for past and future medical expenses, wage loss, pain, suffering, and, in certain cases, punitive damages. In addition, if a victim dies and his or her survivors suffer economic loss or emotional distress as a result, the survivors may be entitled to recover full compensation. Under new Turkish criminal law, there are more severe penalties for negligent acts. Therefore, for employers, workers, safety experts and practitioners, it is important to know who is at fault and which negligent acts are most common when the accident is caused by someone other than the victim. Table 8 reports the primary faulty and negligent acts, drawn from statements made by expert witness committees (consisting of a minimum of three safety experts per case) and submitted to the Labour and Criminal courts. In many cases, court's verdict reflects the expert witness opinion, but it is often very difficult find the final verdict due to long judicial pro-

Table 8. Primary faulty and negligent acts of the related parties in construction accidents

	Primary faulty and negligent acts of the parties	# of times cited in fatalities	%	# of times cited in non-fatal injuries	%
Employer related	Unsatisfactory performance of the inspection and control obligation	317	13.3	107	11.0
	Infringement of the obligation to perform the work under the inspection and responsibility of one or more competent person	233	9.8	105	10.8
	Infringement of the obligation to ensure the performance of the work with personnel protective equipment	134	5.6	70	7.2
	Not to provide health and safety training	115	4.8	44	4.5
	Infringement of the obligation to perform the work with proper installed guard rails and other similar barriers	113	4.7	65	6.7
	Not to follow other technical requirements when performing construction activity	91	3.8	20	2.1
	Insufficient and deficient protective equipment installation	85	3.6	29	3.0
	Infringement of the obligation to perform the work with proper installed protective equipment (other than barriers) and ensure the labour health by giving protective personnel equipment	67	2.8	23	2.4
	Not to ensure scaffolding operations undertaken safely with proper scaffolds fit for technical requirements	57	2.4	27	2.8
	Not to assign skillfull teams for critical construction activities	47	2.0	18	1.9
	Not to provide and employ sufficient number of skilled superintendants, supervisors	39	1.6	20	2.1
	Infringement of the obligation to ensure periodical controls of machinery, equipment and hazardous parts of construction	30	1.3	7	0.7
	Infringement of the obligation to provide proper warning signs or lights	29	1.2	5	0.5
	Infringement of the obligation to perform the work with proper installed fences or panels	23	1.0	2	0.2
	Not to provide proper and sufficient materials	23	1.0	14	1.4
	To employ unskilled workers	22	0.9	17	1.8
	To perform unlicensed construction work without permission	10	0.4	3	0.3
	To give permission for early disassembling of concrete formwork	5	0.2	3	0.3
	To give unqualified, unproper and nonstandart PPE	5	0.2	0	0.0
	Not to ensure excavation activities safely and properly (infringement of technical requirements, regulations)	21	0.9	16	1.6
	Not to install support systems prevention of cave-ins during excavation	19	0.8	7	0.7
	EMPLOYER RELATED TOTAL	1485	**62.2**	602	**62.1**
Employee related	To endanger him/herself by negligence	489	20.5	206	21.2
	Unsafe, careless and negligent usage of the equipment, device, machine or vehicle. Not to follow the usage, installation and maintenance rules those comply with manuals or regulations	58	2.4	13	1.3
	Not to demand protective installation from employer	45	1.9	16	1.6
	Not to use given PPE	43	1.8	17	1.8
	Not to demand PPE	27	1.1	26	2.7
	To ignore and overlook warnings	25	1.0	7	0.7
	To perform activities out of his/her knowledge, skill and profession	25	1.0	13	1.3
	To perform unfit duties (physically unfit)	15	0.6	9	0.9
	Not to demand work equipment qualified and fit for duty	13	0.5	26	2.7
	Not to demand assistant when necessary	13	0.5	3	0.3
	To stock, stack and load materials in a wrong way	12	0.5	7	0.7
	EMPLOYEE RELATED TOTAL	765	**32**	343	**35.4**
Third-party related	To enter the site without permission	22	0.9	2	0.2
	Infringement of the obligation to control and inspect the construction whether the work comply with the current construction license, technical regulations, health and safety legislation etc.	22	0.9	2	0.2
	To permit the construction work which do not satisfy the technical provisions and obligations required by the current legislation	13	0.5	4	0.4
	Absence of parental supervision (for parents)	20	0.8	1	0.1
	THIRD-PARTY RELATED TOTAL	77	**3.2**	9	**0.9**
Other causes (social factors, environmental conditions etc.)		60	**2.5**	16	**1.6**
Total		**2,387**		**970**	

cedures that includes the Supreme Court. Therefore, Table 8 only presents the opinions of expert witnesses. Nearly two thirds of the faulty and negligent acts are carried out by the employers. "Employer related" group contains the employer him/herself and employer representatives such as chief site engineer, site engineer, project manager, safety professional who act on behalf of the employer. "Employee related" group includes not only victims but also construction workers or craftsmen accompanying the victim at the time of the accident. Employee-related acts

account for almost one third of all cases. The most cited faulty and negligent act for employers is unsatisfactory inspection and control obligation while the negligence of the victim was the primary act among employees. These statements tend to be general statements of negligence, but expert witnesses do report specific acts of negligence related to falls (for instance Infringement of the obligation to perform the work with proper installed guard rails and other similar barriers or Infringement of the obligation to provide proper warning signs or lights).

There is a clear connection between the most frequent accidents and faulty/negligent acts of the parties. Any safety management attempt to mitigate and abate the risks due to falls, struck by thrown/projected/ falling object, building/structure collapse, exposure to electricity and cave-ins could prevent up to 90% of fatal accidents on construction sites. Regulations are not implemented properly and Table 8 shows that contractors are often responsible in construction accidents by ignoring very basic safety rules. The main reasons behind this ignorance are firstly lack of safety culture and secondly inadequate governmental inspections. Recent figures of Ministry of Labour and Social Insurance reveals that totally 602 government inspectors are working in Turkey and just 305 of them are technical inspectors from the different branches of engineering[69]. However, the most recent working life statistics, 2011 also shows that, 177,878 of total 1,435,839 companies are construction companies in Turkey and they employ 1,630,851 construction workers[70]. Moreover, as mentioned above, not only the authors' observations on sites, but also views of the officials from Ministry of Labour and Social Insurance show the lack of culture in the form of "indifference" (especially for workers) and conceiving safety as "extra cost" or "must-to-do due to inspection". Related parties in Turkey have pointed the collaboration of governmental bodies, non-governmental organizations, trade unions and universities to establish a safety culture in Turkey[71]. The common opinion in Turkey, especially in the construction industry is that absentmindedness and negligence of unskilled construction workers lead to most of accidents. However, expert witness reports points out the role of employers and lack of control, inspection and implementation of safety management.

Conclusion

Since construction workers are exposed to a wide variety of hazard on construction sites, its great share in fatal accidents, as given in this paper, may be understood. Their exposure differs from trade to trade, from activity to activity, depending even the hour. Unfortunately, recent figures for Turkey reveal not any improvement or success in the industry, but deterioration especially when compared with industrialized countries. This study put forward the main hazards, their way of occurrences, improper and insufficient conditions and responsible parties for occupational injuries as well as in-depth analysis of each type of accident. It should be known that the same sets of hazards are likely to reoccur and in-depth analyses may help professionals to understand the nature of the accidents. The paper also points out that almost two thirds of the faulty and negligent acts are carried out by the employers. Moreover, these faulty and negligent acts are due to lack of very principal and basic health and safety measures. Consequently, as this study reveals, accident information such as how, why, when and whom is critical for the development of accident prevention strategies. Safety professionals usually base their proposal on personal experiences from similar projects. Learning from past experience is important for accident prevention because every construction projects may have some similarities with the past projects. In addition to personal experience, carefully collected accident statistics is necessary for risk estimation, identification, evaluation as well as implementation of risk management. Historical records that include types of accident, trades of work, activity at time of accident, etc., provide necessary background knowledge for those who carry out risk assessment on construction sites. With the aid of historical data on accidents, safety professionals should identify the hazards on their specific construction sites and plan the best methods for eliminating or controlling those hazards.

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