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Assessment of Safety in Residential Construction: The Case of Jordan

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Abstract: Safety issues are a major concern in the construction industry because construction accidents, injuries, and fatalities bring great losses to all parties in the construction field. This study aims to evaluate the number of injuries and safety culture in residential construction sites in Jordan and to emphasize the importance of safety awareness. We used the OSHA Safety Culture Survey to measure safety culture and awareness of supervisors and laborers at various residential worksites. We also used a modified version of the Saudi Aramco contractor's job safety inspection sheet to measure the safety level in these worksites. The resultant data on the number and locations of injuries corresponded to data found by Jordan's Social Security Corporation. The safety level was found to be low in the observed work sites. From the present findings, we propose a number of recommendations to improve safety performance.

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1. Introduction

Construction is one of the most dangerous industries due to the frequency of fatal and non-fatal occupational injuries (Hyoung et al., 2009; Ringen and Seegal, 1995). Risk factors are strongly influenced by human behavior and the working conditions. A safer working environment leads to more reliable, decision-making and responsible behavior from workers at construction sites (Choudhry and Fang, 2008; Heinrich, 1936; Saurin et al., 2005). Recently, many countries around the world are becoming increasingly interested in the concept of "safety culture" as cultivating such a culture in the workplace can reduce the potential harm of large-scale disasters and occurrence of accidents. Uttal (1983) defined safety culture as "shared values and beliefs that interact with an organization's structures and control systems to produce behavioral norms.", while Turner et al, (1989) defined it as "the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious".

Schein (1992) defines organizational culture as: a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems. Moreover, Guldenmund (2000), differentiated safety culture and climate according to a general framework based on work by an organizational culture. This framework distinguishes three levels at which organizational culture can be studied.

According to multiple authors (Cheng et al., 2010; Dedobbeleer and Beland, 1991; Gillen et al, 1997; Laitinen et al., 1999; Liebing, 2001; Loosemore and Lee, 2001; Ringen et al., 1995; Sertyesilisik et al., 2010; Tam and Fung, 2011;Tam et al., 2004), safety performance is affected by many factors, including (but not limited to) (1) poor work and safety organization; (2) company size; (3) lack of coordination; (4) economy and time; (5) lack of data standardization; (6) poor internal and external communications; (7) poor worker involvement in safety matters; (8) constantly

changing worksites; (9) workers´ specializations; (10) workers' responsibility; (11) inadequate training and fatigue of practitioners; (12) improper selection, use, or inspection of equipment; (13) lack of protective equipment; and (14) poor safety awareness of top management and project managers.

In Jordan, both the society and economy have suffered human and financial losses because of the poor safety performance in the construction industry. Annual reports published by the Ministry of Labour (1995–2005) indicate that the number of work accidents for all industries has continued to increase at alarming rates. The Occupational Safety and Health Institute (OSHI) in Jordan reports that accidents in the Jordanian construction industry account for about 10.5% of incidents (OSHI, 2006). The Ministry of Labour in Jordan takes full responsibility for legislating and enforcing safety regulations (Articles 78-85 of the 1996 Labor Law).

Construction research in Jordan addressed many industry-related issues such as construction delays (Sweis et al, 2008; Abu Hammad et al , 2010), Construction productivity (Sweis et al 2008; Sweis et al 2009; Attar and Sweis, 2010), Construction customer satisfaction (Sweis et al 2013a, Sweis et al 2013b, Sweis et al 2015). However, not much research has been conducted in the area of construction safety. This study aims to build on previous work by evaluating injuries and safety culture in residential construction sites in Jordan. It specifically measures safety culture and awareness of supervisors and laborers at various residential worksites and compares the results with data on the number and locations of injuries found by Jordan's Social Security Corporation.

2. Literature review

Lingard and Rowlinson (2005) asserted that the construction industry is the most dangerous land-based work sector, reflected by its high rate of accidents and injuries. In the process of building, multitasking workers may put their lives in danger. Therefore, the project manager must supervise and maintain awareness of the level of risk at the worksite.

Planning the construction site is essential to controlling and reducing hazards to achieve an acceptable level of risk**.** Lingard and Rowlinson (2005) suggested that improving the working environment and employees' safety awareness would lead to the development of a safety culture. However, Schein (1986) defined culture as a pattern of beliefs and values shared by workers and employees that operates unconsciously to ensure health and safety. In a later article, Schein (1992) included two of the three responses commonly associated with attitudes, i.e. cognitive (``perceive", ``think") and affective (``feel") responses while he left out the behavioral response.

Due to the high number of recorded injuries and deaths in construction sites in the United States, many organizations and programs have been established to keep employees safe and healthy and to maximize the injury reduction while minimizing costs. The Occupational Safety and Health Administration (OSHA) was established in 1970, and is one of the USA's earliest organizations. OSHA focuses on the importance of human life: Their concern is to decrease the numbers of accident and injuries throughout the country. So far, OSHA has succeeded in reducing the number of annual occupational injuries in the USA from 14,000 in 1970 to 4,340 in 2009. (https://www.osha.gov/osha40/timeline.html)

O'Toole (2002) studied the causes of construction accidents and found that unsafe methods, equipment, and site conditions, lack of proper training, and deficiencies in safety enforcement are among the major causes of construction accidents. To achieve a strong safety culture, McGeorge and Zou (2013) stated that there is a need to balance the science (systems, standards, and technology) and the art (human factors) of safety management.

According to Occupational Safety and Health Act in Canada, each employer is obligated to provide and maintain a safe and healthful workplace for all employees. On the other hand, many researchers suggest that employees' positive conception of management's obligation to safety can result in injury reduction (Bailey, 1989; Clarke, 1999; Cohen, 1977).

Hecker et al (2005) showed that a fairly large percentage of construction accidents could have been avoided by using better choices in the design and planning stages of a project. Regulations and legislations on occupational injuries aim to achieve zero construction site accidents and injuries (Ratay, 1997). Therefore, site safety programs should emphasize management's commitment to safe work habits and focus on developing a safety culture and encouraging safety awareness for all workers. Safety investments must be included in the project budget plan. These investments may appear to be expensive at first, but studies have demonstrated that effective safety management systems are ultimately profitable for construction organizations (Zou et al., 2010).

The Middle East, with its high economic growth rate, has distinct cultural, environmental, and economic systems. Many researchers, such as Coble and Haupt (1999), have shown that the construction industry reflects the economic development pattern in the country. However, there are many problems and challenges to be considered in the construction sector in the Middle East. For instance, the United Arab Emirates, because it contains a large number of multi-storied buildings and towers, has highly dangerous construction sites. Therefore, it is considered one of the

less developed countries. Langford et al. (2000) and Hughes (2007) mentioned that using an immigrant workforce leads to safety problems.

Egypt is a developing country with large number of accidents and injuries. Hinze and Harrison (1981) referred to human behavior and poor worksites as the main reasons for unsafe and dangerous construction.

Currently, there is limited research about safety in construction sites in Jordan. One study by Hiyassat and Talhouni (2000), examined construction safety management in Jordan; the authors aimed to increase contractors' and workers' awareness of the importance of health and safety. Their results showed that Jordan has a weak safety culture in terms of both the quality and quantity of safety laws and regulations. They also found that safety in construction sites in Jordan is below the acceptable levels.

Sarireh and Tarawneh (2013) studied safety management in the Jordanian construction industry. They stated that the safety of the construction worksite is a priority for all project parties, and that management must make safety tools available for workers at the project sites at all times. Furthermore, they proposed employing a safety team for each project, whose job is to develop a safety program that provides training and monitors site safety. Finally, Sarireh and Tarawneh recommended the cost of safety be included in the total cost of the project during planning, bidding, and construction.

Mashaleh et al. (2010) suggested that organizations hold training and formal meetings for all workers. Currently, the Ministry of Public Works and Housing and OSHI have submitted new regulations that aim to improve the safety culture of worksites throughout the country. Among the few completed studies about safety in construction sites in Jordan, none discussed the notion of a safety culture or its relationship with the number and locations of injuries. Given this gap in the literature, this study seeks to evaluate the safety culture in residential construction sites in Jordan.

3. Methodology

Two types of data were collected to evaluate the level of safety. First, secondary data about the number and locations of injuries from 2007 to 2012 were collected from Jordan's Social Security Corporation (SSC). In general, to get disability benefits at the Jordan SSC, you must meet two different earnings tests: a "recent work" test based on your age at the time you became disabled; and a "duration of work" test to show that you worked long enough under Social Security. The SSC does not engage in any direct inspection of construction sites.

Second, primary data was collected using the modified version of the Saudi Aramco contractor's job safety inspection sheet (Saudi Aramco Construction Safety Manual, 2011) and the OSHA Safety Culture Survey (U.S Department of Labor, 2014).

Primary data were collected using the inspection sheet of Saudi Aramco Company, which was modified for the purposes of this study. Since its introduction, the inspection sheet of Saudi Aramco Company has provided safety criteria for all construction work performed by Saudi Aramco and its contractors. In order to validate the instrument for the Jordanian environment, the sheet was presented to a panel of judges (Five professors at the civil engineering department/University of Jordan) who attested to the content validity of the instrument after recommending some minor modifications. The modified inspection sheet and its results are shown in Table 1.

The inspection sheet is divided into six categories: site layout; protective equipment and site safety administration; electrical; scaffolding; concrete formwork; and fire prevention. Each category has a number of items that participants rated to evaluate the safety level. Each item is given a score ranging from 0–100 according to the safety level observed by the researchers (see Table 2). The total average was calculated for all categories to determine the overall safety level of the project.

In Jordan, the annual growth of population is 2.8%. Apartment building has become the most prevalent housing type to meet new demands on housing with rapid urbanization and high population density (Al Momani and Hikmat, 2008). Sweis et al. (2013) reported that 87% of all residential buildings in Jordan are located in the capital, Amman. Since it is impossible to observe all the residential construction sites in Amman, a Judgment sampling was used as the sampling design that involves the choice of subjects who are most advantageously placed or in the best position to provide the information required by this research. A sample of 50 sites in different areas in Amman was inspected by the researchers to determine their safety level using the modified Saudi Aramco inspection sheet.

Finally, our most important primary data was that collected by the OSHA's Safety Culture Survey. This survey consists of eighteen questions with a five-point Likert scale response format (ranging from 1 = Strongly Disagree to 5 = Strongly Agree). Eighty questionnaires were distributed at buildings under construction in different areas of Amman. The questionnaires were distributed to respondents by hand. Each respondent was first briefed on the research problem and research objectives. Forty were completed by supervising engineers and the rest by laborers to illustrate the variation in the safety culture

level for each participant. Supervising engineers returned 36 questionnaires while the laborers returned 30. The survey and its results are shown in Appendix A.

The majority of respondents who participated in the study were fairly young (67.5%) with ages ranging between 30 and 40 years old. All of the laborer respondents have graduated from high school and over half of the engineers (55%) hold bachelor's degree. It is important to note that 45% of the engineer participants have completed graduate studies.

The analysis of the questionnaire included ranking the different responses according to their frequency for supervisors and laborers (see Appendix A). Furthermore, a one-way analysis of variance (ANOVA) was implemented on the response means for each question in the survey to test for significant differences in respondents' perceptions of worksite safety.

Table 1: The modified version of the Saudi Aramco contractor's job safety inspection sheet.

Site Layout	Value	Score	Scaffolding	Value	Score
Site access roads	0 - 100	70	Condition of frame members	0 - 100	40
Security Fences/gates	0 - 100	0	Plumb and level	0 - 100	40
Site access signs	0 - 100	50	Proper loading	0 - 100	30
Trash containers/lids	0 - 100	0			
Daily clean-up	0 - 100	30			
Material stacking	0 - 100	60			
Old timber derailed	0 - 100	60			
Overall condition	0 - 100	65			
Lights	0 - 100	0			
Protective equipment & site safety administration			**Concrete formwork**		
Helmets	0 - 100	50	Timber adequate strength	0 - 100	70
Eye protection	0 - 100	0	Supports plumb& level	0 - 100	70
Gloves	0 -100	50	Protective clothing & equipment	0 - 100	20
Safety shoes	0 - 100	50			
Accident reports	0 - 100	0			
Construction safety manual on site	0 - 100	0			
First aid station/kit	0 - 100	0			
Electrical			**Fire Prevention**		
Correct voltage	0 - 100	80	Adequate fire extinguishers	0 - 100	50
Ground fault interrupters used	0 - 100	0	Test smoke detectors	0 - 100	0
Overall condition	0 - 100	60			
Warning signs	0 - 100	0			
				Average	**33.75**

Table 2: The scoring scale of the inspection sheet**.**

Project Rating				
Poor	Fair	Good	Very Good	Excellent
0-59	60-69	70-79	80-89	90-100

4. Data analysis and results

4.1 SSC and the modified Saudi Aramco inspection sheet data

SSC data is divided into three main categories, based on the results, locations, and causes of injuries. The percentages of these data are shown in Tables 3, 4, and 5. Results indicated the highest percentages of injuries were located in the head, lower extremities, and upper extremities, respectively. Comparing this to inspection sheet data, we conclude that a deficit in protective equipment usage resulted in this high percentage of injuries.

Scaffolding is considered as an important cause of injury, as revealed by the high rate of injuries due to falling objects and people. All items related to protective equipment and scaffolding categories had poor safety level ratings. The safety level total average was found to be poor for the fifty construction sites.

Table 3: Accidents percentages as a result of accidents (2007-2012)

Cause	Disability 30% or more	Death	First aid less than 3 days	Under Processing	Disability less than 30%	Healed injury more than 3 days
Percentage	.38	.82	5.69	7.51	8.44	77.08

Table 4: Accidents percentages according to the location of accident (2007-2012)

Accident's location	Neck	Trunk and internal organs	All parts of the body	back	Head	Lower extremities	Upper extremities
Percentage	.47	3.01	5.93	6.50	16.45	29.94	37.68

Table 5: Accidents percentages according to the cause of Accident (2007-2012)

Cause of Accident	Transportation means and lifting equipments	Exposure to electrical current or touching	Being caught between or inside object	Excessive efforts and violent movement	Road injuries	Walking or heading against objects	Machinery tools	Hand tools	Other causes	Objective falling	People falling
Percentage	.76	0.81	1.28	1.61	3.22	8.09	8.66	9.49	15.26	16.58	32.65

4.2 OSHA Safety Culture Survey data

The classification of safety performance was recorded by taking the respective average score of the reported data for all respondents. The resulting averages are presented in Appendix A.

The highest three averages were; (1) workers who break safety rules are treated fairly (4.27), (2) being safe on the job is important to workers (4.15) (3) At my worksite, being safe on the job is more important than getting the work done. (4.04). The lowest three averages were; (1) I have the materials and equipment to work safely (2.38), (2) safety rules and procedures are enforced (2.16), (3) safety issues are included in meetings (1.46).

4.3 One-way ANOVA

An ANOVA is a statistical test for determining the heterogeneity of the means through an analysis of group variances. We performed a one-way ANOVA on the survey questions to test for significant differences in respondents' perceptions. The p-values are presented in Appendix A. with the respondents 'averages. The series of one-way ANOVAs reveals that responding supervisors and laborers agreed that:

- Workers who break safety rules are treated fairly. Sanctions should be applied if the workers do not commit to the enforced rules, but in residential projects, safety rules are not enforced (p value of 0.143).
- Being safe on the job is important to the employees; both supervisors and workers want a healthy environment in which to work safely away from risks and harm (p value of 0.80).
- Materials and equipment are not available to work safely. The majority of construction sites are without safety offices and do not provide safety equipment to workers, such as helmets, eye protection, safety shoes, and gloves (p value of 0.106).
- Safety rules and procedures are not enforced due to poor management and the lack of emphasis on safety awareness for every worker (p value of 0.488).
- Safety issues are not included in meetings and frequently there are no or few meetings held during the entire project (p value of 0.235).

5. Discussion and conclusion

This study sought to evaluate the number of injuries and safety culture in residential construction sites in Jordan. The OSHA Safety Culture Survey assesses the behavior, performance, and degree of consciousness regarding safety among workers, as well as the usage of safety rules in construction sites.

We developed specific results based on the OSHA survey; supervisors and workers showed compatible results in the total averages. Furthermore, this study provides a detailed analysis of the relationships between the numbers, causes, locations, and results of injuries; all obtained from the SSC data. We found the following: (a) The dominant result of accidents from 2007 to 2012 was personal injury (77%); many factors led to these accidents, including lack of safety awareness, inappropriate use of personal protective equipment, irresponsibility, unsuitable behavior, and others. (b) The highest recorded cause of accidents was falling from heights (33%), followed by objects falling (16.58%), and these accidents were reported to be caused by various elements related to the employer, workers, and construction site. The inspection sheet results suggest such accidents, according to the attitudes of both inspectors and labors, occur due to lack of knowledge of protective equipment usage, inappropriate construction equipment (ladders, cranes, and scaffolding), unavailability of suitable protective equipment essential to construction worker safety, worker fatigue or exhaustion, and the unsafe conditions at the construction workplace. (c) The most common injured part of the body was the upper extremities (37.68%), followed by the lower extremities (29.95%). The inspection sheet results and analysis suggest, according to the attitudes of both inspectors and labors, these injuries are caused by poor usage of protective equipment (helmets, gloves, safety shoes, and eye protection) for safety. Another probable cause is the direct contact of the lower extremities with every construction element. Finally, the workers lack knowledge and skill in using personal protective equipment and handling machines and construction equipment.

(d) The small percentage of reported deaths suggests, according to the attitudes of both inspectors and labors, that most construction firms do not record the actual number of deaths in order to preserve their reputation.

6. Recommendations to improve safety performance

This paper reported results of a survey and inspection sheet completed to evaluate the safety culture and performance of the construction industry in Jordan. It reveals that several factors affect safety in construction sites. Thus, to promote safety and awareness among workers in the construction industry, we recommend the following to project managers and governmental bodies

- Develop a representative committee to ensure workers' safety.
- Enforce the law that requires the presence of an engineer in each construction site and incorporate safety rules and regulations.
- Provide safety training programs to make workers aware of safety hazards in the worksite.

- Provide personal protective equipment for workers.
- Provide safety signs and posters on the site.
- Try to achieve a "zero accidents" vision by reducing the numbers of occupational injuries.
- Report fatal and non-fatal injuries in the accident records in order to determine and keep track of their causes.
- Discipline workers to encourage their conformance to safety regulations.
- Provide safety guidelines in job contracts.

7. Implications and future research

The most critical implication of this paper is the need to increase safety awareness in residential construction. This research highlights the difficult situation of construction safety in Jordan. These findings and recommendations should help project managers reduce the numbers of accidents and injuries in residential construction sites. Further research in this domain should be encouraged. In particular, it may be useful to examine other construction projects such as large scale corporate projects that were not explored in this study. Although Jordan is a small country, it shares many cultural and economic characteristics of developing countries that utilize similar construction practices: poor infrastructure, fraudulent practices, and government influence. Given this, it may prove useful to perform research in these underprivileged countries, as the results will provide benefits not only for the people of the countries examined, but also for developing countries in general. As such, this study could effectively be expanded by applying the methodology used in the current study to other developing countries.

Appendix A

ID	Question	Supervisors average	Labors averages	Total averages	P-value
1	Safety is a high priority at my worksite.	4.40	1.53	2.96	0.000
2	My worksite is a safe place to work.	2.83	3.18	3.00	0.000
3	I have the materials and equipment to work safely.	2.58	2.18	2.38	0.106
4	I get enough training to do my work safely.	3.25	1.75	2.50	0.000
5	My supervisor cares about me being safe.	4.20	2.20	3.20	0.000
6	My co-workers are committed to being safe.	4.13	2.15	3.14	0.000
7	My co-workers follow safety rules and procedures.	4.00	1.95	2.98	0.000
8	I feel comfortable raising safety issues with others.	3.08	2.25	2.66	0.007
9	Workers who break safety rules are treated fairly.	4.40	4.13	4.26	0.143
10	Safety problems are fixed quickly.	3.25	1.53	2.39	0.000
11	You get recognition for working safely.	2.73	1.83	2.28	0.000
12	Safety rules and procedures are enforced.	2.25	2.08	2.16	0.488
13	Being safe on the job is important to me.	4.13	4.18	4.15	0.806
14	I have the opportunity to make changes that will improve safety.	4.08	1.95	3.01	0.000
15	At my worksite, being safe on the job is more important than getting the work done.	4.43	3.65	4.04	0.000
16	Management listens to safety concerns.	4.33	2.58	3.45	0.000
17	Workers must take shortcuts to get the work done.	2.30	3.55	2.93	0.000
18	Safety issues are included in meetings.	1.55	1.38	1.46	0.235

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