

## Analysis of Accident Causes at Construction Sites in Oman

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### ABSTRACT

The construction sector has poor reputation records in terms of accidents, hazards and fatalities at construction sites around the world. These accidents affect all aspects of construction projects in terms of human, financial, reputation, time, quality and scope issues. In order to handle these accidents and minimize their impacts, there is a need to identify, understand and analyze the root causes behind these accidents. This can be achieved by exploring the main causes that lead to construction accidents and evaluating their contribution to these accidents, especially in Oman. This paper aims to investigate the main causes that lead to construction accidents in Oman. An intensive literature review was carried out to identify possible causes of construction accidents. Then, two case studies and a questionnaire survey were utilized to collect data from realistic projects and construction professionals in Oman. Data was analyzed by using Excel Software. The findings indicate that there are five major causes that lead to construction accidents, which were found from the analysis of the two case studies; namely, poor instruction by the supervisor, lack of training, lack of workers' awareness, lack of maintenance of equipment and underestimating dangers by workers. However, the results from the questionnaire survey revealed that there are four main causes with a very high contribution to construction accidents, which are: lack of contractor awareness regarding health and safety, poor scaffolding, lack of health and safety warning signs at the construction site and lack of safety considerations by site supervisors. The results show that the contractor has the main responsibility of construction accidents in Oman. However, the responsibility of managing these accidents should not be placed solely on the contractor, but should be shared by all parties; namely, the client, consultant, contractor, sub-contractors and site workers.

**KEYWORDS:** Accidents, Safety, Construction sites, Causes of accidents, Building projects, Oman.

### INTRODUCTION

Global studies have shown that the construction sector is one of the most important sectors for developing the economy of any country. In 2014, the construction industry in the UK contributed about £103 billion in the economic output. There were about 2.1 million jobs in the UK in the construction industry in 2015 (Rhodes, 2015). In a similar way, the construction

industry in Oman highly contributes to the national economic growth with around RO 1.654 bn and about five percent of the GDP by 2013 with large numbers of local and foreign labour (Oman Economic Review, 2015).

There are many stakeholders involved in construction industry, including the client, consultant, contractor, sub-contractors, as well as workers from both private sector and the government, where each of the parties has an active role in construction projects.

Construction industry in general has a very poor record history with respect to health and safety

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compared with other business sectors (Alhajeri, 2014). This poor image of construction industry is common in both developed and developing countries. However, in developed countries, there is a large number of studies that investigated the concept of safety in construction industry in detail, such as (Darley, 2012). In contrast, the field of construction health and safety in developing countries received less awareness and attention. Gulf and Omani construction industries are suffering from a high percentage of accidents at construction sites compared to developed countries (Kartam, 1998). However, it was recognized that construction safety received less attention for deep investigation in Oman and that there is a real need to investigate the concept of safety in Omani construction industry.

The main aim of this research is to investigate the major causes that lead to construction accidents in the Omani construction industry. Identifying these causes with understanding their roots and impacts will help decision makers and construction parties reduce the effects of these causes on project performance and industry performance at large.

This paper is divided into five main sections: literature review, research methodology, data collection, data analysis and conclusions with some recommendations.

## LITERATURE REVIEW

### Definitions of Safety, Accident, Hazard and Safety Management Terminologies

There are many common terminologies used in the construction sector, such as: safety, accident, hazard and safety management. For example, the word 'safety' is used frequently in several sectors. Often, it is associated with the term 'health'. Safety according to Hislop (2009) is defined as the process of controlling the different types of hazard with identifying their levels. The term 'accident' is defined according to the Health and Safety Executive (2016) as "any unplanned event that resulted in injury or ill health of people, damage or loss of property, plant, materials or the environment or loss of

business opportunity".

The concept of hazard in building construction was presented as a phenomenon related to conditions that threaten human life, such as: poor conditions of equipment, method of work and environment of the work (Solomon, 2016). The term 'safety management' with respect to construction industry is defined as "identifying risks and reducing accidents to improve site and project productivity" (Yancy, 2013).

### An Overview of Accident Causation Theories

There are several fundamental theories regarding accident causation, which have some explanatory and predictive values, such as Heinrich's Domino Theory and Swiss Cheese Model (Pierucci, 2015). The main concept of the Heinrich's Domino Theory is the definition of accident as the consequences of events. There are five Heinrich factors which affect humans. These are: social environment, fault of the person, unsafe acts, mechanical and physical hazards, accident and injury (Safety Institute of Australia, 2012). The concept of the Swiss Cheese Model is in the form of a layer of cheese for various parties involved in a project. This can include the client, consultant, contractor, sub-contractors and workers. Each party of the project affects the value chain of construction projects. For example, if the client is interested in choosing the tender based on safety standards, this will affect the work of the consultant to apply safety matters in the design, thus affecting the work of the contractor, then that of sub-contractors and workers. This model can help learn from accidents by summing up all the scenarios that can exist in process industries through considering technical and human aspects and identifying the quantitative, which means that it helps analyze accidents (Pierucci, 2015).

### General Overview of Accidents in Different Sectors and Different Countries

Accidents are common in all industrial sectors, such as: agriculture, construction, fishing and mining. These sectors vary in the proportion of exposure to accidents from one country to another. For example, China Labour

Bulletin (2016) declared that the most work accidents which occurred in China in 2015 were within the construction industry. There are many studies that showed the large number of accidents in the construction sector compared to other sectors (Fung, 2009; Kartam, 1998).

Fung (2009) reported that the number of construction accidents in Hong Kong decreased from 16,422 in 1994 to 4367 in 2003. Kartam (1998) study was conducted in Kuwait as one of the Gulf countries in the same aspect. His study showed that there was an increase in the number of construction incidents in Kuwait between 1992 and 1999 from 73 to 176, respectively. It can be said that Oman is similar to Kuwait in terms of increase in the number of projects set up in the country, such as: infrastructure projects, buildings and public services, which is reflected on the number of accidents.

In addition, there are a few studies that investigated accident causes and safety issues in Oman and the Gulf countries, such as: Al-Anbari (2013), Alhajeri (2014) and Kartam (1998).

Al-Anbari (2013) presented in his study six major risks associated with construction accidents in Oman: working at great heights, working on fragile roofs of buildings, using electrical equipment during the work, working under power lines, working in tight places and working without having knowledge of using emergency equipment at construction sites. His study has focused on factors that lead to construction accidents, such as: age, experience, educational level, type of the project (governmental or private), presence of governmental authorities in Oman, such as (Ministry of Manpower and Public Authority for Social Insurance), the degree of company for which the workers work and worker training. Alhajeri (2014) explained that the United Arab Emirates is one of the countries with large growth in construction activity compared with other developing countries. He mentioned that the construction sector in the UAE has a great need for health and safety systems in various construction projects, similar to UK. The findings of his study showed a lack of awareness of

construction companies in terms of health and safety. Kartam (1998) explained that the construction industry plays an important role in Kuwait's economy. He mentioned that the root causes of construction accidents in Kuwait are: reliance on foreign labour, depending on sub-contractors, difficult weather conditions especially in summer, lack of regulations and specific laws for safety in construction projects and poor accident records.

Therefore, to protect the construction projects and their parties from these accidents in Oman, there was a set of laws and regulations governing this aspect as mentioned by Courtney (2014) and Y Magazine (2015). It is noted that safety laws in Oman in terms of the construction sector are considered very simple, far from real practice, not including details and not containing all aspects of the construction sectors similar to laws applied in the UK. This leads to have more accidents in different construction projects across Oman. The following different construction accidents occurred recently in the existing projects in Oman:

- On the 5<sup>th</sup> of March 2017, "several cars were damaged when scaffolding from a building site collapsed in Muscat's Commercial Business District". There were no workers, because it was lunch time and only the parked cars have been damaged in the accident". (Times of Oman Newspaper, 2017).
- On the 15<sup>th</sup> of April 2017, "three workers died and one was fighting for his life in hospital after they fell from the top of a building under construction in Muscat".
- On the 18<sup>th</sup> of April 2017, "a worker died after a burst water pipe caused a trench that he was working in to collapse on top of him, as emergency services have confirmed". (Times Oman Newspaper, 2017).

Compared to the UK health and safety regulations, it seems that Oman has a lack of these regulations and although there are a few regulations, there is an absence of monitoring and controlling accidents and the implementation of these regulations by construction companies in Oman.

### Classification of Accidents Causes

Different authors classify causes of construction accidents in different ways, such as: causes related to project party (Cheah, 2007) and internal and external causes of the project (Hon, 2010). The first classification is based on the project party who is responsible for the accident in the construction project, such as: client, consultant, contractor, sub-contractors, workers and some external causes which are out of any party control. The second classification considers the causes of construction accidents according to various levels of construction industry, such as: macro-, mezzo- and micro-levels as Hon (2010) mentioned in his study. From the literature review, 46 causes of accidents at construction sites were selected based on the various parties involved in construction projects. A list of these causes is shown in Table 3.

### METHODOLOGY

Investigation of the literature review and cause identification reflect the complexity of the construction environment with the hazard conditions and causes that lead to construction site accidents. It can be recognized that these causes involve both qualitative and quantitative aspects. Therefore, a case study and a questionnaire survey were used to handle these aspects. The case study was used to collect actual data from real world projects, while the questionnaire survey was used to obtain

opinions of various construction professionals on the causes of construction site accidents. These will be presented in detail study in the following sub-sections.

### Case Study

Two non-residential building construction projects were selected for case study investigation. These two projects have been constructed by excellent ranked construction companies. The construction companies were named as Company X and Company Y for the purpose of confidentiality and commercial issues. These two building construction companies were selected due to their positive response during the survey stage and since they provided appropriate information serving this study. However, the results of the two cases studied cannot be generalized, because they are special cases.

According to the accident investigation report which was provided by the consultant side, Company X recorded 4 accidents for the project over the last one year. These are: left leg fracture with laceration of skin, diesel tanker body damaged, a minor fire accident and a serious personal injury. But, regarding Company Y which constructed the second project (case 2), over one year, only one accident was recorded by the consultant.

Table 1 presents the causes of recorded accidents in both cases. The frequency of accident causes is presented in the last column to demonstrate the significance of these causes and their likelihood of occurrence.

**Table 1. Causes of construction accidents from the case study**

Causes of construction accidents	Case 1				Case 2	Frequency
	1 <sup>st</sup> accident	2 <sup>nd</sup> accident	3 <sup>rd</sup> accident	4 <sup>th</sup> accident	1 <sup>st</sup> accident	
Poor instruction by supervisor	√	-	√	-	√	3
Unskilled workers	√	-	-	√	-	2
Lack of worker awareness	√	√	√	√	-	4
Lack of training	√	√	-	√	-	3
Underestimating dangers by workers	√	√	√	-	-	3
Lack of equipment maintenance	√	√	-	-	-	2
External cause (exposure to some unforeseen situations)	-	√	-	-	√	2
Lack of communication between workers	√	-	√	-	-	2
Lack of worker experience	√	-	-	√	-	2
Lack of taking into account the design from the contractor side	-	-	-	-	√	1

It can be concluded from Table 1 that the top causes

of construction accidents from both cases were:

- Poor instruction by the supervisor.
- Lack of worker training.
- Lack of equipment maintenance.
- Lack of worker awareness.
- Underestimating dangers by workers.

Poor instruction by the supervisor can be considered the first main cause of construction accidents. This finding is similar to that of Alhajeri (2011) in the UAE. He mentioned that providing instructions by the supervisor or employer is very important, since these instructions are considered to be protecting workers from: injuries, wounds, fires, hazards and deaths.

The second main cause is lack of worker training, which is similar to the finding of Al-Anbari (2013) in Oman. He found through his questionnaire that 54.3% of the respondents said that they never had any training, which led them to have different types of construction accidents through their work.

The third main cause is lack of equipment maintenance, which was repeated in 3 different accidents in the same project.

The last two causes of construction accidents are lack of worker awareness and underestimating dangers by workers. This finding is consistent with Cheah (2007). Furthermore, Sidney (2014) mentioned that workers are not the problem at construction sites, but worker errors are a result of management problems.

However, most of site workers in Oman are expatriates. They are from different poor Asian countries. They do not have enough degree of education, with different environments, languages and cultures. These factors make them more exposed to construction accidents.

### **Data Collection and Analysis through Questionnaire Survey**

A questionnaire survey was employed to collect data from construction professionals on the contributing causes to construction accidents in Oman. This questionnaire consists of three main sections: section A is about personal details which were optional. Section B is about the general data of the respondents and

organizations that they work for and section C is about identifying the significance of each cause to construction accidents. These causes were divided into 6 main groups, including client-related causes, external causes, contractor-related causes, sub-contractors with suppliers, consultant and site workers. The questionnaire items contained both open and closed questions, which gave participants the chance to identify new causes of construction accidents. The questionnaire also included a cover letter, the contact number and an e-mail in case of confusion. A pilot study was carried out through this questionnaire with professional construction persons to make sure that the questions are correct and understandable. Questionnaire forms were handed out to 70 construction professionals directly involved in construction industry using personal communication. 40 responses were received with 57% response ratio. The respondents were asked to provide their opinions on the significance of each accident cause based on a five-point scale (i.e., very low, low, medium, high, very high). Then, the subjective points were converted into numerical values to represent a Likert scale (1: very large, 2: large, 3: medium, 4: high, 5: very high).

### **General Details**

The findings from section B of the questionnaire as in Figure (1) indicate that 98% were having a university level education with a bachelor degree and master degree, which gave more reliable answers. Figure (2) shows that about 45% of the respondents are working in an engineer position from the client side or the contractor side. This demonstrates that they are very close to the construction sites and highly aware of construction accidents. Figure (3) shows the type of organization that they work for, where 55% of the respondents work for the public sector and 45% of them work for contracting and consulting companies. This demonstrates the image of construction site accidents from both public and private perspectives. Figure (4) indicates that more than 80% of the respondents were from the client side, which means that the questionnaire

responses may be biased. Figure (5) shows that about 72.5% of the respondents are having more than 5 years of experience in the construction industry, which means that the respondents could provide reliable answers and opinions. Figure (6) shows that the question: “From your experience, who is the main party causing construction accidents?” was addressed to different project parties. The answer was that more than 70% of the respondents said that the responsibility lies on the contractor, including the responsibility of the contractor toward sub-contractors and site workers. This can be due to that most of the answers were from the client side and the consultant side, who always blame the contractor.



Fig (3): Type of respondent organization

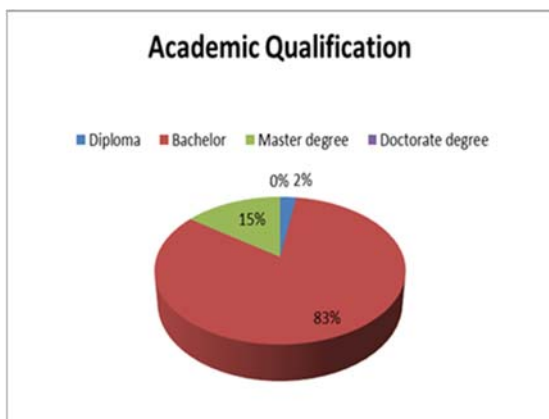


Fig (1): Educational background of the respondents

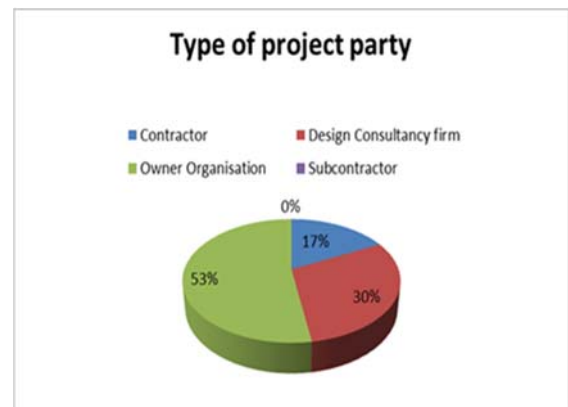


Fig (4): Type of project party

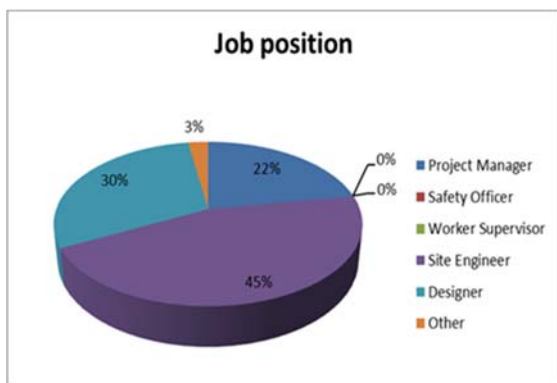


Fig (2): Job position of respondents



Fig (5): Years of respondent experience

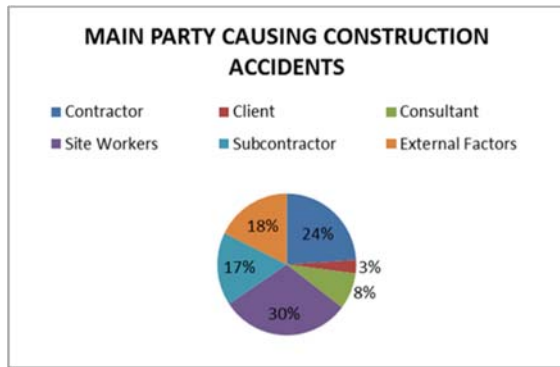


Fig (6): The main party causing construction accidents

In section C, answers were converted from qualitative into quantitative data by using a Likert scale

(very low: 1, low: 2, medium: 3, high: 4 and very high: 5). Table 2 shows the ranking of causes depending on the average and the range. Regarding the average, the formula below has been used:

$$Average = \frac{\sum_{i=1}^n w_i * n_i}{n}$$

For example, the average of procurement method used is calculated based on the number of responses for this cause, referred to as: 6 very low, 8 low, 20 medium, 6 high and no response very high. Then, the average score is calculated based on the above equation as follows:  $(6*1+8*2+20*3+6*4+0*5) / 40 = 2.65$ .

Table 2. Number of respondents who answered this survey

Classified causes	Causes of construction accidents in Oman's projects	Very low (1)	Low (2)	Medium (3)	High (4)	Very high (5)	Average
Client	Procurement method used	6	8	20	6	0	2.65
	Lack of client's awareness of health and safety	3	6	13	15	3	3.225
	Lack of adopting safety standards	1	4	6	20	9	3.8
	Changing client requirements	3	9	13	15	0	3
	Inadequate supervision from client side	2	8	14	9	7	3.275
External factors	Bad condition of soil	2	8	14	7	9	3.325
	Lack of governmental regulations of health and safety	2	7	11	11	9	3.45
	Lack of safety monitoring by the government	3	4	13	14	6	3.4
	Severe weather (including: rain, wind, earthquakes, flooding and landslides)	2	5	10	11	12	3.65
	Exposure to dust and noise	1	10	15	14	0	3.05
Contractor	Lack of control of sub-contractors	0	5	9	18	8	3.725
	Lack of communication between various stakeholders	2	3	11	14	10	3.675
	Lack of safety and accident records for further actions	1	5	12	9	13	3.7
	Lack of contractor awareness regarding health and safety	0	1	5	10	24	4.425
	Lack of award system for workers who are committed to safety standards	0	2	10	17	11	3.925
	Size of contracting firm	1	4	19	11	5	3.375
	Lack of training provision	0	6	5	23	6	3.725
	Lack of safety considerations by site supervisors	0	3	9	10	18	4.075
	Lack of safety instruction regulations	0	3	8	13	16	4.05
	Interaction between various activities	0	4	14	19	3	3.525
	Poor scaffolding	0	3	6	12	19	4.175
	Lack of health and safety warning signs at the site	1	0	6	19	14	4.125
	Lack of provision of PPE	1	2	18	10	9	3.6

	Poor maintenance of equipment	1	2	12	13	12	3.825
	Poor supervision and wrong instructions	2	4	6	14	14	3.85
	Irresponsible motivation orders to workers	2	2	2	19	5	3.575
	Poor working surfaces and platforms	3	0	10	15	12	3.825
	Excessive overtime work for labour	2	9	10	10	9	3.375
	Insufficient lighting and blind spots at the site	3	3	13	13	8	3.5
	Working in an enclosed space with no ventilation	4	5	7	13	11	3.55
	Poor condition of equipment and plant	2	7	8	6	7	3.475
	Poor condition of PPE	4	5	13	12	6	3.275
	Poor storage and handling of materials	3	6	11	14	6	3.35
<b>Sub-contractors and Suppliers</b>	Lack of safety awareness	2	3	10	15	10	3.7
	Lack of familiarity with safety standards	2	6	5	18	9	3.65
	Resistance to safety instructions from contractor	3	4	8	18	7	3.35
	Overloaded works to sub-contractors	2	5	12	11	10	3.55
<b>Consultant</b>	Lack of safety considerations during design stage	2	8	30	44	65	3.725
	Lack of experience with safety standards	2	10	24	56	55	3.675
<b>Site Workers</b>	Lack of safety awareness	2	12	12	64	60	3.75
	Low educational level	1	8	36	48	55	3.7
	Poor communication due to workers' culture, language and characteristics	1	12	21	64	50	3.7
	Alcohol and drugs	4	12	24	24	80	3.6
	Unskilled workers	3	5	6	7	19	3.85
	Working under direct sunlight for a long period of time	0	4	8	14	14	3.95
	Inadequate space or difficult access to perform	2	4	12	18	4	3.45

In order to classify the causes according to their importance and significance, the following method is used. The highest average score is 4.425 and the lowest average score is 2.65. The range between the highest and lowest scores is 1.775. This range is divided into 5 clusters to match the five-point scale used in this study as follows:

- Very low (2.65-3.005).
- Low (3.006-3.36).
- Medium (3.37-3.715).
- High (3.716-4.07).
- Very high (4.08-4.425). Then, all causes are ranked in descending order based on the above clusters as shown in Table 3.

**Table 3. Descending order of construction accident causes**

Project party	Causes	Average
Contractor	Lack of contractor awareness regarding health and safety	4.425
Contractor	Poor scaffolding	4.175
Contractor	Lack of health and safety warning signs at the site	4.125
Contractor	Lack of safety considerations by site supervisors	4.075
Contractor	Lack of safety instruction regulations	4.05
Site workers	Working under direct sunlight for a long period of time	3.95
Contractor	Lack of award system for workers who are committed to safety standards	3.925
Contractor	Poor supervision and wrong instructions	3.85
Site workers	Unskilled workers	3.85



Contractor	Poor maintenance of equipment	3.825
Contractor	Poor working surfaces and platforms	3.825
Client	Lack of adopting safety standards	3.8
Site workers	Lack of safety awareness	3.75
Contractor	Lack of control of sub-contractors	3.725
Contractor	Lack of training provision	3.725
Consultant	Lack of safety considerations during design stage	3.725
Contractor	Lack of safety and accident records for further actions	3.7
Sub-contractors and suppliers	Lack of safety awareness	3.7
Site workers	Low educational level	3.7
Site workers	Poor communication due to workers' culture, language and characteristics	3.7
Contractor	Lack of communication between various stakeholders	3.675
Consultant	Lack of experience with safety standards	3.675
External factors	Severe weather (including: rain, wind, earthquakes, flooding and landslides)	3.65
Sub-contractors and suppliers	Lack of familiarity with safety standards	3.65
Contractor	Lack of provision of PPE	3.6
Site workers	Alcohol and drugs	3.6
Contractor	Irresponsible motivation orders to workers	3.575
Contractor	Working in an enclosed space with no ventilation	3.55
Sub-contractors and suppliers	Overloaded works to sub-contractors	3.55
Contractor	Interaction between various activities	3.525
Contractor	Insufficient lighting and blind spots at the site	3.5
Contractor	Poor condition of equipment and plant	3.475
External factors	Lack of governmental regulation of health and safety	3.45
Site workers	Inadequate space or difficult access to perform	3.45
External factors	Lack of safety monitoring by the government	3.4
Contractor	Size of contractor firm	3.375
Contractor	Excessive overtime work for labour	3.375
Contractor	Poor storage and handling of materials	3.35
Sub-contractors and suppliers	Resistance to safety instructions from contractor	3.35
External factors	Bad condition of soil	3.325
Client	Inadequate supervision from client side	3.275
Contractor	Poor condition of PPE	3.275
Client	Lack of client's awareness of health and safety	3.225
External factors	Exposure to dust and noise	3.05
Client	Changing client requirements	3
Client	Procurement method used (e.g. traditional method)	2.65

The results in Table 2 are analyzed and discussed in two ways: based on the overall ranking of all respondents, as well as with respect to points of view of the main three parties (i.e., client, consultant and contractor) on accident causes.

### **Overall Significance of Construction Accident Causes**

In Table 3, the causes are ranked based on the descending order of their average which is: 4 causes with very high contribution to construction accidents highlighted with red color, 16 causes with high contribution highlighted with orange color, 6 causes with medium contribution highlighted with yellow color, 18 causes with low contribution highlighted with green color and 2 causes only with very low contribution highlighted with blue color.

In this paper, only very high-contribution and high-contribution causes are considered for discussion, since they seem to be the major contributors to construction accidents. Discussing all causes is time- and effort-consuming.

There are four causes with very high contribution to construction accidents. These causes will be discussed in more detail in the following part of the study.

1. Lack of contractor awareness regarding health and safety: This cause is considered a very important reason leading to construction accidents related to the contractor. Lack of awareness by the contractor is represented in the absence of health and safety management system at construction sites, including lack of worker training, failure to inspect and maintain the equipment on a regular basis, not to educate the workers about risks that occur in the project and failure to provide PPE for workers. This cause was also found by Kamar (2014).
2. Poor scaffolding: This cause is a very important cause in construction projects, since it leads to many injuries, blunt trauma to the head, falling to the ground and a slippery condition. This cause is within the responsibility of the contractor. The contractor must verify the validity of the scaffold before use, provide safe access for workers, provide worker

training regarding the scaffold and during using scaffolds. The contractor must also be sure regarding proper access, guard railing, full planning and stable footing. This was also investigated by Haslam (2014).

On the other hand, it is very difficult to have good-quality equipment with regular maintenance from the contractor side due to high cost. Poor conditions of equipment and scaffolding start with the client, because it is too easy to blame the contractor for using inferior equipment. The client must take care of this aspect during the selection of the tender.

3. Lack of health and safety warning signs at the site: Providing warning signs at construction sites is a very important responsibility of the contractor, as these warning signs are alert and warn and draw the attention of workers to avoid several construction accidents. In addition, workers will always be aware by looking at the safety signs through their work. There was a study related to this point by Razak (2014). However, there must be an item in the BOQ for this aspect obliging the contractor to provide these signs. It is regrettable that this point has not been implemented in Oman.
4. Lack of safety considerations by site supervisors: This cause exposes workers to various construction accidents. This result is the same as the case study finding.
  - These 16 high contribution causes of construction accidents can be divided into three main groups: 8 causes are related to the contractor, 5 causes are related to site workers and three causes are related to other parties, such as client, sub-contractors and consultant.

### ***Causes Related to the Contractor***

The contractor should assume the management of safety policy for his company as well as for construction sites. This safety policy should include: applying safety instruction regulations which contain avoiding working under direct sunlight for a long period of time. Therefore, there was a decision numbered 286/2008 by Oman's government that states: "Most importantly,

workers must not work on construction sites or open, uncovered areas of high temperature at noon, from 12.30pm up to 3.30pm throughout June, July and August; subject to certain exemptions for establishments providing essential public services” (Y Magazine, 2017). Safety policy should also include: having maintenance of equipment, creating a suitable place to work (for example, good working surfaces and platforms), providing training for workers which helps get skilled workers at the site, giving good supervision for workers, an award system for workers who are committed to safety standards, which is a type of motivation for workers to encourage them to apply health and safety regulations during their work. This is a good way to prevent productivity pressure. But, it won't work if it is linked to accidents. Having safety and accident records makes the contractor have an idea about types of accidents, create solutions and control sub-contractors by following up their work, encouraging them to use technology in their work, as Zhenghui (2010) mentioned.

**Causes Related to Site Workers**

- 5 causes are related to site workers. These causes are: working under direct sunlight, unskilled workers, lack of safety awareness, low educational level and poor communication due to workers’ culture, language and characteristics. It is noted that all these causes have a very strong relationship with the contractor. Therefore, the contractor should assume the responsibility of providing sufficient training to his workers.

**Causes Related to Other Parties**

- The remaining three causes are divided among the client, the sub-contractors and the consultant. This will be explained below.
  1. Lack of safety considerations during the design stage is the responsibility of the consultant. The consultant must design a building, facility or structure with accepted engineering practices, local building codes and safety rules. Cheah (2007) supported this point in his study.
  2. Lack of adopting safety standards from the client side will lead to have construction accidents. The client must have an awareness of applying safety standards in the project by attending meetings with inspection visits to follow up and find out what is going on in the project. This finding is similar to that of Cheah (2007).
  3. Lack of safety awareness by sub-contractors leads to construction accidents, because they do not care about applying safety standards during their different works in the project. This result is supported by Zhenghui (2010).

It is not logical to ignore other causes that lead to construction accidents which may be perceived by respondents as unimportant or unnecessary, but may be viewed by others as very important and playing an important role in construction accidents, such as: lack of enforcement from the government side regarding the regulations of health and safety, poor condition of the equipment and plant and lack of provision of PPE.

**Table 4. Significance of construction accident causes according to various project parties**

Cause S/N	Description of the causes	Responsibility	Accident cause rank			Overall ranking
			Client	Consultant	Contractor	
14	Lack of contractor awareness regarding health and safety	Contractor	1	9	1	1
21	Poor scaffolding	Contractor	2	7	5	2
22	Lack of health and safety warning signs at the site	Contractor	7	3	24	3
18	Lack of safety considerations by site supervisors	Contractor	10	10	4	4
19	Lack of safety instruction regulations	Contractor	3	11	23	5
45	Working under direct sunlight for a long period of time	Workers	9	20	4	6

15	Lack of award system for workers who are committed to safety standards	Contractor	6	28	40	7
25	Poor supervision and wrong instructions	Contractor	18	5	25	8
44	Unskilled workers	Workers	11	24	30	9
24	Poor maintenance of equipment	Contractor	5	2	11	10
27	Poor working surfaces and platforms	Contractor	19	12	19	11
3	Lack of adopting safety standards	Client	13	30	16	12
34	Lack of safety awareness	Sub-contractors	30	14	13	13
11	Lack of control of sub-contractors	Contractor	16	39	7	14
17	Lack of training provision	Contractor	29	33	9	15
38	Lack of safety considerations during design stage	Consultant	4	37	14	16
13	Lack of safety and accident records for future actions	Contractor	28	31	33	17
40	Lack of safety awareness	Workers	12	8	22	18
41	Low educational level	Workers	24	21	15	19
42	Poor communication	Workers	9	38	28	20
12	Lack of communication between various stakeholders	Contractor	17	40	8	21
39	Lack of experience with safety standards	Consultant	21	23	2	22
9	Severe weather	External causes	27	1	39	23
35	Lack of familiarity with safety standards	Sub-contractors	20	27	26	24
23	Lack of provision of PPE	Contractor	5	4	35	25
43	Alcohol and drugs	Workers	26	19	29	26
26	Irresponsible motivation orders to workers	Contractor	23	22	43	27
30	Working in an enclosed space with no ventilation	Contractor	41	6	36	28
37	Overloaded works to sub-contractors	Sub-contractors	38	29	20	29
20	Interaction between various activities	Contractor	36	34	10	30
29	Insufficient lighting and blind spots at the site	Contractor	43	13	6	31
31	Poor condition of equipment and plant	Contractor	32	16	12	32
7	Lack of governmental regulations on health and safety	External causes	15	42	22	33
46	Inadequate space or difficult access to perform	Workers	34	25	31	34
8	Lack of safety monitoring by the government	External causes	25	35	32	35
16	Size of contractor firm	Contractor	35	32	34	36
28	Excessive overtime work for labour	Contractor	37	26	45	37
33	Poor storage and handling of materials	Contractor	40	18	37	38
36	Resistance of safety instructions from contractor	External causes	31	15	27	39
6	Bad condition of soil	External causes	15	43	17	40
5	Inadequate supervision from client side	Client	22	44	42	41
32	Poor condition of PPE	Contractor	42	17	35	42
2	Lack of client's awareness of health and safety	Client	39	41	41	43
10	Exposure to dust and noise	External causes	46	36	18	44
4	Changing client requirements	Client	44	46	44	45
1	Procurement method used	Client	45	45	46	46

### Comparison of Construction Accident Causes According to Various Project Parties

Table 4 shows the ranking of construction accident causes based on the points of view of the three main

parties of the project.

The results showed that the client placed more blame on the contractor for most of very high-contribution causes, such as: lack of contractor awareness regarding

health and safety, poor scaffolding, lack of health and safety warning signs at the site and lack of safety considerations by the site supervisor. This can be true in the environment of construction industry in Oman, since the client wants to keep himself away from liability, as in most developing countries (Einarsson, 1998). In contrast, this might not be true in developed countries. In this case, it is suggested to present a 'Swiss Cheese Model' format which includes the client, consultant, contractor, sub-contractors and workers. This will show that any decision made by the client will be filtered through the layers of decisions made by the rest of the project parties. For example, when the client chooses a tender, he should not choose the lowest bid price as in developing countries. In developing countries, the client procurement methods force prices down, which will affect the consultant during the design time. Then, this will impact the safety aspects of the consultant design and affect the contractor paying for regular works to protect workers through maintenance, training and providing PPE. Thus, neglection from the contractor side regarding health and safety will affect the work of sub-contractors as well.

It is also evident that the consultant places more blame on the contractor, as most of the very high-contribution causes in his view are related to the contractor, such as: poor scaffolding, lack of health and safety warning signs at the site, poor supervision, poor maintenance of equipment and lack of safety awareness. This may also be true in the construction industry in Oman. This is due to the fact that there is no continuous follow-up and inspection visits by the consultant to control the work of the contractor at the site and there is no supervision of projects to ensure the application of general engineering requirements for the safety of the project. However, this does not mean that consultants do not visit and inspect sites. Unfortunately, they do that only in order to fill out the form of inspection for quality, but not for safety.

Most of the construction accident causes mentioned by the contractor are of medium level and some of them are related to external factors, such as lack of

governmental regulations of health and safety. Others are related to workers, like poor communication and to sub-contractors, such as lack of familiarity with safety standards. As known, the contractor avoids blaming the client and the consultant due to the nature of their work in the project, as these two parties have more strength. For example, the client is the owner of the project and has the ability to give the project to another contractor. In addition, the contractor maybe not aware of the potential roles of the client and designer to enhance safety through their work.

The perceptions and opinions of the client and consultant differ from those of the contractor. The client responses are very close to the consultant's responses on the order of the causes of construction accidents. This may be because the sample type (client and consultant) is biased to blame the contractor for being the nearest party to the project and the one responsible for workers and sub-contractors.

It can be said that the absence of the government role in terms of safety in construction projects in developing countries is a very important cause that leads to construction accidents, as mentioned by Courtney (2014). There is no explicit law pushing the client to choose a tender that contains safety standards; for example, to force the consultant to have a temporary design of some services in the project, as well as to force the contractor to have a safety policy regarding equipment maintenance, training of workers and selection of sub-contractors.

## CONCLUSIONS

Since construction sites are exposed to a wide range of accidents, it is very important to identify the causes of these accidents, as is shown in this paper. Exposure to accidents differs in both developed and developing countries. Unfortunately, there is an increase in the number of construction accidents in several projects in Oman, which reveals no improvement in this industry. This paper reviewed various aspects related to construction safety and accidents. It discussed accident

causes with respect to construction project parties, such as: the client, consultant, contractor, sub-contractors and site workers. A list of accident causes was identified for further investigation considering the Omani construction industry, with main focus on non-residential building projects, from construction professionals by means of a case study and a questionnaire survey. The case study findings indicate that there are five major causes leading to construction accidents; namely, poor instruction by the supervisor, lack of training, lack of worker awareness, lack of maintenance of equipment and underestimating dangers by workers. However, the results from the questionnaire survey revealed that there are four main causes with very high contribution to construction accidents, which are: lack of contractor awareness regarding health and safety, poor scaffolding, lack of health and safety warning signs at the construction site and lack of safety considerations by site supervisors. This study also points out that the major causes of construction accidents from the case study are similar to those revealed by the questionnaire survey findings. Very high-contribution causes are related to the contractor. In addition, the findings are according to the point of view of each project party. As well known, the client and consultant always blame the contractor. Historical records that include the causes of construction accidents provide important background knowledge for all project stakeholders, deep understanding of these causes, analyzing them and suggesting a set of recommendations to improve construction safety in Oman in the future.

Based on the main findings, the following recommendations can be provided to various stakeholders of construction projects.

*Recommendations to the Government:* Issuing safety building regulations, laws and legislations as soon as possible, punishing companies that do not apply these laws, by means of financial penalties, encouraging construction companies to apply safety standards during

their work and providing training to construction workers. During the submission to the tender by contractors, the government must take into consideration that the tender contains the safety items and records and encourage contractors who adhere to safety standards at work by providing them with a certificate or giving them first priority for new government projects.

*Recommendations to the Client:* Clients should clearly define their needs and requirements in terms of design and style before starting any construction project and when evaluating the tenderers, the client must consider the safety record of each of them.

*Recommendations to the Consultant:* The consultant should consider safety during the design stage. He must have knowledge of construction methods, as well as of the technology available in the market and in the construction industry. There should also be ongoing inspection visits to control the contractor's work from the consultant side to ensure the work quality of the contractor.

*Recommendations to the Contractor:* Each contractor must establish a safety policy for his company, which contains: safety organization structure, roles and responsibilities of each project party and using effective technology to reduce errors. Depending on site conditions, the contractor must create a site safety plan before starting the project, establish a special budget for the company for training the workers and motivating them. The contractor must have safety records to protect himself from repeating the construction accidents which have previously occurred and create solutions to these accidents. He should also conduct a health inspection of workers on a periodic basis to ensure their health.

*Recommendations to the Site Workers:* Workers should take part in safety training to advance their knowledge of construction safety. They must also have responsibility for implementing safety standards during their work and apply all regulations and safety guidelines at construction sites.

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