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Research paper

Analysis of the Falling Accidents at the Makkah Holy Mosque Expansion Project

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Abstract

The current research study aimed to identify the causes of the falling accidents that occurred at the Makkah Holy Mosque Expansion Project in 2014. The categories of falling accidents used in the study were obtained from a record of 429 accidents. Other aspects of falling accidents were also considered in the analysis, including the time of day and the season when the accidents occurred. The analysis results indicated that 42% of the fatal accidents were due to falling and that the plurality of falling accidents during the Holy Mosque project involved falling from a height (27%), followed by falling objects hitting workers (22%) and falling on the same level (10%). More than half of the accidents (55%) occurred during the morning shift. Sorting the accident records based on Islamic Arabic (Hijri) calendar months revealed that the accidents had a specific pattern related to those seasons. These results were aided to reduce the falling accidents in the Project.

Keywords: *Falling Accidents; Construction; Makkah Holy Mosque; Fatal Accidents; Hajj Season; Umrah Season; Body Parts Injury; Time of Day; Hijri Months; Falling Objects.*

1. Introduction

This paper analyses the accidents that occurred during the Makkah Holy Mosque Expansion Project based on the project's overall accident records for 2014 and its fatal-accident record from the project's beginning in January 2012 through the end of 2015. This topic was investigated because of the increasing number of accidents in the area and the lack of well-established regulations, which, if they existed, would minimize accidents. This study was implemented to identify any safety breaches. The results of this study are also applicable beyond the Makkah Holy Mosque Expansion Project because Makkah City is going through an overall renovation phase implemented by the city's government to modernize the city and make it the primary holy place in Saudi Arabia .

Construction accidents are an issue of significant concern worldwide, as has been demonstrated by the numerous studies on this topic. Previous studies have proposed different solutions and recommendations for reducing accidents in the construction industry. In this industry, falling is the most common cause of both regular and fatal accidents; at the Holy Mosque, during this study's time frame, 37% of normal accidents and 42% of fatalities were the result of falling.

This research was motivated by two main issues: 1) regular and fatal accidents at the Holy Mosque Expansion Project in Makkah are at unacceptably high levels, and 2) the data collection in this project's accident reports is inadequate, which limits the decision-making ability for safety plans and measures.

Specifically, discussions regarding the enforcement of safety regulations at the project site are largely subjective (based on the attendees' safety experience and backgrounds); some prefer the American construction-safety standards, whereas others prefer the British standards. This ambiguity reflects a weakness in the current safety regulations, namely, that action from higher authorities is required to support such personal initiatives as those investigated in this study.

Many studies emphasize a lack of safety training as a common cause of falling accidents. One study considered the issue to be in the safety design, in which designers and architects must consider safety in the design phase of a project [1]. Another study found that workers can be tempted to act in an unacceptably high-risk manner if a task is of short duration. In other words, workers believe that their experience and awareness will not fail them in trivial, short-term tasks. The hypothesis was that when more safety measures are taken, workers become more careless regarding their safety; in psychology, this behaviour is called risk homeostasis [2-3].

Each project's unique circumstances contribute to its accident patterns; for example, in a study conducted in 2003 in the USA [4], most accidents occurred in the summer because of excessive work. Similarly, in the Makkah Holy Mosque Project, most accidents occurred in the time preceding the religious seasons of Hajj and Ramadan. Previous studies have shown that accidents are more likely to occur in low-cost, private, and residential projects [4]; hence, the accidents at a sizeable, well-funded public project, such as the Makkah Holy Mosque Expansion Project, are of particular concern.

In Hong Kong, regular accidents must be reported to the general contractor within seven days, and severe or fatal accidents must be reported within three days [1]. A search of the websites for the related Saudi authorities (Ministry of Labour and Social Development "MOLSD", Civil Defence, and General Organization of Social Insurance "GOSI") revealed that GOSI is the only authority that has such a reporting form; it must be filed manually and submitted to the GOSI offices. Globally, this reporting requirement is considered an ancient procedure. In the UK, a significant regulation distributes the responsibility among participating parties: "In design risk assessment the designer is legally required to try to anticipate any activities in the construction process that might expose operatives to

risk (HMSO, 1994a, 1994b)"; no equivalent regulation exists in such detail within the regulations of the related Saudi legislative bodies [2].

Although the penalty, as an administrative control, only appears near the bottom of the Hierarchy of Controls [5], it is still an effective method for reducing the number of accidents. For example, the US Occupational Safety and Health Administration (OSHA) has a well-established penalty system, which is a reflection of having well-established safety standards that does not permit vagueness to be an excuse for violations that cause harm to people or properties. In contrast, the Saudi entities in charge of safety enforcement, such as MOLSD, Civil Defence, and GOSI, only provide guidelines for safety measures and violations. Any of these authorities could take the initiative to build an outline of safety regulations and codes and then create a penalty system based on that outline, as all the authorities are non-profit, governmental organizations. The initiation of such a system would surely cover the safety departments' expenses, including the officers' salaries and documentation costs, within a short period. One of the OSHA website pages entitled "Top Enforcement Cases Based on Total Issued Penalty" indicates that some inspections have yielded penalties of more than eighty million dollars [6]. That high penalty undoubtedly has caused many companies in the USA to consider safety as a top priority to ensure they avoid such massive losses; furthermore, a history of poor behaviour could lead to bans on many privileges in the USA. There is no excuse for not having such a system, as even Malaysia has had a similar act [7] in effect since 1994, along with other detailed safety documentation [8].

It is also important to examine previous studies conducted within the Gulf Cooperation Countries to identify their similarities. A study on general construction safety that was published in Kuwait in 2010 yielded the following essential findings and ideas: first, due to a lack of standards, construction-site safety judgements in Kuwait had become subjective; second, as construction projects are temporary and unique by nature, lessons and standardized processes based on previous projects could fail because of unpredicted hazards in new projects; and finally, the majority of workers on construction sites had limited education and lacked the training necessary to perform their tasks, with the most common problem being the language barrier, as most of the workers came from South Asian countries [9-10].

The paper summarized its most crucial point in this statement: "On-site safety standards are specified in the conditions of the contract, to which the project parties agree. Some projects specify British Safety Standards; others follow the OSHA regulations." This fact reveals the necessity of an initiative to create local safety standards [9]. Consequently, the current study aimed to analyse the types of falling accidents that occurred during the expansion of the Holy Mosque. This type of analysis facilitates the accident-control process and provides solutions to reduce serious accidents and fatalities in similarly large projects.

2. Methods

2.1. Data collection

The accident data used for this study are the accident records of the following elements of the Makkah Holy Mosque Expansion Project: the Haram Building, the Central Utilities Compound (CUC) and Security Plots 1, 2, and 3. A total of 429 accident records were used for 2014 see Fig. 1. In addition, the fatality records since the beginning of the project, in January 2012, through the end of the year 2015 were used. The data were collected from the safety reports of the general contractor of the Holy Mosque Expansion project.

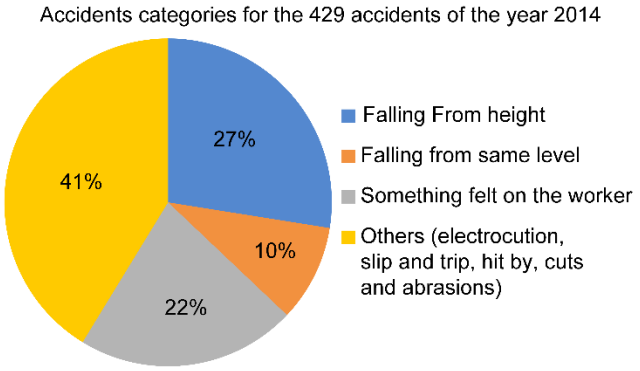

Fig. 1: Major Accident Categories for the Makkah Holy Mosque Expansion Project, 2014.

2.2. Methods and sorting data

The data were statistically analysed to identify which factors contributed significantly to the accidents; a Pearson correlation coefficient was determined for the falling accidents' heights and the injured body parts. The analysis also revealed a gap in the data. Furthermore, the project statistics were compared to the GOSI statistics for Makkah City.

The accident records for the Makkah Holy Mosque Expansion Project were categorized by examining the accidents' written descriptions, leading to main categories based on accident type, season, and time of day. The following are the categories for accident type: worker fell from a height, something fell on the worker, worker fell on the same level, other (electrocution, slip and trip, hit by, cuts and abrasions).

The findings of the analysis revealed the most common accidents in the Makkah Holy Mosque Expansion Project; these findings could be used to create proper safety measures that will reduce accidents generally and falling accidents in particular.

The data were also categorized according to time of occurrence as follows:

1)The season of the year

The activities of the Makkah Holy Mosque Expansion Project are oriented based on the Islamic religious seasons. The meaningful patterns that appeared when the data were analysed in the time domain in relation to the seasons of the Arabic Hijri calendar (the analysis was based on that calendar and not the Gregorian one) are as follows:

Hajj (month of Dhu Alhejjah).

Umrah (month of Ramadan) and,

The remaining months of the year

2)The time of day, divided into 2-hour periods (twelve slots for a 24-hour day).

For each accident record, the data were grouped based on the availability of data on the: injured body parts, height of the fall (in falling accidents), activity, worker's age, exact location (area and level).

The major factors that contributed to the accidents were identified based on the findings. Another issue was that the original data records were not in a unified form; as a result, the information included in the accident descriptions was not complete for many of those records. Such incomplete data are one of the major reasons for conducting this study, i.e., to ensure that future data collection will not be in such insufficient forms or based on individuals' efforts.

3. Results

The accident data for Makkah Holy Mosque were analysed regarding various aspects, as noted above. The numbers of accidents in each category and for each sub-project are shown in Table 1, and the fatality statistics of the project are provided in Table 2.

Additionally, to determine any patterns in the accidents, the accidents were sorted based on the time of day that the accident occurred, as shown in Fig. 2.

Table 1: Makkah Holy Mosque Expansion Project Accidents, 2014

Accident Type	Projects Haram Building	Central Utilities Compound	Plots
Falling from a height	72	31	15
Falling object hitting a worker	41	35	17
Falling on the same level	27	4	10
Others	75	67	35
Total	215	137	77

Table 2: Makkah Holy Mosque Expansion Project Fatal Accidents from Jan. 2012 through Dec. 2015

Haram Building	Central Utilities Compound	Plots
29	2	9

One unique aspect of the Makkah Holy Mosque Project is that its schedule is based on the annual Islamic religious seasons (related to the Arabic Hijri calendar) instead of the Gregorian calendar. Moreover, as shown in Figure 3, there is a high level of activities year-round (reflected in a significant number of accidents), except during the religious seasons of Umrah and Hajj (the months of Ramadan and Dhu Alhejjah, respectively).

The Pearson correlation coefficient (r) between the fall heights and the number of falls in each range was calculated to be (-0.599) "a high negative correlation", indicating that lower heights are associated with a higher probability of falling accidents.

4. Discussion

The previous section presented the statistical analysis and results of the accident records; those results are in line with the global trend, with falling being the common significant cause of both injuries and fatalities in the construction industry. In the Makkah Holy Mosque Expansion Project, falling contributed to 37% of all accidents and 42% of fatalities from the project's beginning in January 2012 through the end of 2015.

According to Fig. 2, more than half of the accidents (57.5%) occurred in the four-hour period between 8:00 am and 12:00 pm (17% of a 24-hour day). This interesting finding can be further explained based on the method by which the activities at the Makkah Holy Mosque Expansion Project are executed. The supervisors distribute the work by tasks every day, i.e., each team of labourers is free to go home whenever the team's daily tasks are completed, regardless of the actual working shifts (which is from 6:00 am to 6:00 pm for the day shift). That observation is also in line with previous studies, which found that construction accidents have distinct time patterns [4] that, if adequately predicted, can help the safety team to provide better preventive safety measures and tools.

Experts in the construction safety field have found that falling accidents are caused by many contributing factors; those factors accumulate until they reach the failure point and a falling accident occurs. These factors include the height of the working platform, the time of day, and the platform type. These factors can be adequately controlled by aggregating them into one unique model that efficiently optimizes minimizing the hazard created by each one factor to an acceptable level based on the hierarchy of hazard control of practice. These factors are combined in Table 3 below to more easily understand the status of the Makkah Holy Mosque Expansion Project.

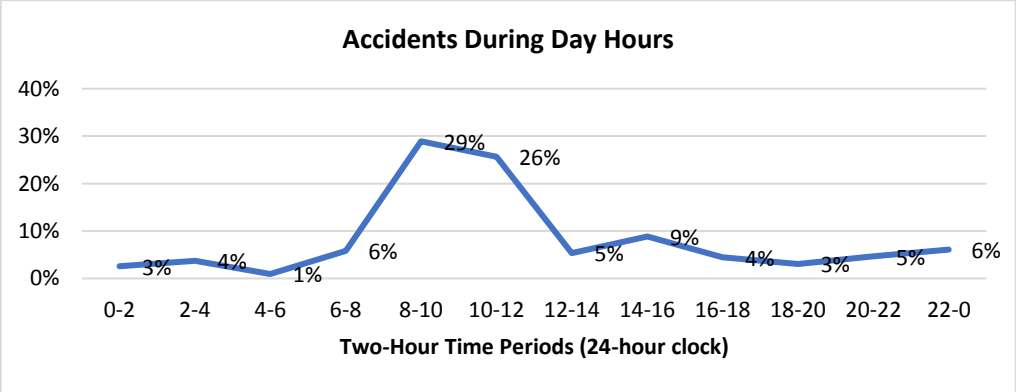

Fig. 2: Accidents during the Day, in Two-Hour Periods (24-Hour Clock).

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Table 3: Factors Contributing to Falling Accidents

Factor contributing to a falling accident	Summary of its effect
Height of the working platform	80% of the falls occurred from platforms with a height of 4 meters or less.
Time of day	57.5% of accidents occurred between 8:00 AM to 12:00 PM.
Arabic calendar date (the religious seasons)	79% of accidents occurred outside of the Omrah to Hajj seasons because of the strict prohibitions and restrictions applied.
Total number of injured body parts vs. falling height	90% of injuries occurred because of falls from platforms with a height of 2 metres or less.
Platform from which the worker has fallen	46% of the platforms are scaffolds.

Regarding the seasonality of accidents, this project interferes with public access to the mosque all year in terms of detours; the general contractor's safety team and the many other parties involved in this project, including governmental authorities and private-sector companies, can control this interference on regular days. However, it is too dangerous and challenging to manage construction in the Umrah and Hajj seasons. Moreover, the government (which owns the mosque) requires the contractor to temporarily hand over many parts of the project during these seasons and to install temporary finishes during those times. The contractor can proceed with the construction activities when those seasons are over. As shown in Fig. 3, a slight increase in the number of accidents occurred between Ramadan and Dhu Alhejjah, as in those two intervening months, the contractor typically attempts to catch up on the small tasks that can be completed in a short time without affecting the handover for the coming Hajj season. Moreover, fewer accidents occur in the Ramadan season than during Hajj because the Holy Mosque is not explicitly required during the Hajj season; instead, visitors are mainly resting on the mosque's ground level or passing through it to access another area called Almataf to perform the ritual known as Tawaf around the Alkaaba building. This ritual occurs irregularly for a few days of the month. Hence, the Haram Building is rarely used during Hajj. Based on this schedule, the contractor often attempts to finalize minor work in the less central areas of the project, such as the upper levels of the 8-story Haram Building.

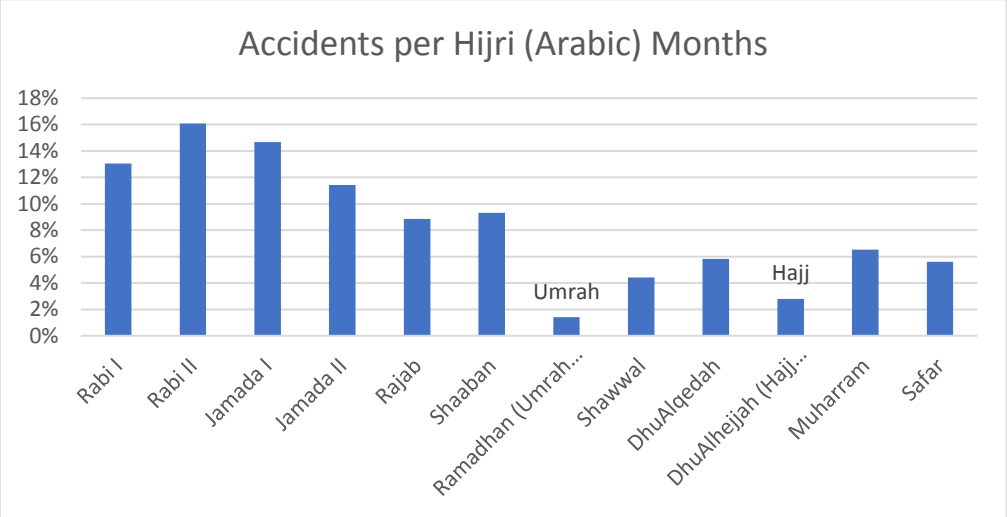

Fig. 3: Accidents in the Months of the Arabic Year (1435 Hijri) Corresponding to 2014.

The high negative correlation between the falling heights and numbers of accidents indicates that regardless of the injury type or level, lower heights are the main point of concern. This negative correlation may arise from the fact that low-height activities are given less attention, and less effort is made to verify compliance with safety measures. In contrast, as soon as the fall height reaches the height that requires safety measures to be enforced based on the standard, a high level of attention that should be given to all working-at-height activities, regardless of height, is generated.

These observations regarding the project will help in assigning the proper number of workers to each team and in preparing appropriate safety plans. Moreover, these observations provide information and leading indicators on how to manage future projects in the Makkah Holy Mosque area in particular and in Makkah City more generally, as the seasons affect the entire city.

The weaknesses in the data collected from the accident records will affect the quality of the study's outcomes for investigations of past events and preventive measures to be taken in the future. Unfortunately, as shown in Fig. 4, none of the records noted the activity that the workers were executing when the accidents occurred. The activities could have influenced the accidents; thus, this lack of detail represents a significant loss for future decision-making, as it is impossible to know which activities produce more severe or more frequent accidents. The other primary contributing factor, as mentioned in many other studies [4], is the age of the victim; more experience does not correspond to fewer accidents, and in fact, younger workers were shown to be more cautious and to respond more quickly to avoid accidents. The last drawback in the accident records is the inadequate description of the accident locations. The zone is insufficient for such a massive project and is in fact often meaningless. For example, zone 4 of the project consists of eight floors; thus, providing only the zone in the accident record does not help to determine which parts of the zone have the highest hazard rate. Increasing the level of safety for an entire zone is costly and a waste of resources; such wide-ranging efforts can even be ineffective if inspections occur only in well-facilitated areas, as accidents could still occur in other parts of the same zone.

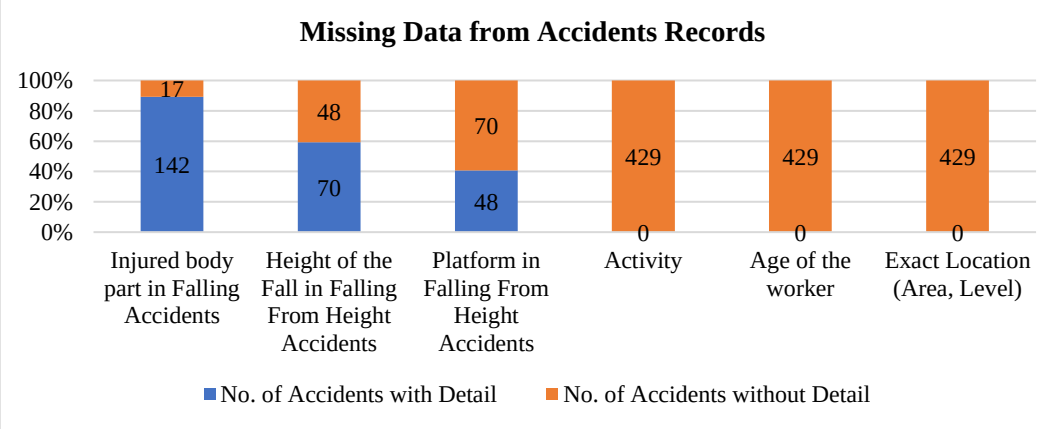

Fig. 4: Details Missing from Accident Records.

4.1. Limitations of this study

The analysis of the accidents of the Makkah Holy Mosque Expansion Project has a variety of limitations. The first limitation is the geographical location, as Makkah is well known for its extremely hot summer; in contrast, work can be easily performed in the summer in other places in the world. The second limitation is the unique seasonality related to Islamic events, making the annual accident pattern applicable for Makkah city and surroundings at most. Because of improper data collection, it was difficult to obtain further data on accidents for other years (i.e., 2013 and 2015). The findings were only indicative to these years to some extent, as per the researchers' experience with the project, the accidents had gradually decreased over the years following the study due to the extensive safety awareness and the pressure applied by HEPTC as an owner representative in the project. The missing data regarding accidents, worker ages, activities, the subcontractor to which the worker belongs, and the exact location of the accident resulted in limited conclusions and findings; if such data existed, then further conclusions could be obtained, such as the age range for victims, most hazardous activities, subcontractor with weak safety culture, and locations of inadequate safety supervision.

5. Conclusion

The analysis performed in this study can provide conclusions regarding the causes and factors of falling accidents, injuries and results of falling accidents and the omissions in the data collected on accidents. Moreover, solving managerial safety problems, which are typically the root causes of safety problems, requires an affiliation with international bodies that already have well-established safety management systems, such as ANSI Z10, OHSAS 18001 and ISO 14001. Furthermore, inadequate investigation of accidents results in an inadequate analysis of data, which in turn leads to poor decisions and hence the recurrence of accidents. This insufficient investigation level is noticed at not only the project level but also the country level. The only authority that requires accidents to be reported is GOSI, and no enforcement occurs if no compensation can be claimed after such reporting. The integrity between these solutions will result in considerably safer workplaces; the contributing factors are going to be controlled by the enforcement of current existing regulations in addition to the further application of international safety standards. Hence, accidents will occur with less frequency and severity. For the investigations of accidents, the enforcement of reporting and the training courses for people in charge are among the critical success factors for the system. Because this study focused on the falling accidents occurring during the Makkah Holy Mosque Expansion project, the analysis revealed more weaknesses in the safety of the construction industry locally; addressing these weaknesses will have a significant impact on falling accidents and other types of accidents. Future studies may consider the risk assessments conducted in local construction projects, their reliability, and the qualifications of the individuals who conduct and approve the safety conditions and plans for the projects. Future studies can also focus on enhancing and enforcing the reporting of the workplace accidents and the acceptable level of details in investigation reports. The conclusions of such studies could be used to improve construction safety in Saudi Arabia.

Acknowledgement

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