Safety practices and causes of fatality in building construction projects: A case study for Bangladesh

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Safety Practices and Causes of Fatality in Building Construction Projects: A Case Study for Bangladesh

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ABSTRACT

Construction industry is known for its poor safety records compared with other industries. The objectives of this study were to evaluate the existing safety practices and discover the causes of fatalities in building construction projects in Bangladesh. To achieve these objectives, related studies were reviewed and field data collected by structured interviews with project managers, engineers and foremen. In addition a questionnaire survey has been conducted among engineers. Data has been analyzed by using descriptive statistics. The results showed that many construction sites did not practice proper safety measures for site protection and that workers did not take personal protective measures mentioned in Bangladesh National Building Code (BNBC). Besides, the study results revealed that the leading cause of fatal accidents is falling from different heights. Furthermore, a strong positive correlation has been found between fatal reports and survey results to find the most vulnerable age group (26-41 years) and construction floor levels (6^{th} - 10^{th}) for fatality. Thus, the study recommends for protecting construction sites and ensuring workers' personal safety measures the provision of better on-site safety practices to reduce fatalities. At the end, this study suggests some future studies on construction safety in Bangladesh as well as in other developing countries.

KEYWORDS: Bangladesh, Building, Construction, Site safety, Personal safety, Fatal accidents.

INTRODUCTION

Safety is an important issue to ensure uninterrupted work and save lives of workers in any type of industry. Due to improper or lack of safety practices, different levels of work accidents ranging from minor injuries to fatal accidents have occurred (Solís-carcaño and Arcudia-abad, 2013; Fung et al., 2010). Finding the safety risks in construction sites with associated hazards is a significant step to control on-site work accidents (Rozenfeld et al., 2010). Although work safety is a well-established issue in manufacturing industries, it is still ambiguous in construction industry owing to its dynamic nature (Molen et al., 2005; Zhou et al., 2008). For example, frequent changes in work team and type, varying weather, mass gathering of unskilled workers and change in equipment and methods of construction are some of the aspects of that dynamic nature (Rozenfeld et al., 2010). Thus, construction industry is recognized as one of the most unsafe industries, presenting frequent accidents in different parts of the world (Chi et al., 2005; Sorock et al., 1993).

Accidents at construction sites can be physical incidents caused by site malpractices or behavioural incidents caused by workers' unsafe acts (Behm, 2005; Kartam, 1997). Unsafe construction sites cause minor injuries as well as fatal accidents for workers (Haslam et

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al., 2005). Previous studies reported that most of the accidents have occurred due to human errors, improper interaction of humans and machines and organizational faults (Saurin et al., 2008). Besides, it has been noticed that negligence by the management to ensure proper safety practices at sites and lack of using personal safety measures are the major sources of fatalities in construction industry (Guha and Biswas 2013; Solís-carcaño and Arcudia-abad, 2013; Hassan, 2012). To ensure safety in construction industry, Bangladesh National Building Code (BNBC) mentions the guidelines to ensure site safety and personal safety during work at sites (BNBC, 2012). In this regard, the research questions are: what is the level of safety practices in building construction projects in Bangladesh according to BNBC (2012)? What are the major causes of fatal accidents there? Unfortunately, there are very few studies found to assess safety practices in building construction projects in Bangladesh. Therefore, the objectives of this study are: to discover the existing safety practices in building construction projects in different cities, to find the major causes of fatal accidents and to find the vulnerable age group (workers) and potential heights (i.e., floors) for fatalities in building construction projects in Bangladesh. The outcome of this study will present more insight into the safety practices in building construction industry. It will also help manage the critical factors of fatal accidents for reducing construction hazards in building projects.

LITERATURE REVIEW

Construction industry has encountered the highest number of fatal accidents among all other industries (Albert and Hallowell, 2012). Thus, studying construction safety practices and fatalities has gained increasing importance to researchers. Therefore, many studies have been conducted in this area of research in different parts of the world. Few of them are discussed below.

Priyadarshani et al. (2013) developed a safety assessment framework for construction industry in Sri Lanka. According to their study, lack of commitment of management and negligence of individuals to respond to proper safety practices were the most important factors leading to accidents at sites. Occupational safety risk has been studied in Indian construction industry by Guha and Biswas (2013). They found that catching nets, unsafe ladders, inadequate scaffolding and personal safety measures were the major causes of construction hazards in India. Hassan (2012) studied the safety practices in construction industry in Pakistan and applied descriptive statistics for data analysis. His study revealed that lack of using personal protection, falling from heights, lifting objects and electric shocks were the leading causes of fatal accidents. Halvani et al. (2012) studied accidents' types and causes in relation with age and occupation in Iran. Their study revealed that the highest rate of accidents was happening from falling (48%) and that (20-29) years old workers were acknowledged as the most vulnerable age group for fatal accident. López et al. (2012) studied the probable causes of accidents with subsequent mitigation actions for Spanish construction industry. Their study found that the maximum rate of accidents (80%) was in the age group (30-39) years working at building construction sites. Cheng et al. (2010) analyzed the characteristics of construction accidents in small projects in Taiwan using descriptive statistics, analysis of variance (ANOVA) and correlation coefficients. They discovered that the most critical cause of accidents was careless acts about the implementation of safety measures at project sites, followed by insufficient safety training for novice workers and absence of competent health and safety professionals. Chi et al. (2005) studied fatal accidents in Taiwan with respect to risk factors, like: age group, gender, experience and lack of using proper personal protective equipment. According to this study, the victims' ages were mostly (25 – 44) years. Besides, falling down from roof edges, building girders and ladders with overexertion, unprotected stairs and roof openings were the principal causes of fatal accidents. Dong et al. (2011) studied fatalities caused by falling down of aged workers at construction sites. They followed descriptive statistics, regression analysis and t-test for data analysis regarding causes of fatal falls. The study stated that workers with the age of 55 years or more are highly susceptible to fatal accidents by falling down from roofs, ladders, scaffold stagings, floors,… etc. Dong et al. (2013) investigated fatal accidents resulting from roof falls in U.S. building construction. They found that victims were mostly lower than 22 years and over 44 years old. Also, almost 67% of fatal accidents from roof falls occurred in small construction enterprises. Among those, iron workers working on roofs had the highest fatality rate.

Like in the U.S., Turkish researchers found that falling from heights is the major cause of accidents, in addition to electric shock, accidents by heavy equipment, collapse of building/structure,… etc. (Gürcanli and Müngen, 2009). Significant numbers of accidents in Malaysian construction industry have been discovered by Hamid et al. (2008). They conducted a questionnaire survey among contractors, owners and consultants and analyzed the collected data by simple descriptive statistics. This study reported that unconscious and careless acts about personal and site safety, work at high altitudes, handling equipment without proper safety measures and work pressure were the main causes of accidents. Chen and Jin (2012) studied the effective safety management of construction sites in the U.S.A. and identified four major types of hazard; "falling, being struck by, being caught-in-between and electricity". They found that 82% of the violations were in the places of fall protection. Yi et al. (2012) studied the causes of accidents in construction projects in South Korea. They discovered that the major causes of accidents were: lack of wearing personal safety dress, safety net, scaffolding and passages' safety at sites.

On the other hand, some studies proposed few actions to overcome the existing safety problem in construction industry. Zou and Sunindijo (2013) conducted a study to understand the skills required for a project team managing safety risk effectively. They recommended personnel as well as social consciousness, social wisdom, individual's sincerity for respecting safety marks and working in danger zones as the important tasks to reduce work accidents at construction sites. Ahmed and Abid (2013) stated that good commitment of top management, skilled safety team and effective government policies are prerequisites to ensure proper safety in construction industry.

METHODOLOGY

Data Collection

This study reviewed construction safety-related research articles to discover study methodologies, proper safety practices and major causes of fatal accidents in different parts of the world (see literature review part). Based on the literature review, a questionnaire has been designed for collecting data on safety practices. The questionnaire contained 10 questions with yes/no answers as well as questions of descriptive type. For example, the answers regarding site protection were like: well protected, partially protected and not protected. If all conditions mentioned in BNBC (2012) for site fence and fall protection have been followed, this is termed as well protected. If any condition is missing, such as: catching net is there, but no toe board exists on the open area in a floor, this is defined as partially protected. If no precautions are taken, this is termed as not protected. The answers of all other questions were of yes/no type. The questions were related to the site safety measures and the workers' personal safety measures according to BNBC (2012). Then, the survey was conducted by interviewing the project professionals, like: the project manager, site engineer and foreman of each of the selected building projects. Thirty building projects have been randomly selected from three metropolitan cities; Dhaka, Sylhet and Chittagong in Bangladesh. Therefore, the total respondents were 90 (3 from each project).

After that, reports on fatal accidents in the period from March 2008 to March 2010 have been collected from randomly selected police stations of the mentioned cities. Total 184 fatal reports have been studied for this research. Based on accident reports and results of the first survey, a second questionnaire was designed to find the critical causes of fatal accidents. This questionnaire was structured with 8 questions. Question 1 was for finding the vulnerable age group, question 2 for the most risky floor level and question 8 for the personal details of the respondent. The other questions were concerning the level of influence of each factor leading to fatal accidents at construction sites. In these questions, the respondents had the choice to answer the questions as: very low, low, medium, high and very high which represent: 1, 2, 3, 4 and 5, respectively on a Likert scale. A 1-5 point Likert scale is one of the best choices for raking the factors, because it is an ordinal scale representing equal intervals between adjacent points (Guha and Biswas, 2013; Priyadarshani et al., 2013). The second survey has been conducted online. The questionnaire was sent by e-mail and online message to respondents who were civil engineers having been working 5 years or more in building construction projects. The engineers were randomly selected from all over the country (Bangladesh). The questionnaire has been sent to 90 expected respondents, but received were 38 completed replies.

Data Analysis

The methodology for data analysis is divided into three major parts: (1) descriptive statistics (frequency tables and bar diagrams), (2) computing relative risk index and (3) Spearman's rank correlation between two sources of data for establishing the accuracy of the correlation between fatal accidents and age groups or floor levels. The descriptive statistics, relative risk index and Spearman's correlation methods have been respectively used for construction safety studies in Pakistan (Hassan, 2012) and USA (Dong et al., 2011), Sri-Lanka (Priyadarshani et al., 2013) and China (Yu et al., 2014). These methods of data analysis have already been used in different parts of the world as well accepted methods. So, this methodology for data analysis is not only used in a particular study area like Bangladesh, but it can be used for studying safety risks in other parts of the world. The overall methodology for data analysis is discussed below.

(1) This study has drawn frequency bar diagram, where project frequencies (%) regarding different types of safety practices with respect to different cities in Bangladesh have been shown (Figures 1, 2 and 3). Besides, the fatal reports have been analyzed in terms of death frequencies (%) among the three cities, causes of fatal accidents, age groups and floor levels and presented in Tables 1, 2, 3 and 4, respectively. An age group is simply divided into 6 intervals and a floor level is divided into 4 levels. The age groups and floor levels have been ranked considering the fatality numbers and frequencies.

(2) Table 5 shows the descriptive statistics of the online survey. The survey data has also been analyzed for ranking the risk factors by relative risk score (RRS). The following equation has been used for computing the RRS (%) (Priyadarshani et al., 2013):

$$(RRS)_j = \frac{\sum a*n}{R*5} \times 100 \qquad \text{………(1)}$$

where: $(RRS)_j$ = mean risk score of the factor j, a = any score from the scale 1-5 answered by an individual respondent, n = frequency of respondents to answer the score "a" for a single factor, R = total number of respondents. The RRS (%) is defined as the likelihood of fatal accident; for example, very low, low, medium, high and very high if it is 1-20%, above 20-40%, above 40-60%, above 60-80% and above 80-100%, respectively.

(3) Finally, Spearman's rank correlation test has been conducted to find the correlation between fatal accidents and age groups and between fatal accidents and floor levels. Because Spearman's correlation establishes the relationship of ranking found by two independent groups of data (Yu et al., 2014), the value of Spearman's correlation coefficient (r_s) close to +1 means a strong positive relation between two groups, whereas (r_s) close to -1 indicates a strong

negative relation between two groups.

RESULTS AND DISCUSSION

Safety Practices at Construction Sites

The level of safety practices at different construction sites in Bangladesh has been discovered and discussed here from three points of view: site safety measures, supporting safety measures and personal safety measures ensured at sites guided by Bangladesh National Building Code (Part 7, Chap. 3) and peer-reviewed journals.

Regarding safety for site protection, BNBC (2012) recommends that the site should be protected by fences. In this regard, all the construction sites of Dhaka and only 45% of the sites in Chittagong have been found well protected (Figure 1). On the other hand, 27% of the sites were found to be well protected in Sylhet. In BNBC (2012), it is also mentioned that any kind of fall; for example, equipment, material and worker, must be protected by providing a safety guard like railing with toe board, catching nets or hinged cover on any opening (i.e., the least dimension = 300 mm or more) in a floor. Besides, open edges of the floor must be guarded by the same means (BNBC, 2012). But, the real situation was far away from the safety code. This study observed that 85% of the sites in Dhaka, 45% of the sites in Chittagong and 27% of the sites in Sylhet were well protected against falling (Figure 1). This scenario is very potential to produce fall-related fatal accident. The lesson can be learned from the studies conducted in India, Pakistan and Taiwan (Guha and Biswas, 2013; Hassan, 2012; Chi et al., 2005), where it was discovered that this factor is one of the critical factors of fatal accidents. Therefore, any kind of opportunity for falling should be prevented (well protected) and 100% of the sites should follow the safety code.

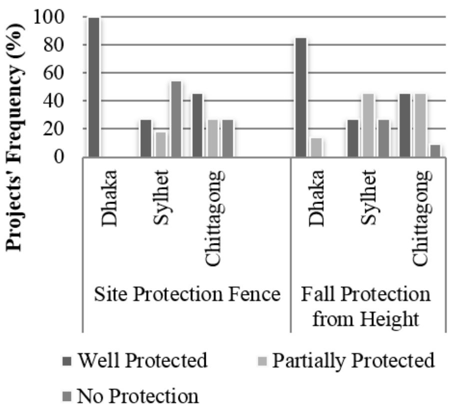

Figure (1): Level of site protection in different cities

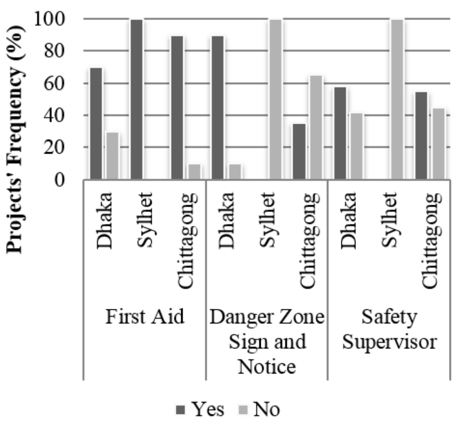

Figure (2): Available safety supports at sites in different cities

The levels of supporting safety measures, such as available first aid facilities, danger zone signs and notice boards, as well as safety instructors at construction sites of the major cities in Bangladesh, have been presented in Figure 2. Although many construction sites in Bangladesh have first aid services, danger zone signs and notice boards were significantly absent in Sylhet (100%) and Chittagong (65%). Unlike in Sylhet and Chittagong, most of the construction sites (90%) in Dhaka were following the safety rules in this regard. The safety sign and notice board can significantly reduce on-site accidents, because the vulnerable zones become more visible to workers or pedestrians (Yi et al., 2012). Like safety signs and notice boards, there was no safety supervisor in any site in Sylhet who should instruct, guide and train workers on safety at construction sites. On the other hand, just over 50% of the construction sites in Dhaka and Chittagong appointed safety supervisors to ensure site safety.

Personal safety measures (PSM); for example, safety belts, helmets, aprons, hand gloves, boots and eye goggles, are very important to protect against fatal accidents as acknowledged by many researchers in India (Guha and Biswas, 2013), Pakistan (Hassan, 2012), Malaysia (Hamid et al., 2008), Taiwan (Cheng et al., 2010) and Iran (Halvani et al., 2012). Furthermore, falling from heights is a common fatal accident in many countries (Dong et al., 2013; Chen and Jin, 2012; Fung et al. 2010) and proper PSM can considerably reduce fall-related fatal injuries. Therefore, BNBC (2012) highly prescribes to use these PSM during work at construction sites. Frequency distribution (%) of construction projects in selected cities in terms of PSM has been depicted in Figure 3. We noticed that there was no PSM for workers in a substantial number of sites (65 to 80%) in Sylhet. On the other hand, about 60% of the sites in Dhaka and Chittagong ensured PSM for their workers. The percentage of wearing aprons and hand gloves was also very poor in Sylhet and Chittagong (e.g. 10% and 35%), respectively.

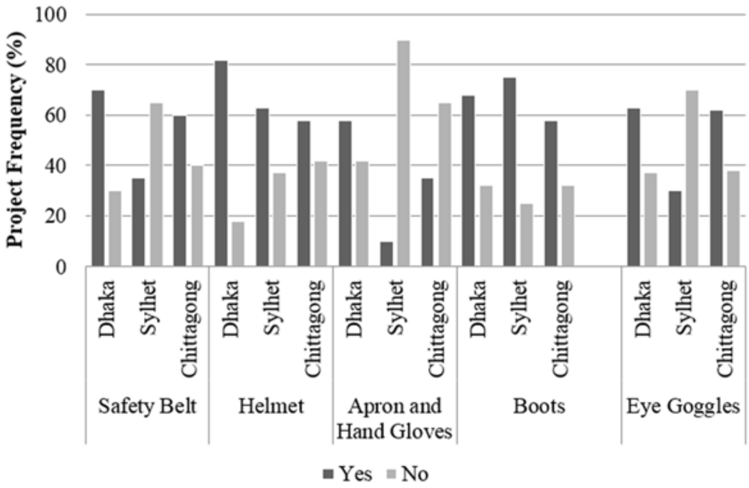

Figure (3): Workers' personal safety practices in different cities

A focus group and individual discussion with workers during data collection discovered that they are not feeling comfortable to use these safe guards. There are two reasons for not using PSM; i.e., companies do not provide PSM and individuals are not willing to use PSM. Therefore, the overall performance of using personal safety at work sites in Bangladesh is unsatisfactory and is one of the basic reasons of fatal accidents (Yi et al., 2012).

Fatal Accidents in Major Cities

Table 1 shows the distribution of accidents among different cities in Bangladesh. Highest percentage of death (48.91%) has been recorded from building construction sites in Dhaka, followed by Chittagong (27.71%) and Sylhet (23.37%). The reasons behind this large percentage of fatal accidents in Dhaka would be the number of projects, organization size of each project, among some other reasons. Numbers of construction projects and employees in the construction sector in Dhaka are larger than in other cities. As a limitation, this study did not consider the project size, number of workers or site constraints in a city to compare the number of fatal accidents with their numbers in other cities. Besides, the collected information was a small-scale sampling from the gigantic study areas. Thus, the number and rate of fatalities in the capital city would be significantly higher than in other cities. Similarly, Chittagong is the second largest city and construction projects as well as number of workers in Chittagong are also larger than in Sylhet, which is reflected in the number and rate of fatalities.

Table 1. Number and rate of fatalities (%) in different cities

Major cities in Bangladesh	No. of fatalities (2008-2010)	Rate of fatalities (%)
Dhaka	90	48.90
Sylhet	43	23.37
Chittagong	51	27.71
Total	184	100

Causes of Fatalities

Table 2 shows the causes of accidents with respect to the number and percentage of fatalities in three major cities in Bangladesh. The study identified 10 principal sources of hazards at construction sites. Among them, falling during steel erection (iron work) at an elevated level was the leading cause of fatal accidents. The rate of accidents for this reason was about 32%, 40% and 33% for Dhaka, Sylhet and Chittagong, respectively. Same cause of fatal accidents was discovered in the U.S.A. (Dong et al., 2013), the Netherlands (Aneziris et al. 2012) and Hong Kong (Fung et al., 2010). Falling from an unprotected edge and open areas in lifts and stairs were the next highest factors of such accidents. These factors were also responsible for occupational hazards in Taiwan (Chi et al., 2005). Therefore, almost 70% of fatal accidents occurred by falling, as a major source of safety factor at sites. Some other causes of fatal accidents were: electric shock, collapse of structure/scaffold, removing formwork, fatigue… etc. Turkish construction industry has been encountering these causes of construction accidents (Gürcanli and Müngen, 2009).

Thus, from the discussion above, this study reports that although site safety measures and workers' personal safety measures have major contribution to produce fatalities in construction projects, according to the BNBC (2012), these factors are not at satisfactory levels in building construction projects of Bangladesh.

Table 2. Causes of fatal accidents and frequency of death (%) in three metropolitan cities of Bangladesh (2008-2010)

Causes of accidents	Dhaka		Sylhet		Chittagong	
	No. of accidents	%	No. of accidents	%	No. of accidents	%
Falling during steel erection	29	32.22	17	39.53	17	33.33
Falling from unprotected edges, lifts and stair cases	9	10.00	7	16.28	9	17.65
Falling during slab concreting	6	6.67	3	6.98	6	11.76
Unmindful falling	9	10.00	3	6.98	3	5.88
Falling during plastering/painting of exterior walls	9	10.00	0	0.00	2	3.92
All falling (sum of above)	62	68.89	30	69.7674	37	72.549
Electric shock	10	11.11	6	13.95	3	5.88
Collapse of structure/scaffold	6	6.67	0	0.00	0	0.00
Removing formwork	3	3.33	5	11.63	3	5.88
Gas exploration	5	5.56	0	0.00	4	7.84
Fatigue	4	4.44	2	4.65	4	7.84
Total	90	100.00	43	100.00	51	100.00

Ranking and Rank-Correlation of Age Groups and Fatal Accidents

Fatal numbers, percentage frequencies of fatal accidents and ranks of age groups have been shown in Table 3. Our study found that the highest frequency (43%) of fatalities was in the age group of (26- 33) years, followed by the age groups (34-41) years (25%) and the age group (18-25) years (21%). Therefore, this study stated that the most vulnerable age limit of construction workers is (26-41) years, because almost 68% of the accidents happened in this range. This result is very similar to that related to the vulnerable age group in the U.S. and Taiwan. In the U.S., the highest rate of fatal accidents was recorded in ages between 22 and 44 years (Dong et al., 2013), while in Taiwan, it was recorded in ages between 25 and 44 years (Chi et al., 2005). Another argument may arise against this statement which is that the highest number of these people would be in construction industry. However, establishing a relation between population size in different age groups and accident rate is beyond the scope of this study.

Table 3. Ranking the age groups based on fatality along with Spearman's correlation coefficient (r)

Age group (years)	Total fatal no. by reports	Frequency (%) by reports	Frequency (%) by online survey	Ranked by the reports	Ranked by the survey	Spearman's correlation coefficient (r)
26-33	83	43	36	1	1	+0.933
34-41	49	25	9	2	4	
18-25	40	21	24	3	2	
42-49	16	8	4	4	6	
50 and above	4	2	20	5	3	
Less than 18	1	1	8	6	5	

At this point, we decided to carry out more investigation to find the relation between fatal accidents and age groups. For this purpose, an online survey has been conducted by a structured questionnaire as mentioned in the data collection part. We have sent e-mails to 90 civil engineers who have been working in building construction projects as project engineers, site engineers or consultants. Among them, we received 38 fully completed e-mails. The response rate was 42%. Question 1 in the questionnaire was related to the most vulnerable age group for fatal accidents. According to the respondents, frequencies (%) of likelihood of fatal accidents and ranks of age groups are shown in Table 3. Similar to fatal reports, they also agreed that the age group (26-33) years was the most vulnerable group, but the second group in terms of vulnerability was the age group (18-25) years. In addition, the survey results showed that workers of ages (50 years and above) ranked as the third most vulnerable group in terms of fatal accidents in Bangladesh. Spearman's rank correlation test showed a strong positive correlation of (+0.933) between real data (fatal reports) and survey results regarding the ranking of age groups for fatal falling accidents in building construction projects.

Ranking and Rank Correlation of Floor Levels and Fatal Accidents

Previous studies in Mexico, the Netherlands, Iran, the U.S. and Malaysia revealed that falling from heights is the major source of fatal accidents (Aneziris et al., 2012; Chen and Jin, 2012; Halvani et al., 2012; Hamid et al., 2008; Solís-carcaño and Arcudia-abad, 2013). From this point of view, this study investigated the frequency of accidents at particular floor levels to discover the high-risk zone in terms of altitude. Table 4 shows the percentage frequency of fatal accidents and ranking of floor levels based on real data found by investigating the fatal reports at construction sites and the online survey among engineers (Question 2 in the questionnaire). Analyses of fatal reports and survey results provided the same results concerning the ranking of floor levels in terms of fatal accidents. For example, most of the accidents occurred at construction level (6-10), followed by level (over 10) and (3-5) of building projects in Bangladesh. The engineers have also responded to rank the floor levels for the likelihood of fatal accidents exactly in the same way. Then, Spearman's rank correlation was shown for ranking the floor levels in terms of fatal accidents by fatal reports and survey results. The correlation coefficient was found to be +1.00, which indicates a strong positive correlation between the fatal reports and survey results among engineers. Therefore, we can conclude that high concern is required during building construction at level (6-10) to protect workers aginst fatal fall.

Table 4. Ranking the floor levels based on fatality along with Spearman's correlation coefficient (r)

Floor level	Total fatal no. by reports	Frequency (%) by reports	Frequency (%) by online survey	Ranked by the reports	Ranked by the survey	Spearman's correlation coefficient (r)
1-2	2	2	5	4	4	
3-5	12	10	8	3	3	+1.00
6-10	73	62	47	1	1	
Over 10	31	26	40	2	2	

Ranking of Causes of Fatal Accidents

Beyond the analysis of fatal reports, we have conducted an online survey among engineers based on a structured questionnaire assuring the most important factors of fatal accidents. Table 5 shows the statistical analysis of the survey data. According to Equation 1, the relative risk score (RRS) has been computed. Means, medians, modes, variances, standard deviations and ordered rankings are also shown in Table 5. Data analysis shows that median and mode for a particular risk in all cases are the same and that mean scores do not have any impact to alter the rank of risks by RRS. Variances and standard deviations are also considerably small. Thus, the ranking of risk factors based on the survey results is statistically valid.

Now, it is noticed that the combination of some risks in question 3 (i.e., site unprotected against falling; high noise level; no personal safety; fatigue) is ranked first, followed by risks in question 4 (i.e., no personal safety; fatigue; high noise level, but site is protected), question 7 (i.e., site is unprotected, but workers have personal safety; no fatigue; no noise), questions 5, 6 and 8. According to the definition of RRS mentioned in the data analysis part, the likelihood of fatal accidents at construction sites for risks in question 3 is very high (RRS is over 80), while for other conditions mentioned in questions 4, 5, 6 and 7, there is a high level of likelihood for fatal accidents (RRS =60-80). However, median and mode scores of questions 5, 6 and 8 are the same. For example, 3, which indicates likelihood of fatal accidents in such cases is medium. To sum up, respondents were also very concerned about personal safety and site safety measures for protecting any type of fall from heights to reduce the likelihood of fatal accidents at building construction sites. This statement is very similar to the result found from fatal reports, where 70% of fatal accidents occurred only by falling from heights.

Table 5. Descriptive statistics of data found by the online survey for the factors influencing fatal accidents

Question no. (risk factors)	RRS	Mean	Median	Mode	Variance	Standard deviation	Rank on RRS
3	94.4	4.72	5	5	0.376	0.614	1
4	72	3.6	4	4	0.75	0.866	2
7	71.2	3.56	4	4	1.17	1.083	3
5	68	3.4	3	3	0.833	0.913	4
6	61.6	3.08	3	3	0.826	0.909	5
8	51.2	2.56	3	3	0.84	0.917	6

RRS = Relative Risk Score

CONCLUSIONS

This study investigated the current situation of safety practices in Bangladesh regarding the guidelines mentioned in Bangladesh National Building Code (BNBC, 2012) and previous studies on safety at construction sites. Besides, in order to find the critical causes of fatal accidents and the correlations of fatality rate with workers' age groups and floor levels, the causes of fatal accidents have been analyzed based on collected accident reports and a survey among engineers who have been working in building construction projects. Moreover, the results in terms of the causes of fatal accidents found in Bangladesh have been compared with those found in other countries. From this study, the following findings have been revealed.

- BNBC (2012) has mentioned that all the construction sites should be protected against any kind of falling from heights. However, high percentages of construction projects in Sylhet (73%) and Chittagong (55%) are not following this rule. This condition is moderately improved in Dhaka, where 85% of the sites are following this rule.
- Literature review acknowledges that safety sign and notice board significantly reduce on-site accidents. But, this safety system is completely absent in Sylhet. A high percentage (65%) of building projects in Chittagong and a low percentage of projects (10%) in Dhaka are also disregarding this safety measure.
- Personal safety measures (PSM) are very important to reduce fatal accidents at sites as acknowledged by some studies in Iran, Taiwan and Pakistan. BNBC (2012) also strongly recommends ensuring PSM at sites. However, workers in (65%-80%) of the projects in Sylhet and in 40% of the projects in the other two cities have no proper PSM.
- Regarding fatal accidents, the highest percentage of death has been recorded in Dhaka (48.91%), followed by Chittagong (27.71%) and Sylhet (23.37%).
- Accident reports show that the most critical cause of fatal accidents was falling from heights, followed by electric shock and collapse of scaffolding. Construction industries in the Netherlands, Hong Kong, Taiwan and the U.S.A. were also encountered by falling from heights as one of the critical causes of fatal accidents.
- Both fatal reports and the online survey show that the most vulnerable age limit for workers in terms of fatal accidents is (26-33) years. This result is mostly similar with those in construction industries in the U.S. and Taiwan. Spearman's rank correlation test shows that there is a strong positive correlation (i.e., r = +0.933) between accident reports and survey findings in terms of the vulnerable age groups for fatal accidents.
- Besides, both data ensure that the most potential floor levels for fatal accidents are (6-10). Similar to age groups, Spearman's rank correlation test has also

shown a strong positive correlation (i.e., r = +1.00) in this regard.

- Ranking of the causes of fatal accidents by the online survey shows that if the site is unprotected against falling, along with the absence of personal safety, the presence of high noise level and fatigue, there is a very high chance of fatal accidents at sites.

Therefore, to reduce fatal accidents at construction sites in Bangladesh, respective management should be aware of ensuring proper site safety and personal safety during work at sites following BNBC (2012) and the guidelines of previous studies reviewed in this paper. At the end, this study recommends some further studies; for instance, organizational behaviour and its impact on safety system in construction industry, comparative study of safety management in construction industry in Bangladesh and other developing countries, as well as causative investigation of fatal accidents and safety in the developing world.

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