



Causes and Effects of Accident at Construction Site: A Study for the Construction Industry in Bangladesh

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Abstract: Accident at construction site has shaped a horrific figure of death for every year in Bangladesh. This study aims to identify and rank the causes and effects of accident at construction projects in Bangladesh. The study also discusses the characteristics of top-ranking causes and effects. Various direct and indirect linkage of top causes and effects are also analyzed in this study. A widespread literature review and interviews with experts take place to identify the causes and effects of construction accident and design the questionnaire. The questionnaire-based survey was used to elicit the perception of construction professionals towards causes and effects of accident at construction site. This study has identified 77 causes under 14 major groups and 22 effects of accident and ranked them based on Relative Importance Index (RII). The top 5 causes of accident are: unaware of safety-related issue, lack of personal protective equipment, lack of safety hazards eliminating design, unfit equipment, and lack of knowledge and training on equipment respectively. The major 5 effects of accident are: loss of human lives, demotivation of workers/reduce morale, conflict with workers, loss of productivity of project, and delay in work progress respectively. This study will help the project participants and authorities to know and understand the various characteristics and linkage of causes and effects of construction accidents to improve the safety management in the Bangladeshi construction industry. It contributes to the body of knowledge, as it reveals for the first time the causes and effects of accident in the Bangladeshi construction industry.

Keywords: Bangladesh, accident, construction project, causes, effects

1. Introduction

Construction industry is one of the most hazardous industries in the world because of its unique nature. The construction projects are being experienced troubles by many risks, uncertainties, complexities due to frequently happened accident in construction project (Sousa, Almeida, & Dias, 2014). The developing countries are the extreme victim of construction accidents because they have no strict regulation or no strict practicing of construction safety where both authorities and employees don't aware of construction safety issue (Biswas, Bhattacharya, & Bhattacharya, 2017). But most of the developed countries are trying to reduce the horrific damages and losses from construction accidents by preventing, eliminating and bypassing the possible accidents in construction projects. Bangladesh has one of the most accident-prone construction industry among all the developing countries of the world (Ahmed, Islam, Hoque, & Hossain, 2018). The Bangladeshi construction industry experiences more death, injury, physical damage of properties, risks and complexity than other countries in the world due to lack of effective safety management which

leads the horrific figure of accident and fatality rate (Islam, Razwanul, & Mahmud, 2017). This proves that the concerning level of construction safety practice in Bangladesh.

Every year, an average of 150 persons died and thousands of people get injured due to the accidents in construction sites in Bangladesh (Ahmed, Sobuz, & Haque, 2018). In 2017, the Bangladeshi construction industry faced about 179 deaths due to accident and the figure of deaths was 145 and 172 in 2016 and 2015 respectively (Ahmed, Houqe, & Sobuz, 2017; Ahmed, Islam, et al., 2018). Just in 2017, construction accident in Bangladesh takes life 15 times higher than Singapore, 6 times higher than Britain, 8 times greater than Japan and 8 times higher than North Carolina State, USA (HSE, 2017; Kearney, Balanay, & Mannarino, 2017; Muralidhar, Ahasan, & Khan, 2017; Sadarangani, Lim, & Vasoo, 2017). This scenario of accident means that a vulnerable level of safety regulations and practices exist in the Bangladeshi construction project. High officials from OSHE Bangladesh said in a newspaper (K. Hasan, 2018) that “accident in construction project is the topmost serious issue for the Bangladeshi construction. It is considered as the main barrier of innovation and development of the construction industry in Bangladesh. It brings so many complexities in many ways. It is bad, it is really bad for the Bangladeshi construction industry and the effects of accident is consequential to the project”. Construction accident is the mother of others many problems and complexities in construction project. Failure of adoption and assurance of construction safety against accident in construction project has affected the project negatively. It is the main cause of project delay (Aziz & Abdel-Hakam, 2016; Burr, 2016), affecting the quality of construction work (Larsen, Shen, Lindhard, & Brunoe, 2015; Rumane, 2016; Zeng, Tam, & Tam, 2015), decreasing the labor productivity (Hiyassat, Hiyari, & Sweis, 2016; Sveikauskas, Rowe, Mildenerger, Price, & Young, 2016), cost overrun of the project (Jadhav, Desai, & Gupta, 2016; Shehu, Endut, Akintoye, & Holt, 2014), arising dispute between stakeholders (Gunduz, Birgonul, & Ozdemir, 2016), affecting the psychology of worker negatively (Fung, Tam, Sing, Tang, & Ogunlana, 2016; Leung, Liang, & Olomolaiye, 2015). It shows a clear picture that the Bangladeshi construction industry is not going with good progress due to many issues but the prime one is accident in the recent years. Experts said that there are 80% of construction projects experience injuries and death from accidents in Bangladesh during the whole construction period (Ahmed, Sobuz, et al., 2018). The consequences of these accidents go far beyond for construction project which experienced such accident.

Today, it is a basic right of every worker to work a safe and accident-free workplace. Other countries in the world started working to reduce the accident rate in the construction industry and they had shown success in various ways to reduce or even eliminate accidents in the construction projects. But Bangladesh is backward from them. Bangladesh has to work with this issue seriously to reduce the accident rate and improve the construction industry with modern technologies and strategies by understanding the reasons and effects of accident. Numerous examinations have demonstrated that a fairly large percentage of fatal accident at construction project could have been eliminated, reduced, or avoided if straightforward safety systems would have been applied at the sites and the employees would have been trained and made aware of the safety hazards present in the particular site. A comprehensive safety program has to be designed for these. To prevent and control accident at construction project based on the causes which are responsible for the accident become the first step in this process. Bong et al., (2015) indicate that when a designer knows and understands the accident elements and consequences in details, he/she provides the best design to ensure safety. So if the real scenario behind the accident comes to light, it will be easier for the authority to take effective necessary steps to improve the safety program and reduce the accident rate in Bangladesh. For this, at first, it is necessary to find out the reason behind construction accident and effects arise due to this accident in Bangladesh. To assist the authority and reveal impact of the accident, the main purpose of this study is to investigate, identify and analyze the causes and effects of accidents in the construction project in Bangladesh. In this study, causes and effects are discussed and distributed in categories to investigate the characteristics and direct and indirect linkages of causes and effects. This study may help the authorities and project executives to know and understand about the causes and effects of accidents in the construction project in Bangladesh. This study could make aware the authorities and stakeholders that what a huge adverse impact the accidents have on construction project and which are the reason behind the accident. It may guide the potential readers that can play a vital role to decrease the accident rate and assist the stakeholders to introduce the accident-free construction project with an effective safety management system. This study is unique in the way that it is the only research which digging out the causes and effects of accident. Actually, this study is the first which is bring construction accident in light in Bangladesh.

2. Current Status of Accident at Construction Industry in Bangladesh

Bangladesh is facing accident issue in the construction industry for many years. A huge number of workers and other staffs get injured and died every year. Shakil et al. (2018) revealed the statistics of death numbers of victims of the construction accident in Bangladesh for 2006-2017 in Table 1.

From Table 1, the Bangladeshi construction industry faced 1861 deaths from 2006 to 2017. These are only the registered deaths at the police station or got newspaper coverage. There are many construction accidents and fatalities in Bangladesh which didn't get registered or covered by the newspapers (Report, 2017). Considering this, Table 1 doesn't represent the exact numbers of death but an estimated number of fatalities. The majority (31.43%) of total death is for electro-caution at the construction site and the number is 585 persons. Fall from height is another dominant direct

cause for 483 deaths at construction sites (25.95%) for 2006-2017. Collapsing building's parts is responsible for another 169 numbers of death (9.08%) which is shown in Table 1. Crushed by objects and suffocation with poisonous gas are responsible for 166 (8.92%) and 165 (8.87%) deaths of construction employees in the Bangladeshi construction industry. Earth collapse and hit by falling objects are other two causes of 129 (6.93%) and 57 (3.06%) persons death. About 3.44% of total death was for the "others" type causes. Rest 2.31% means 43 persons died due to entangled with machine and road accident at the construction site. The highest numbers of death 183 and 179 persons happened in 2011 and 2017. In 2012 and 2013, an equal number of death (175 persons) were experienced in the Bangladeshi construction industry. The similar numbers of death (145 persons) were experienced in 2016 and 2019. Comparatively fewer numbers of death were experienced by the Bangladeshi construction industry in 2008, 2007 and 2006 with the death numbers of less than 140 persons per year.

Table 1 shows the increasing rate of fatalities due to construction accident with time. And from this table, it is not difficult to say that the Bangladeshi construction industry will experience a horrific amount of fatalities in near future. The many complexities and devastating events will arise in the construction project which turns this country's largest industry to a dangerous one. So proper treatment of construction accident in Bangladesh is very important to do a better future even present of construction industry. And the study could be the initiation of these if authorities know and understand the contributions of it.

Table 1 - Statistic of Death Numbers Due to the Construction Accident in Bangladesh from 2006-17

Year	Electro-caution	Fall from height	Crushed by object	Earth collapse	Suffocation with poisonous gas	Building/Wall/Roof collapse	Entangled with machine	Hit by falling object	Road accident	others	Total (persons)
2006	32	23	12	7	9	16	1	11	2	5	118
2007	41	31	17	11	7	13	0	5	0	3	128
2008	44	31	12	12	15	10	2	5	3	4	138
2009	39	32	14	10	14	21	0	6	2	7	145
2010	45	38	8	12	14	16	1	1	0	3	138
2011	65	56	13	14	13	12	0	0	5	5	183
2012	63	52	16	3	20	8	0	2	2	9	175
2013	52	46	19	19	17	13	1	2	5	1	175
2014	56	44	17	10	18	12	0	3	3	2	165
2015	51	43	13	11	11	17	3	11	2	10	172
2016	42	42	10	9	14	13	2	3	2	8	145
2017	55	45	15	11	13	18	2	8	5	7	179
Total	585	483	166	129	165	169	12	57	31	64	1861
%	31.43	25.95	8.92	6.93	8.87	9.08	0.64	3.06	1.67	3.44	100

3. Background Study

Construction industry has encountered the highest number of fatal accidents among many industries in the world (Albert & Hallowell, 2012). Thus, studying the causes and effects of accidents in construction projects has gained importance to researchers in recent years although there is no research conducted before on the topic for the Bangladeshi construction industry. Therefore, many studies have been conducted in this area of research in different parts of the world. Few of them are discussed below.

Cheng and Wu (2013) analyzed the characteristics of construction accidents in small projects in Taiwan using descriptive statistics and correlation coefficients. They discovered that the most critical causes of accidents are careless acts about the implementation of safety measures at project sites, followed by insufficient safety training for novice workers, absence of competent health and safety professionals, improper attention from the authority to safety issue and lack of safety awareness. In Malaysia, Hamid (2008) identified a good number of causes of accidents at his research.

The main causes of accidents are revealed such as unsafe equipment, job sites condition, and unique nature of industry, unsafe method, poor management, poor safety policies and personal protective equipment, poor site management and equipment failure. Priyadarshani et al. (2013) developed a safety assessment framework for the construction industry in Sri Lanka. According to their study, lack of commitment of management, lack of safety measures, and negligence of individuals to respond the proper safety practices and unskilled workers are the most important factors leading to accidents at sites. Work at high elevation, poor site management, equipment failure, lack of skill and experience of executive and lack of worker training are the important causes which work behind construction accident in the United Arab Emirates (Al-Kaabi & Hadipriono, 2003). Uduakobonge et al. (2016) revealed the major causes of construction accident in Nigeria and those were lack of safety measures while handling materials/objects and lifting materials/objects, slips, trip on object, operating damaged equipment, striking by moving objects/machine/equipment, caving in of excavations and falling from height. Haslam et al. (Haslam, 2005) illustrate that accidents occur as a result of poor interaction among workers or work-teams (worker behavior), workplace (poor housekeeping and material storing) and materials/equipment (PPE) that originate due to insufficiency in the construction design and process, project and risk management, customer/owner and economic effects, or safety education and training. Ogwueleka (Ogwueleka, 2013a) conducted a comprehensive literature review to analyze the causes of construction accident and pointed out as the most influencing factors were management commitment, safety awareness of top management/project managers, errors in judgment or carelessness, expert knowledge or training, poor machinery and safety management practices/ procedure/ review. Tsang et al. (2017) identified three types of accident-related factors including working conditions, environmental factors and management actions in construction site.

Udo (2016) explored the 21 effects of construction accidents in the Nigerian construction industry. Some the highest ranked effects in this study are demotivation of workers, negative impact on the reputation of firms, enhancing the project cost, damages to plant/equipment and payment for settlement of injury/death claims. Kadiri et al., (2014) determined some of the effects on construction project due to the consequences of accident at construction sites. The most significant effects are time loss of schedule, reputation loss of firm, the psychology of workers negatively affected and cost of medical expense. Okolie and Okoye (2012) mentioned many effects that make the project more complex and faulty. Some of the top effects are human fatalities, de-motivation of workers, disruption of site activities, delay project progress and affection overall project cost and productivity. Mthlane et al (2008) identified a large number of effects of construction accidents on construction project. The high ranked effects are loss of productivity, disruption of current work, training cost for replacement, damages to plant/equipment/completed work, costs of workman's compensation, payments for settlements of injury or death claims, and legal fees for defense against claims. In Ireland, Hrymak and Perezgonzalez (2007) showed a wide range of negative effects due to the accidents in terms of monetary and non-monetary loss to employer. Some of the identified effects in this study are salary costs for replacement staff or overtime payments, production and productivity losses, retaining costs, personal injury claim compensation, repair cost, quality failure and dispute and litigation. Li and Poon (2009) expressed that there was an excessive number of court cases in Hong Kong with respect to worker's compensation for non-fatal construction accidents. Others effects in Hong Kong construction industry are time loss of schedule, conflicts and legal issues, worker psychology. Trinh et al. (2018) revealed that quality of construction works highly interrelated with the construction accident. Schedule loss of time and cost overrun are another result of construction accident. The accident also bring out the variation in project and dissatisfaction of clients.

Some other researches also have been done research significantly with the topic causes and effects of construction accidents such as for Pakistan (Zahoor et al., 2016), India (Tiwary & Gangopadhyay, 2011), Kuwait (Al-Humaidi & Tan, 2010), Turkey (Ulubeyli, Kazaz, & Er, 2014), South Korea (Yoon et al., 2013), Spain (Arquillos, Romero, & Gibb, 2012) and others (Behm & Schneller, 2013; Gibb, Lingard, Behm, & Cooke, 2014; Hollnagel, 2016). At this study revealed the causes and effects of accident and discussed them with their local aspect.

4. Research Objectives

The main objectives of this study are as follows:

- To identify the causes and effects of accident in the Bangladeshi construction industry; and
- To establish and prioritize the principal causes and effects which have dominating influence in the Bangladeshi construction industry.

The achievement of these objectives in this study will help relevant stakeholders in the Bangladesh construction industry to understand the reasons and caliber of accident and develop appropriate solutions to overcome these curse events. The quantitative methodology that comprises a survey method of data collection and the application of statistical techniques to analyze the data was used to achieve the objectives. In addition, this research represents a platform that would allow performing further contributions related to accident at construction sites in Bangladesh.

5. Materials and Methods

The primary objective of this study is to identify and prioritize the causes and effects of construction accidents in the Bangladeshi construction industry. To perform this study a wide literature review for designing a questionnaire and questionnaire survey method to collect data are used. This research method was used because of its ability to collect an extensive range of agreement from individuals, to deal with a large number of respondents, to have better generalizability of the results. Figure 1 illustrates the method and process of this study.

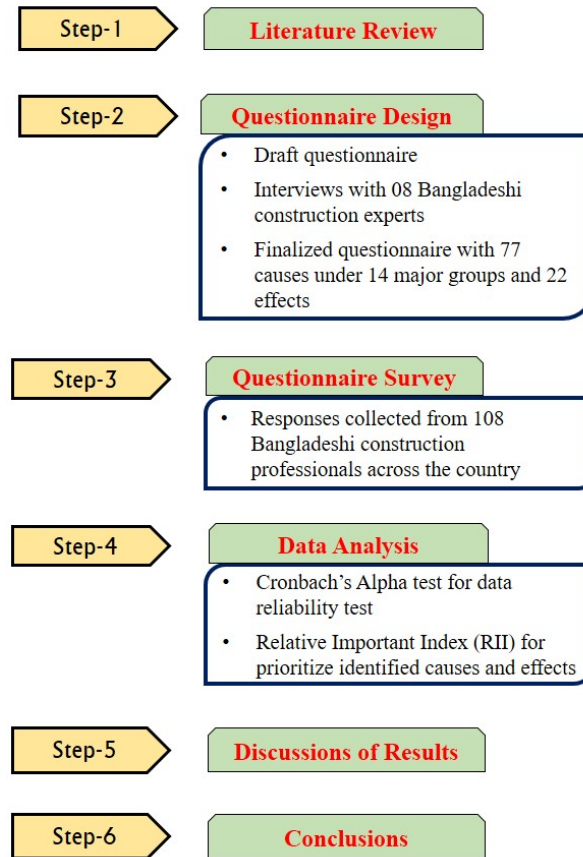


Fig. 1 - Research Methodology Flowchart

5.1 Questionnaire Design

To identify the causes and effects of construction accidents in Bangladesh, a wide literature review was conducted for sorting out a rough list. After that, an open discussion was held with an experts panel (the panel consist of government officials, high officials from NGO, executive of labour organization, experienced contractor, engineers, project managers, university professors and university students) of 8 construction professionals to identify the causes and effects which are reasonable for the aspect of Bangladeshi construction industry. Based on the expert's recommendations, total 77 causes were identified under 14 major groups for the construction accident in Bangladesh and 22 effects of construction accident were finalized to design the questionnaire.

A questionnaire survey was used to elicit the level of agreement of owners, consultants, labours and contractors towards the causes and effects of accidents in the construction projects in Bangladesh. The questionnaire was designed with three major parts. Part I is about the background information of the respondents. Where respondent were asked to answers about the organizational and individual characteristics. The identified 77 causes under 14 major groups of causes are presented in part II. Part III contain the 22 effects of accident in the Bangladeshi construction industry. The respondents were asked to indicate their level of agreement with the 41 challenges in the Bangladeshi construction industry context. To collecting feedback of the respondents, a five-point Likert Scale was used to measure the agreement and disagreement level of the respondents. The five-point scale represents the points as: 1– not important, 2 – slightly important, 3 – moderately important, 4 – very important and 5 – extremely important. There are many studies

(Abdelhadi, Dulaimi, & Bajracharya, 2018; Abusafiya & Suliman, 2017; Barua, 2013; Sambasivan & Soon, 2007) of questionnaire survey conducted by Likert scale and it is considered as the best measuring tool in the case of questionnaire survey of same context (Rowley, 2014).

5.2 Data Collection

Industry-wide data collection is very important to identify the causes and effects of construction industry and to cover the thoughts of a wide range of construction professionals and organizations in Bangladesh. The necessary data were collected through the questionnaire survey among the construction workers by visiting construction sites, labor unions, construction companies, and government agencies and so on. In total 147 questionnaires were distributed as follows: 44 to workers, 27 to owners, 41 to consultants and 35 to contractors. About 108 questionnaires (73.5%) were returned as follows: 32 from workers, 23 from owners, 28 from consultants, and 25 from contractors as respondents. Authors concentrated on IEB, IAB, REHAB and INSUB to select the potential respondents. The Institute of Engineers Bangladesh (IEB) is the largest professional association of the country with Civil Engineers, Building Engineers and Construction Manager. The IAB - Institute of Architects Bangladesh is the professional association of architects in Bangladesh. The Real Estate & Housing Association of Bangladesh (REHAB) another largest platform of construction companies and firms with a good organizational set up (high managerial level, including experienced professionals). The Imarat Nirman Sramik Union Bangladesh (INSUB) (in English, Building construction worker association Bangladesh) is the country's only organization which work for the right, safety and others issues of workers in Bangladesh.

5.3 Data Analysis

The collected data was analyzed by using the statistical package for social sciences (SPSS) software with version 23 and Microsoft Excel Worksheet 2016. SPSS is used for performing the reliability test of the collected data. The output of data analysis is introduced using graphs and tables for further discussion and interpretation in this study. The Relative Important Index (RII) is used to analyze the main response to the causes and effects of construction accident in Bangladesh. Cronbach's Alpha test is used to performing a validation test of the collected data.

Relative Important Index: The Relative Important Index (RII) was used for the determination of the rank between the causes and effect, and prioritize the principles variables. The RII value is range from 0 to 1. A higher value indicates a higher degree of impact and pervasiveness of the causes and effects. The RII was used to determine owners, consultants, labours and contractors perceptions towards the identified causes and effects. The five-point Likert Scale ranged from 1 (not important) to 5 (extremely important) was adopted and transformed to the relative importance index (RII) for each variable. An equation express below was used to determine the value of RII for each variables. Equation 1 is used in many research for the determination of impotency and relative rank (Hamid, Singh, & Arzmi, 2014; Ogwueleka, 2013b; Le-Hoai, Lee, & Lee, 2008).

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \times N} \quad (1)$$

In the above (1) equation 'W' is the weighting given to each factor by the respondents (ranging from 1 to 5), 'A' is the highest weight (i.e. 5 in this case), and 'N' is the total number of respondents in this study (i.e. 108 in this study).

Data Reliability Test: The required data for analysis of causes and effects of construction accident was collected independently from various respondents with various organizational and individual characteristics. So it is necessarily important to check the reliability and validity of the independently collected data. Cronbach Alpha was used as a most common test of the reliability for the case where multiple Likert questions are in the questionnaire. Cronbach's Alpha is used to measure the internal consistency of identified challenges used in this survey. Its value ranges from 0 to 1. A higher value indicates a higher degree of consistency among the items (Z. Zhou, Yang Miang Goh, and Qiming Li, 2015). George et al. (2016) and Pallant (2016) indicate that " $\alpha \geq 0.7$ " is acceptable, but values of " $\alpha > 0.8$ " are more preferable. In this study, the Cronbach's Alpha test is conducted by the software of Statistical Package for the Social Science (SPSS 23). Table 2.1 and Table 2.2 represent the Cronbach's Alpha test result for this study.

Table 2.1: Case Processing Summary

Case	N	%
Valid	108	100
Included ^a	0	0
Total	108	100

^a Listwise deletion based on all variables in the procedure.

Table 2.2: Reliability Statistics for the Collected Data

Cronbach's Alpha, α	Cronbach's Alpha Based on Standardized items	N of items
0.886	≥ 0.7	108

From Table 2.2, the Cronbach's Alpha coefficient is determined 0.886 whereas the acceptable limit is 0.7. The collected data are excellent for the high stakes testing and some advance test results are generated from this data validly.

6. Results

6.1 Background Information of Respondents

Table 3 shows the respondents profile based on the organizational and individual characteristics. Among the respondents of this study, 89 respondents are male and 19 respondents are female which represents the 82 percent and 18 percent of total respondents. The majority 34 percent respondents are more than 40 years old while following 29 percent respondents are less than 20 old, 23 percent are 31-40 years range, and remaining 14 percent are 21-30 year old. Regarding the organizational characteristics of respondents, 21 percent working in developing organizations and individual owners, 26 percent are involved in consulting organizations, 23 percent are involved in contracting organizations, and 30 are involved in labour based organizations.

Table 3 - Background Information of the Respondents

Demographic Characteristics	Frequency	Percentage (%)
Sex		
Male	89	82
Female	19	18
Age		
≤ 20 years old	31	29
21-30 years old	15	14
31-40 years old	25	23
≥ 40 years old	37	34
Education		
Lower Higher Secondary School	42	39
Pre-University	19	17
Graduate	30	28
Post-graduate	17	16
Location		

Dhaka Division	28	23
Rajshahi and Rangpur Division	19	18
Chittagong Division	18	17
Sylhet Division	15	14
Khulna and Barishal Division	30	28
Type of Organization		
Owners	23	21
Consultants	28	26
Contractors	25	23
Workers	32	30
Working Experience		
≤ 5 years	19	18
5-15 years	30	28
15-25 years	23	21
≥ 25 years	36	33
Fields of specializations		
Building	89	51
Roads and Bridge	48	27
Electrical and mechanical	22	13
others	17	09

In this study, the majority 33 percent of respondents had the working experience of more than 25 years and another 28 percent had working experience in between 5 to 15 years. About 21 percent of respondents mention that they had 15-25 years of working experience, while the rest had experienced less than 5 years (18 percent) in the Bangladeshi construction industry. A large portion (39 percent) respondents had education qualification which lower higher secondary school. With graduate level qualification, 28 percent respondents are in this study, while the respondents with postgraduate and pre-university educational qualification are 16 percent and 17 percent. A large portion about more than half of the respondents (51 percent) are working in the building projects and 27 percent are working in road and bridge construction projects. On the other hand, 13 percent respondents are working in electrical and mechanical department of construction and rest only 9 percent are involved in others department of construction projects in Bangladesh.

6.2 Analysis of RII of Causes

Table 4 shows the 77 identified causes under 14 major groups of accident at construction site in Bangladesh with RII and relative rank. The highest ranking (1st) cause is contractor unaware of safety related issue (C35) with RII=0.686. The 2nd highest ranking cause is lack of personal protective equipment of worker (C41) with the RII=0.674. The 3rd, 4th and 5th highest ranking causes are lack of safety eliminating/ avoiding design (C19), unfit equipment (C54), and lack of knowledge and training on equipment (C59) with the RII of 0.669, 0.666 and 0.665. Irregular investigation of consultant (C31) with RII=0.659 and managerial issue “inadequate safety policy” (C62) with RII=0.658 are ranked in 6th and 7th positions in Table 4. The 8th, 9th, 10th, 11th and 12th highest ranking causes are worker’s lack of expertise knowledge or training (C45), unwilling to pay extra cost for safety (C49), unskilled labours (C42), consultant’s unaware of construction safety (C30), and not-strict operation procedures in contract (C11) with the respective RII value of 0.657, 0.655, 0.652, 0.645, and 0.644. C36, C68, C21, C55, C18, C58, C4, and C57 are also in the high ranking causes.

Table 4 - Summary of RII, SD and Ranking of Causes of Accident in Construction Project

Majjr Group	ID	Causes of Accident	RII	SD	Rank (overall)
Project related	C1	Value of project	0.581	-0.0045	43
	C2	Poor Planning/ scheduling of project	0.567	-0.0185	48
	C3	Very tight project schedule	0.606	0.0205	26
	C4	Type and nature of project	0.625	0.0395	19
	C5	Social and communal involvement of project	0.508	-0.0775	71
	C6	Financial body (Government or private)	0.456	-0.1295	77
Site Condition	C7	Project site conditions (exclude equipment, materials , weather)	0.567	-0.0185	49
	C8	Project site layout/space	0.565	-0.0205	51
	C9	Project working environment (light/noise/hot/cold/wet)	0.594	0.0085	33
	C10	Poor housekeeping	0.609	0.0235	23
Contract	C11	Not-strict operation procedures in contract	0.644	0.0585	12
	C12	Coordination between project participants	0.534	-0.0515	70
	C13	Lack of Management commitment in contract	0.557	-0.0285	54
	C14	Type of awarding contract	0.543	-0.0425	66
	C15	Unclear contract conditions on safety issue	0.585	-0.0005	40
Design	C16	Design is not constructible	0.548	-0.0375	61
	C17	Incomplete and inconsistency of design document	0.545	-0.0405	65
	C18	Safety is not consider when design	0.632	0.0465	17
	C19	Lack of safety eliminating/ avoiding design	0.669	0.0835	3
Material	C20	Lack of protection in material carrying	0.479	-0.1065	76
	C21	Lack of protection in material storage	0.633	0.0475	15
	C22	Working with toxic/ hazardous materials	0.558	-0.0275	53
	C23	Hazard during transportation	0.603	0.0175	28
	C24	Lack of knowledge about construction materials	0.556	-0.0295	55
Cost - Time	C25	Cost overrun reduce the safety cost	0.494	-0.0915	73
	C26	Schedule delays and rework in construction project	0.547	-0.0385	62
	C27	Short time assign to worker	0.596	0.0105	31
Consulta nt	C28	Lack of Management/ leadership skills	0.595	0.0095	32
	C29	Lack of knowledge and experience	0.540	-0.0455	68
	C30	Unaware of construction safety	0.645	0.0595	11
	C31	irregular investigation	0.659	0.0735	6
	C32	Flexible to contractor/worker on safety issue	0.551	-0.0345	60
	C33	No interest to change the safety culture	0.593	0.0075	34
Contractor	C34	Inaccurate or incomplete schedule	0.579	-0.0065	44
	C35	Unaware of safety related issue	0.686	0.1005	1
	C36	Unwilling to spend safety related cost	0.642	0.0565	13
	C37	Lack of skill and experience of site staff	0.536	-0.0495	69
	C38	Violating BNBC code/ Bangladesh labour law	0.589	0.0035	38
	C39	Reckless action of contractor	0.574	-0.0115	46
Labou r	C40	Lack of collaboration among labours	0.583	-0.0025	41
	C41	Lack of personal protective equipment	0.674	0.0885	2
	C42	Unskilled labours	0.652	0.0665	10
	C43	Worker empowerment to make decision	0.560	-0.0255	52

	C44	Poor of education of labourers	0.555	-0.0305	56
	C45	Lack of Expertise, knowledge or training	0.657	0.0715	8
	C46	Interference with others role	0.543	-0.0425	67
	C47	Over time for labours	0.605	0.0195	27
	C48	Behaviour of worker	0.610	0.0245	22
Owner	C49	Unwilling to pay extra cost for safety	0.655	0.0695	9
	C50	Owner's interference on schedule and process	0.500	-0.0855	72
	C51	Owner's expectations variation	0.483	-0.1025	74
	C52	Lack of owner's emphasis on safety	0.546	-0.0395	64
	C53	owner's late response (decision making)	0.546	-0.0395	63
Equipment and	C54	Unfit equipment	0.666	0.0805	4
	C55	Poor equipment maintenance	0.632	0.0465	16
	C56	Unused of modern equipment	0.607	0.0215	24
	C57	High cost of advanced equipment and tools	0.623	0.0375	20
	C58	Improper use of equipment	0.630	0.0445	18
	C59	Lack of knowledge and training on equipment	0.665	0.0795	5
Management	C60	Lack of effective Project supervision	0.607	0.0215	25
	C61	Lack of effective Communication	0.588	0.0025	39
	C62	Inadequate safety policy	0.658	0.0725	7
	C63	Improper auditing system	0.591	0.0055	36
	C64	Poor Organization structure	0.582	-0.0035	42
	C65	Lack of information flow	0.591	0.0055	35
	C66	Lack of technique guide	0.553	-0.0325	58
	C67	Lack of teamwork	0.598	0.0125	30
Technology	C68	Unused of safety control system	0.636	0.0505	14
	C69	Unused of schedule system	0.481	-0.1045	75
	C70	Unaware to advanced technology for safety	0.568	-0.0175	47
	C71	Lack of implementation of BIM	0.612	0.0265	21
	C72	Lack of innovation technology	0.575	-0.0105	45
	C73	Lack of implement safety control sensor technology	0.551	-0.0345	59
External	C74	Act of God	0.555	-0.0305	57
	C75	External obstacle/ barrier	0.566	-0.0195	50
	C76	Nature of construction	0.590	0.0045	37
	C77	Bad weather	0.601	0.0155	29

Table 4 also shows the middle-ranking causes of construction accident in Bangladesh. The most noticeable middle ranking causes are managerial related causes like project supervision, housekeeping, information and communication, teamwork, scheduling and planning, organization culture and structure (C28, C10, C60, C61, C63, C65, C67, C1, C2, C3), project, environment and external related like transportation, weather, site condition and nature (C23, C77, C34, C38, C9, C75, and C76), material and equipment related like hazardous and toxic material, backdated and faulty equipment (C22, C24, C23 and C56), technology related (C70, C72, C56 and C71), stakeholders related causes like skills and training of worker and consultant, overtime, empowerment of staffs, mutual collaboration and reckless decisions (C48, C47, C27, C39, C40 and C43) which have the moderate level of impact and influence on construction accident in Bangladesh. The lowest ranking causes in this study are financial body (Government or private) (C6) with the RII=0.456 and lack of protection in material carrying (C20) with RII= 0.479 which are ranked in 77th and 76th positions in Table 4. The 75th, 74th, 73th and 72th causes are unused of schedule system (C69), owner's expectations variation (C51), cost overrun reduce the safety cost (C25), and owner's interference on schedule and process (C50) with the RII of 0.481, 0.483, 0.494, and 0.500 respectively. Lack of technique guide (C66), lack of implement safety control sensor technology (C73), flexible to contractor/worker on safety issue (C32), design is not constructible (C160), schedule delays and rework in construction project (C26), owner's late response (decision making) (C53), lack of

owner’s emphasis on safety (C52), incomplete and inconsistency of design document (C17), type of awarding contract (C14), interference with others role (C46), lack of knowledge and experience (C29), lack of skill and experience of site staff (C37), coordination between project participants (C12), and social and communal involvement of project (C5) are also the causes in the lowest ranking in Table 4.

Table 5.1 - Summary of High-Ranking Causes for Worker and Contractor Groups of Respondent

Rank	Worker		Contractor	
	Causes of Accident	Major Group	Causes of Accident	Major Group
1	Not-strict operation procedures in contract	Contract	Lack of personal protective equipment	Labour
2	Lack of safety eliminating/avoiding design	Design	Lack of knowledge and training on equipment Violating BNBC code/ Bangladesh	Equipment and Tools
3	No interest to change the safety culture	Consultant	labour law	Contractor
4	Unskilled labours	Labour	Inadequate safety policy	Management
5	Unwilling to spend safety related cost	Contractor	Unwilling to pay extra cost for safety	Owner
6	irregular investigation	Consultant	Unfit equipment	Equipment
7	Lack of Expertise, knowledge or training	Labour	Not-strict operation procedures in contract	Contract
8	Unfit equipment	Equipment and Tools	High cost of advanced equipment and tools	Equipment and Tools
9	Lack of knowledge and experience	Consultant	Lack of Management/ leadership skills	Consultant
10	Unaware of safety related issue	Contractor	Unaware of safety related issue	Contractor

Table 5.2 - Summary of High-Ranking Causes for Owner and Consultant Groups of Respondent

Rank	Owner		Consultant	
	Causes of Accident	Major Group	Causes of Accident	Major Group
1	Inadequate safety policy	Management	Unfit equipment	Equipment and Tools
2	Unfit equipment	Equipment and Tools	Unaware of safety related issue	Contractor
3	Lack of teamwork	Management	Lack of knowledge and training on equipment	Equipment and Tools
4	Not-strict operation procedures in contract	Contract	Improper auditing system	Management
5	Unaware of safety related issue	Contractor	Safety is not consider when design	Design
6	Lack of personal protective equipment	Labour	Lack of Expertise, knowledge or training	Labour
7	Lack of knowledge and training on equipment	Equipment and Tools	Inadequate safety policy	Management
8	Lack of safety eliminating/avoiding design	Design	Lack of Management commitment in contract	Contract
9	Unskilled labours	Labour	Lack of safety eliminating/avoiding design	Design
1	Safety is not consider when design	Design	Unskilled labours	Labour

In Table 5.1 and Table 5.2, the highest ranking causes for contractors, consultants, owners and labours groups of

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respondent are presented. The 1st and 2nd highest ranking causes for contractors are lack of personal protective equipment (C41) and lack of knowledge and training on equipment (C59). Not-strict operation procedures in contract (C11) and lack of safety eliminating/ avoiding design (C19) are ranked in 1st and 2nd positions for the workers. The 1st

and 2nd highest ranking causes for consultants are unfit equipment (C54) and lack of knowledge and contractor unaware of safety related issue (C35), while inadequate safety policy (C62) and unfit equipment (C54) are ranked in 1st and 2nd highest positions for the owners. Table 6 represents the major groups of causes with RII based ranking for overall and each respondents groups. Management related causes group is ranked in 1st position and equipment and tools related group is ranked in 2nd position. Other highest ranking major groups are contractor, consultant and labour related groups of causes. The lowest ranking major groups are time and cost (14th). Owner (13th) and contract (12th) related major groups of causes. The management related major group is ranked the 1st position for the respondents of contractor, consultant and labour, while the equipment and tools related group is ranked in the 1st position for the respondent's group of owner. The lowest ranking (14th) cause for the consultants and labours is time and cost related major group. The contract related group is ranked in the 14th position for the contractors and the external related causes group is ranked in the 14th position for the owners in Table 6.

Table 6 - Summary of RII Based Ranking of Major Groups of Causes

Major Group	Rank				Overall Rank
	Contractor	Worker	Owner	Consultant	
Project related	11	12	11	12	11
Site Condition related	6	8	10	5	8
Contract related	14	9	9	13	12
Design related	9	11	6	11	9
Material related	3	7	8	9	7
Cost & Time related	13	14	13	14	14
Consultant related	5	4	2	6	4
Contractor related	7	2	3	3	3
Labour related	4	6	5	2	5
Owner related	12	13	12	10	13
Equipment and Tools related	2	5	1	4	2
Management related	1	1	4	1	1
Technology related	8	3	7	8	6
External related	10	10	14	7	10

6.3 Analysis of RII of Effects

Table 7 shows that identified 22 effects of the construction accident in the Bangladesh construction industry. The highest ranking (1st) effect is loss of human life with the RII= 0.708. The 2nd and 3rd highest ranking effects determined in this study are demotivation of workers/reduce morale (RII=0.668) and conflict of workers (RII=0.642). Loss of productivity (4th), delay in work progress (5th), negative impact on reputation of firms (6th), cost of medical bills/expenses (7th) and loss of opportunity to qualify for future tender (8th) are in high ranking effects in Table 7. The noticeable middle-ranking effects are loss of opportunity to qualify for future tender, disruption of site operation, cost of workman compensation, negative effect on psychology of worker, cost of rework/repair, transporting injured worker(s) to obtain treatment, and payment for settlement of injury/death claims for the Bangladesh construction industry. The lowest ranking effects are damages to completed work (21st) with RII=0.486 and damages to plant/equipment (22nd) with RII=0.483 in Table 7. Other low-ranking effects are cost of cases/litigation (15th), cost of investigating accident (16th), training cost for replacement worker (17th), cost of rescue operation (18th), project stop (19th), and increase in project cost (20th) in this study.

Table 7 - Summary of RII and RII Based Ranking of Effects

Effects	Contractor		Worker		Owner		Consultant		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Loss of human life	0.561	5	0.843	1	0.728	2	0.595	1	0.708	1
Demotivation of workers/reduce morale	0.637	1	0.714	9	0.683	4	0.561	2	0.668	2
Conflict with workers	0.564	4	0.746	4	0.772	1	0.505	8	0.642	3
Loss of productivity	0.54	9	0.764	3	0.700	3	0.504	9	0.627	4
Delay in work progress	0.601	2	0.738	6	0.673	7	0.521	6	0.623	5
Negative impact on reputation of firms	0.526	12	0.795	2	0.679	5	0.491	13	0.62	6
Cost of medical bills/expenses	0.541	8	0.695	12	0.651	10	0.527	4	0.617	7
Loss of opportunity to qualify for future tender	0.558	6	0.689	14	0.654	9	0.523	5	0.601	8
Disruption of site operation	0.555	7	0.734	7	0.676	6	0.518	7	0.6	9
Cost of workman compensation	0.536	11	0.695	13	0.637	12	0.539	3	0.597	10
Negative effect on psychology of worker	0.513	15	0.633	19	0.655	8	0.479	15	0.595	11
Cost of rework/repair	0.578	3	0.715	8	0.604	17	0.501	10	0.584	12
Transporting injured worker(s) to obtain treatment	0.537	10	0.659	17	0.631	14	0.5	11	0.584	13
Payment for settlement of injury/death claims	0.442	20	0.71	10	0.530	21	0.408	21	0.579	14
Cost of cases/litigation	0.521	14	0.678	15	0.621	15	0.491	12	0.57	15
Cost of investigating accident	0.479	19	0.708	11	0.637	13	0.412	20	0.561	16
Training cost for replacement worker	0.505	16	0.647	18	0.649	11	0.457	18	0.554	17
Cost of rescue operation	0.499	17	0.578	21	0.593	18	0.471	16	0.544	18
Project stop	0.526	13	0.668	16	0.58	19	0.486	14	0.532	19
Increase in project cost	0.435	22	0.741	5	0.611	16	0.447	19	0.491	20
Damages to completed work	0.437	21	0.584	20	0.526	22	0.465	17	0.486	21
Damages to plant/equipment	0.49	18	0.575	22	0.535	20	0.406	22	0.483	22

Table 8 also reveals the ranking of effects for each respondents group. Demotivation of workers/reduce morale and delay in work progress are ranked in the 1st and 2nd position for the contractors, while the lowest ranking effects are damages to completed work (21st) and increase in project cost (22nd). Loss of human life is the highest ranking (1st) effect for the workers and consultants, meanwhile damages to plant/equipment (22nd) is the lowest ranking for the groups of respondent. The 2nd highest ranking effect for the workers is negative impact on reputation of firms and for the consultants is demotivation of workers/reduce morale. Conflict with workers and loss of human life are ranked in the 1st and 2nd position for the owners, while the lowest ranking effects are payment for settlement of injury/death claims (21st) and damages to completed work (22nd) in the Bangladeshi construction industry.

6.4 Ishikawa-fishbone Diagram (Cause-effect Diagram)

In this study, identified 77 causes of construction accident under 14 major groups and 22 effects generate a fishbone diagram in Figure 2 and Figure 3. In this figure (Figure 2), the causes are categorized logically, the correlation and linkage of each cause can be understood at a glance. And Figure 3 shows the multiple effects against the single cause (accident at construction site) which is inspired and modified from the Ishikawa diagram concept. These can be a great way to boost the understanding ability and structural brainstorming about the reasons behind for construction accident and its effects because it captures all the variable. The fishbone diagram is the best way of this study to represent the causes and effects of construction accident. The figure helps the reader to understand and know the causes and effects at a glance without wasting any time. Instead of the 6M of the fishbone diagram format, the author uses a modified version of the cause-effect diagram in Figure 2. The 14 major groups are structured as the major subcategories under major six categories. And the seventy-seven (77) causes structured under the fourteen major sub-categories in the

fishbone diagram. Where Figure 3 is a simple cause-effect diagram without any subgroup or category. It is a modified version of the Ishikawa diagram and in this study, it is named the “effect-flow diagram”.

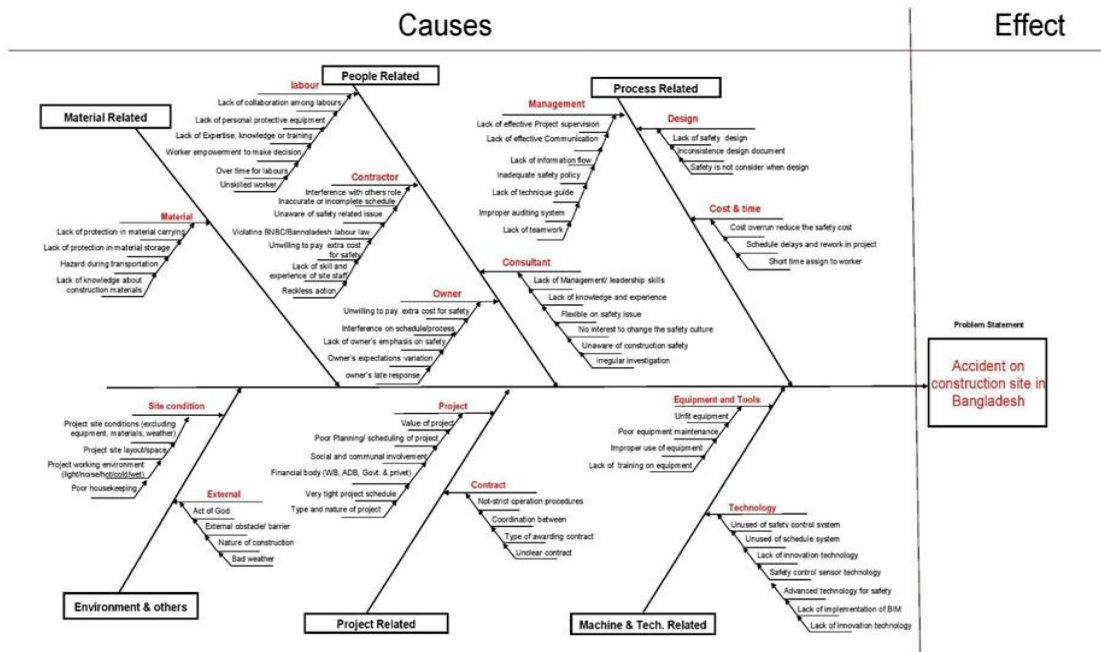


Fig. 2 - Ishikawa-Fishbone Diagram of Accident at Construction Site

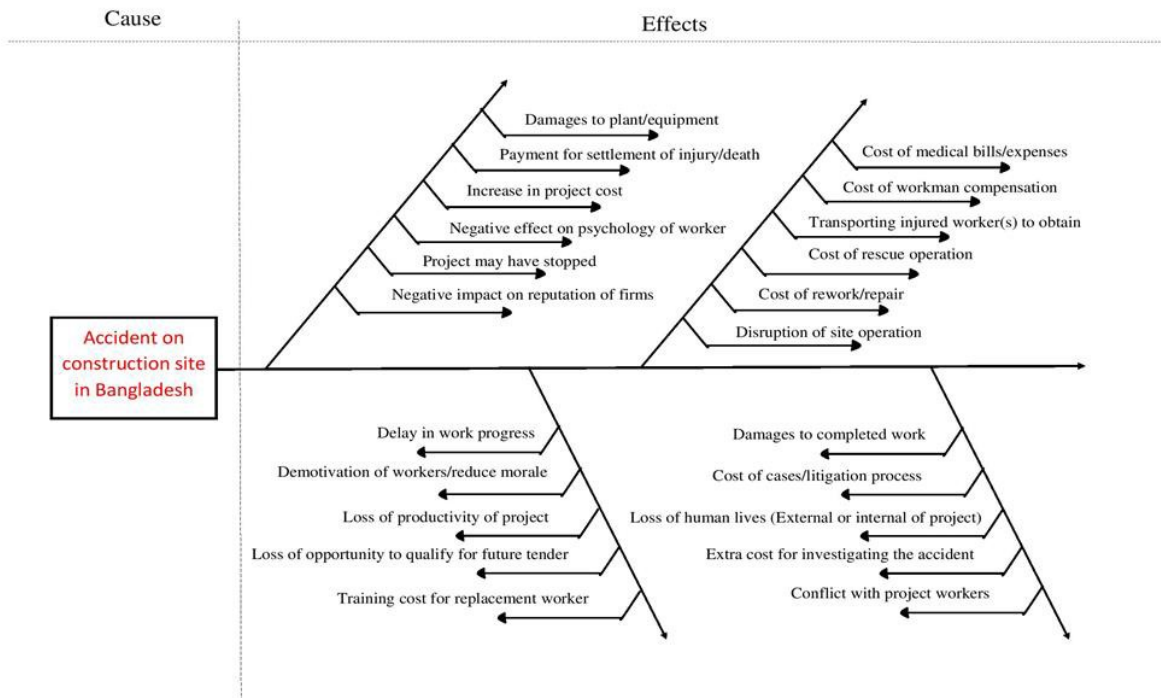


Fig. 3 - Effect-flow Diagram of Construction Accident

7. Discussion of Results

The objectives of this study is to identify the most suitable causes and effects of construction accident in Bangladesh and to establish and prioritize them in the available literature regarding the accident in the Bangladeshi construction industry. The RII based ranking of the variables help to highlight the principles variables to the authorities, so that the construction industry could be benefited through this study.

7.1 High Ranking Causes

There are some causes identified in this study which are very influencing to occur accident at construction site in Bangladesh. And these accident bring out a huge amount of death and complexities for each year. The top-ranked causes are highly liable than other the causes of accident. In Table 8, the high-ranking (top 15) causes from the different major groups of causes are shown based on their RII value.

Table 8 - Summary of High-ranking Causes of Accident

Causes	Major Group	RII	Rank
Unaware of safety related issue	Contractor	0.686	1
Lack of personal protective equipment	Labour	0.674	2
Lack of safety eliminating/ avoiding design	Design	0.669	3
Unfit equipment	Equipment and Tools	0.666	4
Lack of knowledge and training on equipment	Equipment and Tools	0.665	5
Irregular investigation	Consultant	0.659	6
Inadequate safety policy	Management	0.658	7
Lack of Expertise, knowledge or training	Labour	0.657	8
Unwilling to pay extra cost for safety	Owner	0.655	9
Unskilled labours	Labour	0.652	10
Unaware of construction safety	Consultant	0.645	11
Not-strict operation procedures in contract	Contract	0.644	12
Unwilling to spend safety related cost	Contractor	0.642	13
Unused of safety control system	Technology	0.636	14
Lack of protection in material storage	Material	0.633	15

Table 8 indicates the topmost crucial cause of construction accident in Bangladesh is contractor unaware of safety-related issue. This cause is also determined as the high ranking causes in developing countries (Berihha, Patnaik, Mahapatra, & Padhee, 2012; Chong & Low, 2014; Im et al., 2009). Shakil et al. (2018) stated that most of the contractors don't know the safety regulations properly and they don't practice safety policy either. The law enforcement agencies also not strict about the safety regulation in construction site (Report, 2017). For this, those who know about safety regulation, they take the opportunity to avoid it to save safety-related cost and those who don't know they don't interest to know and implement it. If authorities make contractor aware of safety regulation and culture, 35% of accidents can be reduced in Bangladesh (Reaz, 2018). So it the biggest challenge to the authorities to train and educate contractor with safety effects, advantage, regulation and law. If contractors know about the effects of accident, death rate of accident, punishment of violating safety regulations and safety culture in their project, a tremendous change has appeared to the accident scenario in Bangladesh within a few years. The second highest ranking cause is lack of personal protective equipment (PPE) of worker. Shakil et al. (Ahmed; et al., 2018) show that only 9.35% of Bangladeshi worker know and practice safety regulation and others don't. Also, show that just 9.68% of workers use PPE and rest portion does not use. A large amount of accident can eliminate if workers use PPE properly (Mohd Amir Shazwan & Ee, 2018). So it is necessary to educate and train workers on construction safety and make the strict and punishable rule on PPE practice to reduce the accident rate. Not only Bangladesh PPE is important factors to treat to implement effective safety culture but also in Pakistan (Raheem & Issa, 2016), Spain (Murdoch, 2002), Brazil (Benite & Cardoso, 2001) and India (Hasan & Jha, 2013). Third and fourth highest ranking causes are lack of safety design and

unfit equipment use in the construction work. Hossain et al. (Ahmed, Islam, et al., 2018) reported that contractors and owners are not interested to develop safety design along with detail drawing of project. Safety design at the planning and design phase can be the change maker of reducing accident rate. Gambatese et al. (2008) revealed that design plays a very important and effective role in ensuring safety and prevent construction accident. Respondents report that safety design does not adopt by the stakeholders due to extra cost for safety design, unaware of safety design, lack of information about safety design, the uncultured environment of safety design and so on. The unfit equipment is not the highest ranking causes in Bangladesh, many developing, developed and under-developed countries faced this challenge (Aulin & Ågren, 2012; Chong & Low, 2014; Gambatese, 1998; Hasan & Jha, 2013). This cause is very much responsible for the accident of especially workers and technicians. More than 30% of accidents are occurred due to the unfit equipment at construction site (Bourassa, Gauthier, & Abdul-Nour, 2016). So respective authorities, supervisors and safety managers have to serious about the proper testing of equipment before the actual work start.

The fifth highest ranked cause is lack of knowledge and training on equipment. As most of the workers and operators are poor at professional training and safety knowledge in Bangladesh, so this cause is very common and dominating in the countries which share similar context with Bangladesh (Ahmed, Islam, et al., 2018; Ahmed; et al., 2018). Endroyo et al. (Endroyo, Yuwono, & Mardapi, 2015) suggested proving training and workshop on equipment and tools used in construction to avoid fatalities during work especially in developing countries like Bangladesh. The irregular investigation by consultant and inadequate safety policy adopted by management are determined as 6th and 7th highest ranking causes. These two causes purely indicate the vulnerable and poor state of management systems in the Bangladeshi construction project. Irregular investigation and inadequate safety policy are reported many times for the accident occurring reasons in many studies (Reaz, 2018; Report, 2017; Seizel, 2018). Effective and frequently investigation is very important in the safety management system and it encourages the workers to follow the safety regulation and to practice the safety measures in construction site (Enshassi, 2009; Hofmann & Stetzer, 1996). Appropriate safety management policy is obligatory of any construction organization. On the contrary, a horrific figure of construction accident is a reprisal for the absence of safety policy (Yiu, Sze, & Chan, 2018). A large portion of construction accident could be mitigated by implementing appropriate and effective safety management policy in construction industry (Reason, 2016). Lack of expertise, knowledge or training of worker is another high-ranking cause in Bangladesh. Shakil et al. (Ahmed, Islam, et al., 2018) pointed out that worker training and skill is the key factor of any accident-free industry, while unskilled and untrained workers are the key factors of a large amount of construction accident in Bangladesh. This cause of accident is common in developing countries as their socio-economic context is similar such as India (Nirmala & Prasad, 2019), Brazil (Benite & Cardoso, 2001), Nigeria (Williams, Hamid, & Misnan, 2019) and Malaysia (Othman, Majid, Mohamad, Shafiq, & Napiah, 2018). The owner unwilling to pay the extra cost for safety and unskilled labour also has a high impact on accident at construction site. To spend extra cost for safety is usually uncommon and unprecedented at low-income country like Bangladesh. Authorities and government should make conscious owner about the safety policy, accident and its effects on construction project (Winge & Albrechtsen, 2018). Unskilled worker is the another most important construction issue in Bangladesh (Ahmed, Islam, et al., 2018). The majority of fatal victims of construction accident are workers, so the lack of skill is increased the accident rate significantly (Chiang, Wong, & Liang, 2017). Authorities have to deal with the unskilled worker to reduce the accident at construction site.

Consultant unaware of the safety issue is one of the important causes of construction accident. This cause is considered as a key factor of influencing accident in many countries like Ghana (Manu, Poghosyan, Agyei, Mahamadu, & Dziekonski, 2018), UK (Gambatese et al., 2008), UAE (Shibani, Saidani, & Alhajeri, 2013) and China (Yu, Ding, Zhou, & Luo, 2014). Toole (Michael Toole, 2005) stated that consultants are the principal element of construction safety management and they have to be trained and killed on safety related issues at construction sites. Not-strict operation procedures in the contract are a very severe issue in developing and under-developed countries and it plays a very crucial role in construction accident (Chong & Low, 2014). Not-strict operation procedures in contract which allows the stakeholders to avoid and bypass the standard safety policy. So this cause has to consider for designing an effective safety policy. Unwilling to spend safety related cost is usual and common in developing countries to enhance the rate of construction accident and related fatalities (Aulin & Ågren, 2012; Beriha et al., 2012; Chong & Low, 2014). Winge et al. (Winge & Albrechtsen, 2018) recommended that an extra budget on construction safety should be sanctioned in every construction project to reduce the accident and fatalities. Unused safety control system is considered as a high ranking cause in many studies and has an impact on safety policy of organization (Shibani et al., 2013; Tam, Zeng, & Deng, 2004). Another high ranking cause is lack of protection in material storage in Table 5. A large number of accident and fatalities are experienced by the construction industry for inadequate safety at material storage and carrying periods (Ahmed; et al., 2018). All these causes are extremely responsible for construction accident in Bangladesh. Table 5.1 and 5.2 are also covered by the above discussion of high ranking causes.

7.2 High Ranking Major Groups of Causes

Yet above, it is only discussed high ranking causes but not the major groups of causes. In this section, the major fourteen (14) groups were discussed by the RII and RII based rank.

From Table 6, it is revealed that management related group is ranked the highest position among all groups. So the contribution of this group to influence the accident is more than other groups. Management related major group is also determined as the biggest contributor of occurring accident in UAE (Shibani et al., 2013), Hong Kong (Chiang et al., 2017), Gaza (Enshassi, 2009), China (Yu et al., 2014), Sweden (Aulin & Ågren, 2012) and Malaysia (Chong & Low, 2014). Zhou et al. (Z. Zhou, Yang Miang Goh, and Qiming Li, 2015) recommended taking measures on management related causes to reduce the accident rate. The 2nd and 3rd ranking major groups are equipment and tools related and contractor related. Equipment related group is considered as the highest ranking cause in many studies (Aulin & Ågren, 2012; Benite & Cardoso, 2001; Beriha et al., 2012). Equipment and tools related accidents are common and frequent in Bangladesh as well as global construction. Tam et al. (Tam et al., 2004) claimed that equipment and tools are the primary elements of occurring accidents and almost every accident are physically contact with equipment and tools used in the construction sites. This major group demands more attention of authorities to reduce the accident in Bangladesh. Contractors are the key personnel of construction safety management. Baxendale et al. (Baxendale, 2000) stated that contractors play an effective and significant role in safety management and responsible for implementing safety policy in organizations and project during construction. The contractor related causes are undoubtedly dominating in construction accident in Bangladesh similarly with global construction (Enshassi, 2009).

The 4th and 5th highest ranking groups are consultant related and labour related causes. Consultant are the primary element and most responsible person of construction safety management. Consultants are responsible for safety design and planning, safety supervision, providing training on safety, safety controlling and taking action when necessary (T Michael Toole, 2005). Many studies (Gambatese, 1998; Murdoch, 2002; T Michael Toole, 2005) revealed that by ensuring the consultant's role in safety management, a large amount of accident and fatalities could be reduced. Most of the victims of accident are workers and site staffs in construction projects (Probst, 2008). Labours are directly liable for accidents and their responsibility is more than any other project participants (T. Michael. Toole, 2002). This major group is also a crucial one for developing countries (Raheem & Issa, 2016; Shibani et al., 2013; Winge & Albrechtsen, 2018; Yu et al., 2014). These two major groups of causes are clearly highly responsible for frequent fatal accidents in the Bangladeshi construction industry. Technology related causes are very important in the modern age of construction. Lots of technologies are now used in construction safety and the outcome is significantly appreciable and applicable. Many studies (Guo, 2017; Sun, 2010; Zhang, 2013; Y. Zhou, Ding, L. Y., & Chen, L. J., 2013) showed that opportunity, benefits and efficiency of different modern and automation technologies used in construction project. Bangladesh is used very low to the null amount of technology. For this, accident rate is increasing day by day rather reducing in the Bangladeshi construction industry.

7.3 High Ranking Effects

As construction accident is the big issue for the Bangladeshi construction industry and various adverse effects in construction project arise due to the accident. Table 7 reveals the highest ranking effect of construction accident Bangladesh is loss of human lives. This effect is very crucial in all over the world and global construction experience more death due to the accident at construction sites (Ofori, 2015). This effect is very crucial and realistic as mentioned above that every year more than 150 people face death for construction accident on average in Bangladesh (Ahmed; et al., 2018). Not only Bangladesh but also the loss of human lives is the most critical problem in the global construction industry. If authorities try to understand what are the effects of the accident? This effect is enough to answer all the questions. Researcher (Ahmed, Sobuz, et al., 2018) said that the death number in construction sector is more than half of the total death of occupational accidents in Bangladesh. It also pointed out that workers death have negative impacts on family, company and project. The second highest ranking effect is demotivation of workers/reduce morale. If any accident/fatality happen at construction site, it brings extreme negative impacts on the other worker's psychology quickly. Many researchers (Demirkesen & Arditi, 2015; Karakhan & Gambatese, 2017) say that this impact makes worker careless, fearful and anxious, which brings other complex issues like quality, delay, productivity and so on. Demotivate or low-moral is opposite of encourages confidence, discipline, and willingness to perform the job in the best possible manner (Chiang et al., 2017). So the Bangladeshi construction industry as well as global construction industry face suffers more due to this effect of accident. The third highest ranking effect is conflict with workers which is shown in Table 8. When any accident/fatality take place at construction site, it is obvious in Bangladesh that workers get angry on the owner or contractor and come to the road (Evans, 2014). At the same time, they call strike on many issues likes safety, compensation, decrease productivity and so on (Evans, 2014). In many times the conflict goes to the court/litigation process. This issue is highly responsible for schedule delay and loss of productivity in construction (Aires, 2010). Chi et al. (Probst, 2008) pointed out that the construction project which faces accident issue definitely experience cost-overrun due to litigation, conflict and compensation for accident.

From Table 7, the fourth and fifth highest ranking effects are loss of productivity and delay in work progress. Loss of productivity is a key effect of the accident and most of the developing countries are suffering from this effect (Aulin & Ågren, 2012; Beriha et al., 2012; Chong & Low, 2014). The industry which experienced accident at job site must face the degradation of productivity and slow production rate which leads the project behind the schedule (Sun, 2010). It is common to Bangladesh that post-accident project schedule is delayed against the planned schedule (Islam & Suhariadi, 2018). And this a very serious problem for the Bangladeshi construction industry so far. Negative impact on reputation of firms is another high ranking effect of accident in Bangladesh. This effect ruins the future of any reputational construction organization not only Bangladesh but also over the world claimed many researchers (Probst, 2008; Sun, 2010; T. Michael. Toole, 2002). Probst et al. (Probst, 2008) stated that this effect has influence not only the current project but also on the projects in pipeline or even future projects of the organization. Cost of medical bills/expenses is determined as the high ranking effect in Table 7. It is the most common effect in any country and project's budget suffer a lot for this effect. This effect is one of the causes of cost overrun and conflict between stakeholders in construction project (Ahmed; et al., 2018; Swuste, 2012). These high ranking effects of construction accident in Bangladesh have adverse impacts on construction industry directly and indirectly in the monetary and non-monetary ways.

8. Conclusions

This study was designed to assess the perception of construction professionals regarding the key causes and effects of construction accident in the Bangladeshi construction industry. By conducting and analyzing a questionnaire survey, this study identified the key causes and effects of construction accident and prioritize them using RII. The survey was based on causes and effect of accident extracted from findings research of existing literatures, together with socio-economic factors specific to Bangladesh context that were identified through interviews with Bangladeshi construction experts. Cronbach Alpha test was performed to validate the collected data for this study. Because of high rate of construction accident and fatality, the main purpose of this study is identify the causes and effects of accident at construction site in Bangladesh. One part of finding of this study demonstrated that there is significant correlation among accident proneness and workers psychology and health, conflict among stakeholders, compensation and medical cost, quality failure, schedule delay, loss of productivity, reputation and future of firm and many more. It clearly represent the huge monetary and non-monetary loss in direct and indirect ways of construction projects. Other part showed that identified 14 major groups of causes significantly responsible for the large amount of accident in Bangladesh in directly and indirectly.

Among the 77 causes, contractor unaware of safety related issue is ranked in 1st position, lack of personal protective equipment of worker is ranked in 2nd position, lack of safety eliminating/ avoiding design and unfit equipment use in the construction work are 3rd and 4th highest ranking causes of accident in the Bangladeshi construction industry. Lack of knowledge and training on equipment, irregular investigation by consultant, inadequate safety policy adopted by management and lack of expertise, knowledge or training of worker are also in high ranking and very impactful causes. The lowest ranking causes are also determined in this study and these are: financial body (Government or private), lack of protection in material carrying, unused of schedule system, owner's expectations variation, cost overrun reduce the safety cost, and owner's interference on schedule and process. The highest ranking causes for the contractors are lack of personal protective equipment and lack of knowledge and training on equipment. Not-strict operation procedures in contract and lack of safety eliminating/ avoiding are the highest ranking cause for the workers. The highest ranking causes for consultants are unfit equipment and lack of knowledge and contractor unaware of safety related issue, while inadequate safety policy and unfit equipment causes are highest positions for the owners.

This study also prioritize the major groups of causes. The management related causes group is ranked in 1st position and equipment and tools related group is ranked in 2nd position. Other highest ranking major groups are contractor, consultant and labour related groups of causes. The lowest ranking major groups are time and cost, owner and contract related major groups of causes. Management related major group is ranked in 1st for the contractors, workers and consultants while equipment and Tools related major group is ranked in 1st for the owners. The lowest ranking major group is cost & time related major group for the workers and consultants, contract related major group is for the contractors and external related major group is for the owners.

The study represents the 22 effects of accident which are determined by the RII. The high ranking effects are: loss of human lives, demotivation of workers/reduce morale, conflict with workers, loss of productivity of project delay in work progress and negative impact on reputation of firm. Demotivation of workers/reduce morale and delay in work progress is ranked in the 1st for the contractors, while the lowest ranking effect is increase in project cost. Loss of human life is the highest ranking effect for the workers and consultants, meanwhile damages to plant/equipment is the lowest ranking for both groups of respondent. Conflict with workers is ranked in the 1st position for the owners, while the lowest ranking effect is damages to completed work for the Bangladeshi construction industry.

In addition, the study generates the Ishikawa-Fishbone diagram of causes of accident and Effect-flow diagram of effects of accident. Both diagrams make causes and effects of accident easy to understand at a glance.

It is mention above that Bangladesh is a very accident prone country among all the developing countries in the construction sector. A large amount of people die every year for the construction accidents at project site. And

numerous negative effects are raised due to accident at construction site and project participant suffered lots for these in Bangladesh (Ahmed, Islam, et al., 2018). This study could help the potential reader, stakeholders and authorities to know and understand the effects and reasons behind the accident, to understand that what the significance level of impact of each identified cause and effect is. And to understand what the stakeholders is thinking about causes and effects. All of these are necessary to reduce the accident rate and increase the success rate of project by designing an effective safety program considering the causes and effects of accident at construction site in Bangladesh.

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