

Investigation of the Causes of Accident in Construction Projects

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Abstract. Bangladeshi construction industry suffers a lot of safety and accidental issues than other developing countries in the world. Among many of these, accident of construction project go far beyond and shape a horrific figure of death for every year. The aims of this study is that analysis and discussion of causes of accident at construction project in Bangladesh. A widespread statistical data collection and data analysis take place to identify the causes and design the questionnaire. The questionnaire-based survey was used to elicit the attitude of four stakeholders as workers, owners, consultants, and contractors towards passive causes of fatal accident at construction site. This study also identifies 77 passive causes under 14 major groups and ranked them based on Relative Importance Index (RII). The top 5 major group of causes are (1) Management related, (2) Consultant related, (3) Technology related, (4) Labour related and (5) Contractor related. The top 5 passive causes are: (1) Unaware of safety-related issue, (2) Lack of personal protective equipment, (3) Lack of safety eliminating/ avoiding design, (4) Unfit equipment, (5) Lack of knowledge and training on equipment.

Keywords: Accident; Construction Project; Causes; Bangladesh; RII Based Rank

1. Introduction

Construction industry is one of the most hazardous industries in the universe because of its unique nature. The construction projects are experiencing so many risks, uncertainties, complexities due to frequently happened accident in construction project (Sousa, Almeida, & Dias, 2014). Most of the developed countries trying to reduce the horrific damage and losses from construction accident by preventing, eliminate and bypass the possible accident in construction projects. But the developing countries are the extreme victim of construction accident because they have no strict regulation on construction safety and

authorities and employee both don't aware of construction safety issue. (Biswas, Bhattacharya, & Bhattacharya, 2017). Bangladesh has one of the most accident-prone construction industry among all the developing countries of the world. Bangladeshi construction industry experience more death, injury, physical damage of properties, risks and complexity than other countries in the world due to the horrific figure of occurring accident and it's fatality rate (Islam, Razwanul, & Mahmud, 2017).

Every year, an average of 150 persons died and thousands of getting injured due to the accident in construction project in Bangladesh (Ahmed, Sobuz, & Haque, 2018). In 2017, Bangladeshi construction industry face about 179 person died due to accident and in 2016 and 2015 the figure of death is 145 and 172 persons (Ahemd & Bashar, 2018). Just in 2017, in Bangladesh construction accident take life 15 time's 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 how the vulnerable level of safety exist and practice in Bangladeshi construction project. High officials from OSHE Bangladesh said "accident in construction project is the topmost serious issue for Bangladeshi construction. It is considered as the main barrier of innovation and development of construction industry in Bangladesh. It brings so many complexities in many ways. It is bad, it is really bad for Bangladeshi construction industry". Construction accidents 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 have various 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 (Leung, Liang, & Olomolaiye, 2015). It shows a clear picture that the Bangladeshi industry is not going with the good condition due to many issues but the prime one is accident in construction projects. Experts said that in Bangladesh there are 80% construction project experience injuries and death from accidents. The consequences of this accidents go far beyond the particular construction project.

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 construction industry and they have shown success in various ways to reduce or even eliminate accident in construction projects. Bangladesh has to work with this issue seriously to reduce the accident rate and improve the construction industry with modern technologies and strategies. 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 were applied at the sites and the employees were trained and made aware of the safety hazards present in the particular site (Zhang, Teaser, Lee, Eastman, & Venugopal, 2013). A comprehensive safety program has to be designed to prevent and control accident at construction project based on the cause which responsible for the accident. If the real scenario of 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 in Bangladesh. To assist the authority and to improve the accident scenario, the main purpose of this study is to investigate, identify and analyze the causes of accident in construction project in Bangladesh. This study may help the authorities and project executives to know and understand about the causes of accident in construction project in Bangladesh. It will also offer some suggestions which can play a vital role to decrease the accident rate and assist the stakeholders to complete construction project successfully with current flow.

2. Background Study

Construction industry has encountered the highest number of fatal accidents among all other industries in the world (Albert & Hallowell, 2012). Thus, studying the causes of accident in construction projects has gained increasing importance to researchers in the recent years although there is no research conducted before on the topic for 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 (Cheng & 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 cause of accidents was 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, proper attention from the authority to safety issue and lack of safety awareness. In Malaysia, Abdul Rahim Abdul Hamid (Hamid,

Majid, & Singh, 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, unique nature of industry, unsafe method, management, poor safety policies, personal protective equipment (PPE), work at high elevation, poor site management and equipment failure. Priyadarshani et al. (Priyadarshani, Karunasena, & Jayasuriya, 2013) developed a safety assessment framework for construction industry in Sri Lanka. According to their study, lack of commitment of management, lack of safety measure, negligence of individuals to respond to proper safety practices and unskilled worker were 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 United Arab Emirates (Al-Kaabi & Hadipriono, 2003). Uduakobonge et al. (Uduakobonge E. Udo, 2016) revealed the major causes of construction accident in Nigeria and these are lack of safety measure while handling materials/objects and lifting materials/objects, slips, trip on object, operating damaged equipment, struck by moving objects, struck by moving machine/equipment, caving in of excavations and fall from height. Haslam et al. (Haslam, 2005) illustrate that accidents occur as a result of the poor interaction between workers or work-team (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) conduct a comprehensive literature review to analyze the causes of construction accident and pointed out as the most influencing factors are 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.

3. Methodology

Mixed method enriches the validity and reliability of the results of a study and the comprehension of the studied phenomenon while enabling new dimensions to the study to emerge. The mixed research approach was used in this study considering the nature of the research problem. This study conducted through a comprehensive literature review and expert opinion to identify the causes and design the questionnaire and a comprehensive questionnaire survey to rank the causes.

3.1. Questionnaire Design

To identify the causes of construction accident in Bangladesh a deep and broad literature review is conducted for sorting out a rough factors list. After that an open discussion was happened 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) to identify the causes which are reasonable for the aspect of Bangladeshi construction industry. A total of 71 causes are identified under 14 major groups for the construction accident in Bangladesh. The 14 major groups of causes are (1) Project related, (2) Site Condition related, (3) Contract related, (4) Design related, (5) Material related, (6) Cost & Time related, (7) Consultant related, (8) Contractor related, (9) Labour related , (10) Owner related, (11) Equipment and Tools related, (12) Management related, (13) Technology related, and (14) External related.

A questionnaire survey was used to elicit the attitude of owners, consultants, labours and contractors towards the factors influencing the accidents in construction projects in Bangladesh. The questionnaire was designed with two major part. Part I is about the background information of the respondents. And in part II the respondents were asked to evaluate, based on their local experience the level of importance of each one of the identified 71 factors under 14 major groups that influence the accident on a seven-point Likert Scale as: (1) strongly disagree, (2) disagree, (3) moderately disagree, (4) neutral, (5) moderately agree, (6) agree and (7) strongly agree.

3.2. Data Collection

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. 147 questionnaires were distributed as follows: 44 to workers, 27 to owners, 41 to consultants and 35 to contractors. 108 questionnaires (73.5%) were returned as follows: 32 from workers, 23 from owners, 28 from consultants, and 25 from contractors as respondents.

3.3. Data Analysis

The Relative Important Index (RII) is used for the determination of the rank between the 71 causes. The relative importance index method (RII) is indicate herein to determine owners, consultants, labours and contractors perceptions of the relative importance of the identified influencing factors. An equation express below is used to determine the value of RII for each factor. 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 7), ‘A’ is the highest weight (i.e. 7 in this case), and ‘N’ is the total number of respondents in this study (i.e. 108 in this study).

4. Results and Discussion

In this study there 77 causes under 14 major causes are identified. A huge amount of fatal accident at construction site take place in Bangladesh. And a tremendous amount of people died in the accident in construction projects in Bangladesh. In Bangladesh, behind the huge amount of accident, these 77 causes are responsible directly and indirectly in any ways at all. But which one is the highest contributor than others and what is the level of contribution than others to influencing accident in construction project? This question is answered by the RII of each cause and the RII based rank. The seventy-seven (77) causes of fatal accident at construction site are not as same as for all respondent groups. The different respondent group expressed different type of attitude toward the causes. So their giving rank for the causes of accident are not same. For revealing the actual scenario of accident to various stakeholders of construction project it is essential to know the opinion of all groups of respondents toward each cause of accident. Table 1 shows the Summary of RII and RII based rank of each causes for four (4) respondent group worker, contractor, owner and consultant.

Table 1. Summary of RII and rank of causes of accident in construction project

Major Group	Causes of Accident	RII	Rank (overall)	Rank (among the group)
(1) Project related	Value of project	0.581	43	3
	Poor Planning/ scheduling of project	0.567	48	4
	Very tight project schedule	0.606	26	2
	Type and nature of project	0.625	19	1
	Social and communal involvement of project	0.508	71	5
	Financial body (Government or private)	0.456	77	6

(2) Site Condition related	Project site conditions (exclude equipment, materials, weather)	0.567	49	3
	Project site layout/space	0.565	51	4
	Project working environment (light/noise/hot/cold/wet)	0.594	33	2
	Poor housekeeping	0.609	23	1
(3) Contract related	Not-strict operation procedures in contract	0.644	12	1
	Coordination between project participants	0.534	70	5
	Lack of Management commitment in contract	0.557	54	3
	Type of awarding contract	0.543	66	4
	Unclear contract conditions on safety issue	0.585	40	2
(4) Design related	Design is not constructible	0.548	61	3
	Incomplete and inconsistency of design document	0.545	65	4
	Safety is not consider when design	0.632	17	2
	Lack of safety eliminating/ avoiding design	0.669	3	1
(5) Material related	Lack of protection in material carrying	0.479	76	5
	Lack of protection in material storage	0.633	15	1
	Working with toxic/ hazardous materials	0.558	53	3
	Hazard during transportation	0.603	28	2
	Lack of knowledge about construction materials	0.556	55	4
(6) Cost & Time related	Cost overrun reduce the safety cost	0.494	73	3
	Schedule delays and rework in project	0.547	62	2
	Short time assign to worker	0.596	31	1
(7) Consultant related	Lack of Management/ leadership skills	0.595	32	3
	Lack of knowledge and experience	0.540	68	6
	Unaware of construction safety	0.645	11	2
	irregular investigation	0.659	6	1
	Flexible to contractor/worker on safety issue	0.551	60	5
	No interest to change the safety culture	0.593	34	4
(8) Contractor related	Inaccurate or incomplete schedule	0.579	44	4
	Unaware of safety related issue	0.686	1	1
	Unwilling to spend safety related cost	0.642	13	2
	Lack of skill and experience of site staff	0.536	69	6
	Violating BNBC code/ Bangladesh labour law	0.589	38	3
	Reckless action of contractor	0.574	46	5
(9)	Lack of collaboration among labours	0.583	41	6

	Lack of personal protective equipment	0.674	2	1
	Unskilled labours	0.652	10	3
	Worker empowerment to make decision	0.560	52	7
	Poor of education of labourers	0.555	56	8
	Lack of Expertise, knowledge or training	0.657	8	2
	Interference with others role	0.543	67	9
	Over time for labours	0.605	27	5
	Behaviour of worker	0.610	22	4
(10)Owner relate	Unwilling to pay extra cost for safety	0.655	9	1
	Owner's interference on schedule and process	0.500	72	4
	Owner's expectations variation	0.483	74	5
	Lack of owner's emphasis on safety	0.546	64	3
	owner's late response (decision making)	0.546	63	2
(10) Equipment and Tools related				1
	Unfit equipment	0.666	4	3
	Poor equipment maintenance	0.632	16	6
	Unused of modern equipment	0.607	24	5
	High cost of advanced equipment and tools	0.623	20	4
	Improper use of equipment	0.630	18	2
	Lack of knowledge and training on equipment	0.665	5	1
(11) Management related	Lack of effective Project supervision	0.607	25	2
	Lack of effective Communication	0.588	39	6
	Inadequate safety policy	0.658	7	1
	Improper auditing system	0.591	36	5
	Poor Organization structure	0.582	42	7
	Lack of information flow	0.591	35	4
	Lack of technique guide	0.553	58	8
	Lack of teamwork	0.598	30	3
(13) Technology related	Unused of safety control system	0.636	14	1
	Unused of schedule system	0.481	75	6
	Unaware to advanced technology for safety	0.568	47	4
	Lack of implementation of BIM	0.612	21	2
	Lack of innovation technology	0.575	45	3
	Lack of implement safety control sensor technology	0.551	59	5
(14) External related	Act of God	0.555	57	4
	External obstacle/ barrier	0.566	50	3
	Nature of construction	0.590	37	2

	Bad weather	0.601	29	1
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4.1. High Ranked Causes

There are some causes are identified in this study which is very influencing to occurring accident at construction project in Bangladesh. And these accident bring out a huge amount death for each year. In Table 3 top twenty (20) high ranked causes from different major group of causes are shown based on their RII value for all groups.

Table 2. Summary of top high ranked causes of accident for all groups

Passive 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

Table 2 indicates the top most crucial cause of construction fatal accident in Bangladesh is contractor unaware of safety related issue (RII=0.686). The second highest cause is lack of personal protective equipment of worker (RII=0.674). Third and fourth highest ranked causes are lack of safety eliminating/ avoiding design (RII=0.669) and unfit equipment use in the construction work (RII=0.666). The fifth, sixth and seventh top ranked causes are lack of knowledge and training on equipment (RII=0.665), irregular investigation by consultant (RII=0.659) and inadequate safety policy adopted by management (RII=0.658). Another top ten (10) causes are lack of expertise, knowledge or training of worker (RII=0.657), owner unwilling to pay extra cost for safety (RII=0.655) and Unskilled labour (RII=0.652).

Consultant unaware of construction safety (RII=0.645), not-strict operation procedures in contract (RII=0.644), contractor unwilling to spend safety related cost (RII=0.642), unused of safety control Technology (RII=0.636) and lack of protection in material storage causes (RII=0.652) are also within the top fifteen

(15) cause of fatal accident at construction site in Bangladesh.

4.2. Low Ranked Causes

Among the initially identified 77 causes of accidents, some are determined as a very low contributor for the influencing accident on construction project in Bangladesh. These very low ranked causes have scattered in table 2 but Table 4 shows the low ranked causes as ascending order with their respective major group of causes according to Relative Important Index (RII).

Table 3. Summary of top low ranked causes of accident on construction project

Causes	Major group	RII	Rank
Financial body (WB, ADP, Government or private)	Project	0.456	77
Lack of protection in material carrying	Material	0.479	76
Unused of schedule system	Technology	0.481	75
Owner's expectations variation	Owner	0.483	74
Cost overrun reduce the safety cost	Cost & Time	0.494	73
Owner's interference on schedule and process	Owner	0.500	72
Social and communal involvement of project	Project	0.508	71
Coordination between project participants	Contract	0.534	70
Lack of skill and experience of site staff	Contractor	0.536	69
Lack of knowledge and experience	Consultant	0.540	68

Table 3 indicates the topmost low ranked, 77th factors of construction accident in Bangladesh is financial bodies decision and attitude (WB, ADP, Government or private) with the RII=0.456. The second lowest, 76th cause is lack of protection in material carrying (RII=0.479). Third and fourth lowest ranked causes are unused of schedule system (RII=0.481) and owner's expectations variation (RII=0.483). The fifth, sixth and seventh lowest ranked causes mean 73th, 72th and 71th causes are cost overrun reduce the safety cost (RII=0.494), owner's interference on schedule and process (RII=0.500) and social and communal involvement of project (RII=0.508). Rest of the top ten (10) means 70th, 69th and 68th causes are coordination between project participants (RII=0.534), lack of skill and experience of site staff (RII=0.536) and lack of knowledge and experience of consultant (RII=0.540).

4.3. High Ranked Causes for All Respondent Groups

As the respondent groups show the different attitude toward the causes of accident. So, the rank for the causes of fatal accident at construction site in Bangladesh are

not same for each respondent groups, Table 4 and Table 5 shows the high ranked causes for each respondents groups. Table 4 represents the high ranked causes for the respondent groups of the worker and contractor and Table 5 represents the high ranked causes for the respondent groups of the consultant and owner.

Table 4. Summary of high ranked causes for Worker and Contractor groups

Rank	Worker group		Contractor group	
	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	Equipment and Tools
3	No interest to change the safety culture	Consultant	Violating BNBC code/ Bangladesh 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

From Table 4, it is shown that the highest ranked causes for worker group are not-strict operation procedures in the contract. Lack of safety eliminating/ avoiding design, no interest to change the safety culture, unskilled labours, and unwilling to spend safety related cost are also in the top five causes for the worker respondent group. The contractor group determines that, lack of personal protective equipment of labor is the topmost crucial causes of influencing fatal accident at construction site. The other most important contributor of influencing accident for the contractor group is lack of knowledge and training on equipment, violating BNBC code/ Bangladesh labour law, inadequate safety policy, unwilling to pay extra cost for safety and unfit equipment.

Table 5. Summary of high ranked causes for Owner and Consultant groups

Owner group	Consultant group
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Ran k	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

From the Table 5, inadequate safety management policy is the highest ranked causes for the owner group. Unfit equipment, lack of teamwork, not-strict operation procedures in contract, unaware of safety related issue, and lack of personal protective equipment are also considered as a great contributor for occurring fatal accident at construction site based on the owner aspect. The top most critical cause for consultant group is unfit equipment. The consultant group is also point out that unaware of safety related issue, lack of knowledge and training on equipment, improper auditing system, and safety is not considered when design is highly responsible for influencing fatal accident at construction site in Bangladesh.

From the analysis of both table it is figured out that not-strict operation procedures in contract, lack of safety eliminating/ avoiding design, no interest to change the safety culture, unskilled labors, unwilling to spend safety related cost, irregular investigation, lack of expertise- knowledge or training, unfit equipment, inadequate safety policy, ineffective audit and supervision system, and unaware of safety related issue are the most crucial causes for all respondent groups.

4.4. Ranked of Major Groups of Causes

Yet above, it is only discussed and analysis of seventy-seven (77) causes but not the major groups of causes of fatal accident at construction site in Bangladesh. In this section, the major fourteen (14) groups are analyzed by the RII and RII based rank. In this section of study table 6.1 is discussed for the rank of major groups of causes.

From Table 6 it is revealed that management related causes group is ranked the highest position among all group. So the contribution of this group of influencing accident is more than other groups. The second and third highest ranked groups are consultant related and technology related. This two groups of causes also highly responsible for frequent fatal accident in Bangladeshi construction industry. The lowest ranked group is contract related and the second lowest is cost & time related causes. Contractor, labor and equipment related factors are also very intensive for influencing fatal accident at construction site in Bangladesh.

Table 6. Summary of RII based rank of major groups of passive causes for each groups of respondents

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

Table 6 shows the RII based rank of major groups of causes according to the feedback of different respondent groups toward the major groups of causes. It shows that equipment and tools related group is hold the highest rank for the contractor, labor and consultant groups. But the owner group is thought that the highest contributing major group is labor related causes. And the second highest contributor group is management related causes for contractor group, contractor related causes for worker group, consultant related causes for owner group, and labour related causes for consultant group. Material, technology and site

condition related causes also high ranked for all respondent groups.

The lowest ranked groups of causes for contractor is contract related causes, for labor is cost & time related causes, for owner is external related causes and for consultant is cost & time related causes. These are also important for influencing accident but not as much as the high ranked groups of causes.

4.5. Analysis of Major Group Causes of Accident

Previously identified seventy seven (77) causes are grouped into fourteen (14) major group. In a group, all the causes are not considered as the same priority for contributing to occurring accidents on construction site. So in this section, it is discussed about the causes and compared them with others causes of same group.

4.5.1. Project related causes

The project related group consist of six (6) causes which are influenced construction accident in Bangladeshi construction project. The relative importance index (RII) and rank of project related causes are summarized in Table 2.

From Table 2 it is shown that the type and nature of project is the highest ranked cause among project related causes. It is also listed as top twenty crucial causes of accident in construction project. The second highest ranked cause is very tight project schedule. Most of the respondents considered it as very important causes among the project related causes. And the lowest ranked cause is financial bodies profile (WB, ADP, Government or private). The financial bodies have influence on regulation and work procedure topic but not as much as important than other causes of this major group. Other causes of this group are shown in Table 7 with their RII and rank.

4.5.2. Site condition related causes

Site related causes group contain four (4) important causes that responsible for accident in construction project. The relative importance index (RII) and rank of Site condition related causes are summarized and shown in Table 2.

Site related causes are evaluated by the respondent of this study is not so much crucial than other major groups of causes. Among them poor housekeeping is hold the highest position. Respondents thought poor housekeeping and project working environment (light/noise/hot/cold/wet) are mostly important from this group. Project working environment is determined as the second highest ranked and project site conditions (exclude equipment, materials, weather) is determined as the third most important cause among this major group. Project site layout/space is hold the lowest ranked in the group.

4.5.3. Contract related causes

This group is form with five (5) causes of accident in construction project. This five causes relative important index (RII) and ranked are summarized in Table 2.

Table 2 shows the highest ranked cause of this group is not-strict operation procedures in contract. This cause is determined as the most crucial one which is highly responsible for accident in construction project. The second highest is unclear contract conditions on safety issue. Lack of Management commitment in contract and Type of awarding contract are stand for the third and fourth position based on contribution to occurring accident. Coordination between project participants is the lowest ranked cause determined for this major group of causes.

4.5.4. Design related causes

The design related major group is consist of four (4) accident influencing factors in Bangladeshi construction project. Table 2 shows the summary of RII and rank of this major group.

From Table 2 it is clear that among all the causes of the group, lack of safety eliminating/ avoiding design is hold the highest rank for the greatest contribution to occurring accident. It is also determined as 3rd highest ranked cause among 77 other causes based on overall evaluation of respondents. Safety is not consider when design is hold the second highest rank for noticeable contribution to occurring accident. This cause individually ranked stand 17th rank among 77 causes. The 3rd rank cause for this group is design is not constructible. The lowest ranked cause for this group is incomplete and inconsistency of design document which have small influence on accident in construction project.

4.5.5. Material related causes

This group is consist of five (5) important causes of accident in construction project in Bangladesh. Table 2 shows the RII based rank among the causes of material related causes group.

Lack of protection in material storage is determined as the highest ranked cause based on respondent's evaluation for this major group. This cause is in the top 20 crucial causes among 77 causes which are mostly responsible for accident. Hazard during transportation and working with toxic/ hazardous materials are stood for 2nd and 3rd highest rank for their impotency of influencing. Lack of knowledge about construction materials is the 4th important cause of accident. And the lowest ranked causes in this major group is lack of protection in material carrying.

4.5.6. Cost and time related causes

The major group of cost and time related causes have three cause of accident in

Bangladeshi construction project. Table 2 shows the summary of Relative Importance Index (RII) and RII based rank for all causes of this major group.

Short time assign to worker is determined as the highest contributor among this group to occurring accident in construction project. Schedule delays and rework in project is stood for 2nd highest rank in this group. And the lowest ranked cause is cost overrun reduce the safety cost. All the causes of this major group is low ranked respect to overall ranking among 77 causes.

4.5.7. Consultant related causes

Consultant related group is consist of six (6) weighted causes of accident in Bangladeshi construction project. In table 2, the summary of RII and RII based rank of the causes under this major group.

Table 2 indicates the highest ranked cause among the group is irregular investigation. This causes is absolutely very important for accident and it is stood 6th position among the other 77 overall causes according to the respondents rating. The 2nd and 3rd highest ranked cause in this group are unaware of construction safety and lack of management/ leadership skills. No interest to change the safety culture and flexible to contractor/worker on safety issue are also play an important role on the topic of accident in construction project in Bangladesh. And the lowest ranked cause is lack of knowledge and experience.

4.5.8. Contractor related causes

This major group is formed with the six (6) intensive causes of accident in construction project. All the causes of this group are summarized in the Table 2 with RII and RII based rank.

Table 2 reveals the highest ranked (1st) cause among the group is unaware of safety related issue. This cause is determined the highest contributor to occurring accident in construction project among all other 77 causes. It is also the primary cause of safety hazards and accident around the world. The 2nd highest ranked cause is unwilling to spend safety related cost and it is stood 13th rank among 77causes based on the respondents rating. Violating BNBC code/ Bangladesh labour law and inaccurate or incomplete schedule are also ranked 4th and 5th in this group. The lowest (6th) contributor of this group is lack of skill and experience of site staff and second lowest ranked (5th) cause is Reckless action of contractor for contractor related major group.

4.5.9. Labor related causes

The labor related causes group is remain nine (9) furious causes of accident in construction project in Bangladesh.

Table 2 indicates that the 1st ranked cause in this group is lack of personal protective equipment. It is also determined as the 2nd highest contributor to the occurring accident among other 77 causes. The second and third highest important causes in this major group are lack of expertise, knowledge or training and unskilled worker. Lack of expertise, knowledge or training is also obtained the 8th rank and unskilled worker is stood for 10th rank among overall 77 causes of accident. The 4th, 5th, 6th and 7th rank causes among this group are behavior of worker, over time for labours, lack of collaboration among labours and worker empowerment to make decision. The second lowest (8th) ranked cause is poor of education of labours and the lowest (9th) ranked is interference with others role. It is clear from the respondent's perspective that this major group is very much responsible for the accident in construction project in Bangladesh.

4.5.10. Owner related causes

This major group is consist of five (5) important causes of accident in construction project in Bangladesh. Table 2 shows the Summary of this group with RII and rank of each cause based on respondent's evaluation.

The most contribution is determined from the group is unwilling to pay extra cost for safety. This cause is also stood for the 9th rank position among all 77 causes. The second highest contributor in this group is owner's late response (decision making). The 3rd and 4th ranked causes are lack of owner's emphasis on safety and owner's interference on schedule and process among the owner related major group of causes. The lowest ranked (5th) contributor is owner's expectations variation in this group.

4.5.11. Equipment and Tools related causes

This major group is consist of six (6) crucial causes of accidents on construction project in Bangladesh. Table 2 shows summary of this group with RII and RII based rank.

From the above table the highest ranked cause in this group is unfit equipment. The second highest ranked cause is lack of knowledge and training on equipment. This two are individually stood for the 4th and 5th rank position among all over 77 causes of accident. Poor equipment maintenance and improper use of equipment are two important causes in this group that have great influence on occurring accident. And the lowest ranked (6th) and second lowest (5th) cause is unused of modern equipment and high cost of advanced equipment and tools for this major group. This major group is very high ranked among other major group. So it is important to take a serious look after this group of causes.

4.5.12. Management related causes

Management related major group is formed with eight (8) causes of accident in construction project in Bangladesh. Table 2 shows the RII and rank of causes under this major group.

The highest ranked (1st) cause in the group is inadequate safety policy and the second highest ranked (2nd) is lack of effective project supervision. The 3rd and 4th ranked causes in among this group are lack of teamwork and lack of information flow. They are also accused greatly for influencing accident. Other important causes in this group are by ranked improper auditing system (5th), lack of effective communication (6th) and poor organization structure (7th). And the lowest ranked (8th) cause in this major is lack of technique guide. This major group is one of the most responsible group of influencing accident in construction project in Bangladesh.

4.5.13. Technology related causes

The technology related major group of causes is consist of six (6) vital causes. Table 2 shows the summary of this major group of causes with RII and their relative rank.

Table 2 indicates that the highest ranked (1st) cause in this group is unused of safety control system for this major group. Lack of implementation of BIM and lack of innovation technology are stood for the 2nd and 3rd position based on RII rank among the causes of this group. Unaware to advanced technology for safety (4th) and lack of implement safety control sensor technology (5th) are also important in this major group. And the lowest ranked (6th) cause for this group is unused of schedule system.

4.5.14. External related causes

External related major group of causes is formed with four (4) intensive factors that influencing the accident in construction project in Bangladesh. Table 2 shows the summary of the RII and RII based rank of the causes of this major group.

The highest ranked (1st) cause is bad weather and the second highest ranked (2nd) cause is nature of the construction for the external related major group of causes. The lowest ranked (4th) cause is act of God and second lowest (3rd) cause is external obstacle/ barrier. This group is not very much responsible but responsible for occurring accident in construction project.

5. Conclusion

A statistical data analysis based method is used for the design of the questionnaire for this study. The questionnaire-based survey was used to elicit the attitude of

workers, owners, consultants, and contractors towards causes of accident in construction project in Bangladesh. 147 questionnaires were distributed as follows: 44 to workers, 27 to owners, 41 to consultants and 35 to contractors. 108 questionnaires (73.5%) were returned as follows: 32 from workers, 23 from owners, 28 from consultants, and 25 from contractors as respondents. The respondents were asked to evaluate the level of significant of each of the 77 causes of accident in construction project in Bangladesh according to seven point Likert Scale.

For the analysis of causes of accident in construction project in Bangladesh, a questionnaire was designed with 77 causes under 14 major groups of causes. These 14 major groups are (1) Project related, (2) Site Condition related, (3) Contract related, (4) Design related, (5) Material related, (6) Cost & Time related, (7) Consultant related, (8) Contractor related, (9) Labour related , (10) Owner related, (11) Equipment and Tools related, (12) Management related, (13) Technology related, and (14) External related causes. Among the 77 causes, contractor unaware of safety related issue is placed highest rank, lack of personal protective equipment of worker is placed second highest, lack of safety eliminating/ avoiding design and unfit equipment use in the construction work are third and fourth highest rank causes for all groups of respondents. 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 high ranked and very impactful causes.

The study represents that the highest ranked causes for worker group is not-strict operation procedures in contract, for contractor group is lack of personal protective equipment of labour, for owner group is inadequate safety management policy and for consultant group is unfit equipment. The second highest ranked causes for worker is lack of safety eliminating/ avoiding design, for contractor group is lack of knowledge and training on equipment, for owner group is unfit equipment and for consultant group is unaware of safety related issue. It is also revealed that not-strict operation procedures in contract, lack of safety eliminating/ avoiding design, no interest to change the safety culture, unskilled labors, unwilling to spend safety related cost, irregular investigation, lack of expertise, knowledge or training, unfit equipment, inadequate safety policy, ineffective audit and supervision system and unaware of safety related issue are the most crucial for each group of respondents of accident in construction project.

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