SAFETY & CODE OF PRACTICE
IN CONSTRUCTION

Assessing the Impact of Installation and Dismantling of Tower Cranes on Construction Site Safety.

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ABSTRACT
The construction industry plays a central and significant role in the economy of any nation. One of the major reasons for ineffective project delivery in the Nigerian construction industry is the improper assessment of risk factors. Installation and dismantling of tower crane had been previously looked at as a general safety issue along with other factors affecting safety during tower crane usage until, recent research showed that about 69% of accidents related to tower cranes in Korea from 2001-2011, occur during installation and dismantling process. In view of this, this paper aimed at assessing impact of installation and dismantling of tower cranes on safely by determining the degree of impact with a view to establishing the most significant ones. This is why a well-structured questionnaire is designed to collect data with respect to the degree of impact using a 5 point Likert scale. Responses from the administered questionnaire and interactions was collated, interpreted and analysed by using descriptive statistics (mean) and results presented in tables. Results showed that fracture of a wire rope during dismantling had the highest degree of impact with a mean value of 4.63, workers (erectors, dismantlers) arc leaving the work often due to hard working condition had the lowest degree of impact with a mean value of 2.34. The research concluded that fracture of a wire rope during dismantling is a high risk factor affecting construction site safety during installation and dismantling of tower cranes. Adoption of a preventive maintenance strategy or routine check on the tower crane parts and components could help reduce the possibility of accidents occurrence on site and therefore improve safety.

Keywords: Accident, Hazard, Safety risk, Tower crane, Probability, Construction industry.

1.0 INTRODUCTION

Tower cranes are used on construction sites as lifting equipment for their combination of height and lifting capacity. Tower crane accidents, however, are likely to be fatal because of the weight of the objects and the heights to which they are lifted (Beavers, Moore, Rinehart and Schriver, 2006). U.S. Labour statistics recorded 632 crane-related construction worker deaths from 611 crane incidents and 17 multiple death incidents resulting in 38 deaths from 1992 to 2006 (Bureau of Labour Statistics, 2008). A crane safety analysis and recommendation report carried out in Singapore by Annex (2009) indicates that in 2008, there were 162 crane-related fatalities, injuries and dangerous occurrences, a 27% increase from 128 cases in 2007. While most of the cases involve less serious non-fatal injuries, crane accidents can ultimately result to huge and severe damage to physical properties and human lives.

Orji, Enebe and Onoh (2016) posit that construction processes in Nigeria are characterized by unsafe practices leading to accident that leaves severe consequences on both the project and the workers. Accidents in building construction sites, whether minor or fatal could result to injuries, loss of resources, partial or permanent disability and death in case of fatalities. In the analysis of types of accident that usually occur in construction sites, injury from the use of equipment ranked first among nine (9) other types of accident examined. Accidents frequently occur on building construction sites, these accidents could be in the form of workers falling from heights, excavation accidents, the risk of falling debris or equipment's etc. Researches have shown that accidents and injuries in developing countries are generally

high when compared to other European countries (Idoro, 2008).

Effective safety management is to keep the environment safe, make the job safe and to make workers to become safety conscious. In recent years, many developed countries have considered safety as one of the important management issues of construction projects, especially, personal safety (Chen *et al.*, 2011). Ali and Muhamad (2016) opines that without proper safety management of construction machines at construction sites, accidents could happen. Cranes are the machines that contribute to highest fatality rate in construction industry. He concludes that cranes are machines with high risk and should be operated with safety management and strong communication between crane operator and signalman.

The consequences of building construction accidents are enormous and cannot be easily quantified, though inevitable but could be controlled to prevent minor or serious consequences to safety of workers (orji *et al.*, 2016).
Idoro (2011) asserted that although there is no reliable construction accident/incident data in Nigeria. However, a study of 40 contractors in 2006 revealed that accident and injury rates were high in the Nigerian construction industry and the best safety ratios were 2 accidents per 100 workers and 5 injuries per 100 workers.

Erection/climbing/dismantling of tower cranes is a potentially hazardous process involving working at heights, awkward postures, lifting and aligning components of significant size and mass and installing temporary support systems. These activities listed above are all often performed under significant time pressure which could be due to the need for road closures, suitable daylight hours or short weather windows as the case maybe (Safework, 2016).

The most dangerous process that can lead to fatalities at construction sites is the installation/dismantling of tower cranes; for instance, in 2012, the collapse of a tower crane during dismantling at the University of Texas, USA claimed the lives of two workers (OSHA, 2012). There have been five fatal accidents relating to tower crane use during 2002–2006 in Hong Kong, with three workers being killed in July 2007 alone. One such accident in July 2007 caused two fatalities and five serious injuries. The accident happened during the dismantling process, with workers on the tower crane as it was climbing down (Ting, 2007). Also in a related development, out of the 571 incident cases of crane related accidents that happened from 2000 – 2009 in the U.S as examined by Zhao (2011), 41 cases which amounted to 7.18% occurred during assembly/disassembly. He further stated that 22 cases (23.40%) of the 94 cases that occurred from 2007-2009 resulted directly from the operations of assembly/disassembly. More recently, an investigation of tower crane accidents that occurred in Korea from 2001-2011, it was reported that out of the 38 fatal accident cases involving tower cranes, 68.4% of the accidents resulted from the installation/dismantling operation (Shin, 2015).

Chi, Sangwon, Dae and Yoonjung (2015) opines that, risk identification and cautioning can improve the safety of workplaces. By organizing high recurrence risk factors to possibly control accident occurrences can deal with the probability of fatal injuries on construction sites when an accident is unavoidable. Doing this enables safety managers to comprehend the nature of construction accidents and plan for key risk mitigation.

However, Jannadi and Almishari (2003) having concerted to the fact that assessment of risk is crucial for improving safety, they went ahead to say that precise evaluation is not really necessary and that an estimated predicted level of risks will suffice for the safety managers to take necessary actions.
Factors that affect construction site safety due to the work of tower cranes have attracted only moderate attention; they are commonly addressed indirectly and partially within the broader treatment of site safety or of crane work in general (Nunnally, 2000). Literature addressing crane safety that explicitly suggests tower crane related risk factors or safety hazards is limited (Shapira and Lyachin, 2009). Hence

the need to critically examine safety issues regarding the installation/dismantling operation of tower cranes.

The objective of this research is to identify safety risk factors during installation and dismantling of tower cranes and determine their degree of impact on safety.

Safety risk factors during the operation of tower cranes were not considered for this study, only those associated with the process of installation and dismantling of tower cranes were considered.

2.0 Safety Risk Factors during Installation and Dismantling of Tower Cranes

Not much has been done by researchers to clearly identify various factors affecting safety during installation and dismantling operation of tower cranes especially in Nigeria where construction site safety is very poor and accidents on construction sites are rarely reported nor documented for use as contractors are simply concerned with making maximum profit (Odeyinka and Dada, 2016). However, according to OSHB (2012) accidents may occur during crane erection, dismantling and height alteration operations due to failure to follow the correct procedures specified by the crane manufacturers, use of incorrect parts, the wrong size or type of bolt, the incorrect assembly or sequence of assembly, or taking apart of components. Shin (2015) also identified some risk factors affecting safety during installation and dismantling process in construction sites to include insufficient numbers of workers to perform the work correctly and safely, trying to finish the work earlier than the time required for safe work, frequently omitting required safety procedures or rules for various reasons and lack of worker competence. More recently, is the study by Salihu *et al.* (2018) were they reviewed all risk factors associated with tower crane installation and dismantling process and came up with a list of safety risk factors as shown in Table 1.

Table 1: Safety risk factors

S/No.	Safety risk factors during installation and dismantling
1	Insufficient number of workers to perform the work correctly and safely.
2	Workers (erector, dismantler) are leaving the work often due to hard working condition.
3	Time constraints requested from employer/principal contractor.
4	Trying to finish the work earlier than the time required for safe work.
5	Frequently omitting required safety procedures or rules for various reasons.
6	Lack of workers competence.
7	Instruction and supervision at construction sites are insufficient.
8	Contractors do not recognize the need to ensure the safety tower crane installation/dismantling.
9	Unreasonable sites condition (working space, ground conditions and restrictions).
10	Deterioration of tower cranes part (components).
11	Workers attitude (installation/dismantling workers).
12	Overloading with objects exceeding the tower crane load limit.
13	Inexperienced tower crane operators.
14	Not following work procedures in manuals for the installation/climbing/dismantling of tower cranes.
15	Malfunction of a tower crane.
16	Buckling of a telescopic cage.
17	Fracture of a wire rope during dismantling.
18	Failure of working platforms.
19	Incompatibility of components.
20	Falling items.
21	Abrasion (wear and tear of components such as bolts, nuts, or pins.

Salihu *et al.* (2018)

3.0 RESEARCH METHODOLOGY

The study looks at impact of risk factors associated with installation and dismantling of tower cran with respect to determining their degree of impact on construction site safety. This requires eliciti knowledge from practitioners who are directly involved in the process such as safety managers, equipme managers and team leaders among the installation and dismantling worker hence, questionnaire surv was adopted. Population size therefore for the research is unknown as no data is available on exa number of these practitioners. The sample size was determined from a table developed by Louangra (2014) that the minimum sample size for an unknown population for 95% confidence interval wi 5% error level is approximately 34. A total of 57 questionnaires reflecting an additional 40% (23) take care of likely non response were generated and distributed using purposive sampling techniqu However, only 38 (66.7%) questionnaires were analysed using descriptive statistics (mean) and resul presented in tables.

4.0 FINDINGS AND DISCUSSION

4.1 Respondents Profile

This section presents the personal details of the respondents to include; their nature of job, educatio qualification and years of experience as presented in Table 2.

Table 2: Respondents profile

Items	Frequency (No)	Percentage (%)
Job description		
Safety managers	14	36.8
Equipment managers	11	29.0
Installation and dismantling workers	13	34.2
Total	**38**	**100**
Educational qualification		
ND	12	31.6
HND	7	18.4
Bachelors	13	34.2
MSc.	6	15.8
Total	**38**	**100**
Years of experience		
0-5	13	34.2
6-10	20	52.7
11-15	4	10.5
16-20	1	2.6
>20	0	0
Total	**38**	**100**

Source: Field survey (2018)

Table 2 indicates that all the categories of respondents are adequately represented having at least ≈ 30% representation each with safety managers having a higher representation of 36.8% and equipment managers having the least representation of 29%. All the respondents had at least a post-secondary education with 13(34.2%) of them having a bachelors and 6 (15.8%) had MSc. Table 2 also shows that 34.2% of the respondents had between 0-5 years of experience. A cumulative of 65.8% of the respondents have at least 6years of experience working in tower crane environment and were therefore able to make correct and valid judgement.

4.2 Degree of Impact

The impact of each factor were assessed using a five point Likert scale so as to establish their various levels of severity/degree of impact if they eventually occur on construction sites. The mean values were then calculated as shown in Table 3.

Table 3: Degree of impact

S/No.	Safety Risk Factors	Frequency					∑f	∑fx	Mean
		1	2	3	4	5			
1	Fracture of a wire rope during dismantling.	0	0	1	12	25	38	176	4.63
2	Not following work procedures in manuals for the installation/climbing/dismantling of tower cranes.	0	1	8	10	19	38	161	4.24
3	Overloading with objects exceeding the tower crane load limit.	0	0	6	19	13	38	159	4.18
4	Frequently omitting required safety procedures or rules for various reasons.	0	2	9	10	17	38	156	4.11
5	Lack of workers competence.	0	3	8	12	15	38	153	4.03
6	Unreasonable sites condition (working space. ground conditions and restrictions).	0	2	10	12	14	38	152	4.00
7	Trying to finish the work earlier than the time required for safe work.	1	1	11	12	13	38	149	3.92
8	Inexperienced tower crane operators.	1	5	6	11	15	38	148	3.89
9	Deterioration of tower cranes part (components).	1	8	8	5	16	38	141	3.71
10	Abrasion (wear and tear of components such as bolts, nuts, or pins).	1	4	17	2	14	38	138	3.63
11	Malfunction of a tower crane.	1	3	16	8	10	38	137	3.61
12	Incompatibility of components.	1	11	5	9	12	38	134	3.53
13	Buckling of a telescopic cage.	0	8	9	16	5	38	132	3.47
14	Falling items.	1	8	9	18	2	38	126	3.32
15	Contractors do not recognise the need to ensure the safety of tower crane installation and dismantling.	1	10	13	6	8	38	124	3.26
16	Failure of working platforms.	5	6	7	15	5	38	123	3.24
17	Instruction and supervision at construction sites are insufficient.	5	6	13	10	4	38	116	3.05
18	Insufficient number of workers to perform the work correctly and safely.	5	2	23	7	1	38	111	2.92
19	Time constraints requested from employer/ principal contractor.	2	16	10	9	1	38	105	2.76
20	Workers attitude (installation/dismantling workers).	2	17	9	9	1	38	104	2.74
21	Workers (erector, dismantler) are leaving the work often due to hard working condition).	6	21	6	2	3	38	89	2.34

Source: Field survey (2018)

1=Negligible 2=Minor Injury 3=Major Injury 4=Fatality and 5=Multiple Fatality.

From the Table, fracture of a wire rope during dismantling had the highest degree of impact with a mean

value of 4.63 which implies that the resultant effect of this safety risk factor if it occurs is fatality, major injury/injuries, permanent impairment, critical process loss and critical property damage. The factor "workers (erectors, dismantlers) are leaving the work often due to hard working condition" had the lowest degree of impact with a mean value of 2.34 which therefore implies that it's resultant effect if it occur can only lead to minor injury. All the factors however have degree of impact that range from minor injury to fatality as shown in Table 3.

5.0 CONCLUSION AND FURTHER STUDIES

There is a need for construction stakeholders to pay urgent attention on the first six factors as they had mean values ≥ 4.0 which means if they occur, their resultant impact would lead to fatality on site. The research concludes that fracture of a wire rope during dismantling had the highest impact on construction site safety during installation and dismantling of tower cranes just as it affects safety during its operation. Routine check on the tower crane parts and components could help reduce the possibility of accidents occurrence on site and therefore improve safety. A proper evaluation of these factors to look at their probability of occurrence and possible relationship between the impact and probability of occurrence could help solve the safety issue associated with installation and dismantling of tower cranes on construction sites.

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