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FACTORS THAT AFFECT SAFETY OF TOWER CRANE INSTALLATION/DISMANTLING IN CONSTRUCTION INDUSTRY

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ABSTRACT

Construction of high-rise buildings, large-scale apartment blocks, or construction in urban areas (especially busy downtowns) demands increasingly greater use of tower cranes. Therefore, the installation and dismantling of tower cranes on construction sites is an inevitable task, but also one of the most dangerous in the construction industry. Accidents during installation (including assembling and climbing) or dismantling of tower cranes incur the loss of workers' lives as well as delays in construction schedules and/or damage to buildings under construction. The aim of this paper is to investigate factors that contribute to accidents during tower crane installation/dismantling. Accident analysis and focus group interviews (FGIs) were conducted with people involved in crane work. Accidents occurring during installation/dismantling of tower cranes accounted for 68.4% of all fatal accidents. Accident analysis identified "Not following work procedures" as one of the main causes of these accidents, followed by "unsafe acts of workers." The FGIs investigation revealed the following factors that adversely affected the safety of the tower crane installation/dismantling: competence of the workers; roles of stakeholders such as principal contractors in the tasks; deterioration of tower crane components; and working conditions for conducting the tasks. These results may provide regulators as well as practitioners with insights for improving the safety of tower crane installation/dismantling.

Keywords: Tower cranes, lifting capacity, Safety risk and risk factors.

1. 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. United States 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**.** A crane safety analysis and recommendation report carried out in Singapore. 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.

2. CONSTRUCTION

Idoro 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 his analysis of types of accident that usually occur in construction sites, injury from the use of equipment ranked first among nine**.** 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 and so forth. Researches have shown that accidents and injuries in developing countries are generally high when compared to other European countries. Effective safety management is to make the environment safe, to make the job safe and to make workers safety conscious. In recent years, many developed countries have considered safety as one of the important management issues of construction projects, especially, personal safety. Ali and Muhammad opines that without proper safety management of construction machines at construction sites, accidents could happen.

3. OBJECTIVES

The objectives of this research are: i. To determine the probability of occurrence and degree of impact of safety risk factors during installation and dismantling of tower cranes in construction sites. ii. To evaluate the safety risk factors based on established risk rating scales.

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.

4. LITERATURE SURVEY

Idoro, G.I. Effect of Mechanization on Occupational Health and Safety Performance in the Nigerian Construction Industry, Journal of Construction in Developing Countries, Vol. 16, Number 2, pp 27-45,

Idoro [10] 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.

Kadiri, Z.O., Nden, T., Avre, G.K., Oladipo, T.O., Edom, A., Samuel, P.O., & Ananso, G.N. Causes and Effects of Accidents on Construction Sites (A Case Study of Some Selected Construction Firms in Abuja F.C.T Nigeria), IOSR Journal of Mechanical and Civil Engineering, Vol.11, Number 5, pp 66-72, 2014

Kadiri, et. al [11] stated that as the growth of construction industry blossoms in Nigeria, this also causes an increase in competition of projects to execute between construction firms which are however achieved at the expense of the worker's welfare and their safety Therefore identifying the various causes and effect of accidents on construction sites and proposing ways and means of reducing these accidents should be acknowledged. 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.

Ting, F. "The promotion strategy of occupational health and safety by government." Annual meeting of Hong Kong Const

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 crashed down [14]

Shin, I. J. Factors that affect safety of tower crane installation/dismantling in construction industry, Journal of Safety Science, Vol. 72, Number 2015, pp 379-390, 2015

41 cases which amounted to 7.18% occurred during assembly/disassembly. He further went ahead to say that 22 cases (23.40%) of the 94 cases that occurred from 2007-2009 resulted directly from the operations of assembly/disassembly. More recently, is 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 [16]

Chi, S., Sangwon, H., Dae Y.K., & Yoonjung, S. Accident risk identification and its impact analyses for strategic construction safety management, Journal of Civil Engineering and Management, Vol. 21, Number 4, pp 524-538, 2015

Chi, et al. [17] opined that, risk identification and cautioning can improve the safety of workplaces. By organizing high recurrence risk factors to viably control accident occurrence and deal with the probability of lethal injuries on construction sites when an accident is unavoidable, enables/helps safety managers to comprehend the nature of construction accidents and plan for key risk mitigation

5.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. However, according to 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 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 where they reviewed all risk factors associated with tower crane installation and dismantling process and came up with a list of 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 worker's 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.

Table 1: Safety risk factors

6. RESEARCH METHODOLOGY

The study looks at probability/likelihood of occurrence and impact of safety risk factors with respect to determining their frequency of occurrence and degree of impact respectively. This requires eliciting knowledge from practitioners who are directly involved in the process such as safety managers, equipment managers and team leaders of installation and dismantling workers. Hence, questionnaire survey was adopted. Population size for the research was unknown as no data is available on exact number of these practitioners. The sample size was determined from a table developed by that the minimum sample size for an unknown population for 95% confidence interval with 5% error level is approximately 34. A total of 57 questionnaires

were generated and distributed in Kaduna, Abuja and Lagos using purposive sampling technique. However, only 38(66.7%) questionnaires were analysed using descriptive statistics and results.

7. FINDINGS AND DISCUSSION

7.1 RESPONDENTS PROFILE:

This section presents the personal details of the respondents to include their nature of job, educational qualification and years of experience. 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 28.9%. 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. 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.

Items	Frequency (No	Percentage (%)
Job Description		
Safety managers	14	36.8
Equipment managers	11	28.9
Installation and dismantling workers	13	34.2
Total	38	100
Education 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	52.6
11-15	4	10.5
16-20	1	2.6
Total	38	100

Table 2: Respondents profile

7.2 PROBABILITY OF OCCURRENCE FOR SAFETY RISK FACTOR

The probability of occurrence for each safety risk factor were scored by the respondents based on a five-point Likert scale. Mean values were determined, and standard deviation also determined to help rank the factors that have the same mean value. The assessment of the probability of occurrence of each factor which shows that the most probable factor is “Abrasion (wear and tear of components such as bolts, nuts or pins)” with a mean value of 3.63 and the least probable factor is “Incompatibility of components” with a mean value of 2.16. However, the first six (6) factors had mean values ≥ 3.0 which means these factors have a possibility of occurring and may recur occasionally. The factors from 8th position to 21st had mean values ≥ 2.0 which means these factors are unlikely to recur but, have the possibility of occurring. We can conclusively say that these results imply that all the identified factors have the possibility of occurring on our construction sites. Researchers that previously looked at safety issues associated with tower crane installation and dismantling concluded that failure to follow work procedure is the most likely factor that can result to accidents on construction sites as stated by [13, 16]. However, the results presented in Table 5.2 proved otherwise by ranking “not following work procedure in manuals” as 12th position with a mean value of 2.89. This could imply that there have been an increased awareness and recognition of safety issues during installation and dismantling of tower cranes over the years which has made the users more safety conscious by implementing work procedures as stated in the manuals.

The most probable factor being "abrasion (wear and tear of components such as bolts, nuts, or pins)" has affirmed previous research finding that maintenance management is a highly affecting factor on safety when using tower cranes as stated by [9]. This implies that this factor yet plays a great influence on safety during installation and dismantling and/or during operation. It is also interesting to note that operator proficiency or experience of the tower crane operator which has been widely accepted as the major safety determinant on site as cited by [1, 9, 22] was ranked 4th with a mean value of 3.18. This implies that although it remains a probable factor according to this study however, it has a greater influence on safety during the operation of tower crane. Another likely reason for this factor been ranked 4th could be that operators had gained experience over the years thereby reducing its influence on safety as tower cranes are now widely used and becoming a culture in every construction environment. Incompatibility of components ranked the least amongst all other factors assessed which implies that tower crane manufacturers have continuously improved on the compatibility of their tower crane components. More efforts are still required to completely eliminate this factor as it is still a probable factor although not recurring frequently.

S/No	Safety Risk Factors	Frequency						Σfx (Σα)	Mean	Std. Dev.	Rank
		1	2	3	4	5	Σf				
1	Abrasion (wear and tear of components such as bolts, nuts, or pins).	0	9	9	7	13	38	138	3.63	1.19	1st
2	Fracture of a wire rope during dismantling.	0	5	19	9	5	38	128	3.37	0.88	2nd
3	Deterioration of tower cranes part (components).	3	4	11	19	1	38	125	3.29	0.98	3rd
4	Inexperienced tower crane operators.	0	14	6	15	3	38	121	3.18	1.04	4th
5	Lack of workers competence.	0	13	14	4	7	38	119	3.13	1.1	5th
6	Trying to finish the work earlier than the time required for safe work.	1	9	19	5	4	38	116	3.05	0.96	6th
7	Buckling of a telescopic cage.	1	9	22	3	3	38	112	2.95	0.87	7th
8	Frequently omitting required safety procedures or rules for various reasons.	4	5	20	8	1	38	111	2.92	0.94	8th
9	Failure of working platforms.	3	10	15	7	3	38	111	2.92	1.05	9th
10	Falling items.	2	13	14	4	5	38	111	2.92	1.1	10th
11	Not following work procedures in manuals for the installation/climbing/dismantling of tower cranes.	4	5	21	7	1	38	110	2.89	0.92	11th
12	Contractors do not recognise the need to ensure the safety of tower crane installation and dismantling.	3	13	7	15	0	38	110	2.89	1.03	12th
13	Workers (erector, dismantler) are leaving the work often due to hard working condition.	5	11	15	3	4	38	104	2.74	1.13	13th
14	Insufficient number of workers to perform the work correctly and safely.	3	17	8	8	2	38	103	2.71	1.06	14th
15	Unreasonable sites condition (working space, ground conditions and restrictions).	1	19	13	4	1	38	99	2.61	0.82	15th
16	Time constraints requested from employer/principal contractor.	7	8	18	3	2	38	99	2.61	1.05	16th
17	Malfunction of a tower crane.	7	17	6	4	4	38	95	2.5	1.22	17th
18	Workers attitude (installation/dismantling workers).	4	17	13	3	1	38	94	2.47	0.89	18th
19	Instruction and supervision at construction sites are insufficient.	10	12	11	3	2	38	89	2.34	1.12	19th
20	Overloading with objects exceeding the tower crane load limit.	5	21	11	1	0	38	84	2.21	0.7	20th
21	Incompatibility of components.	12	13	10	1	2	38	82	2.16	1.08	21st

Table 3: Probability of occurrence

7.3 DEGREE OF IMPACT FOR SAFETY RISK FACTORS

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 calculating. The 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 had degree of impact that range from minor injury to fatality. There is a need to pay serious attention on the first six factors as they have mean values ≥ 4.0 which means if they occur, their resultant impact would lead to fatality on site.

Overloading tower cranes with objects exceeding its load limit is the 20th probable factor to occur on site as seen from Table 5.2. However, results for degree of impact in Table 5.2. showed that it has a high degree of impact if its accident does happen on site as it was ranked 3rd position amongst other factors with a mean value of 4.18. The latter is in line with previous findings that exceeding tower crane load limit results to accident on site that could be very fatal involving multiple injuries in most cases. From a careful observation of this factor, one would notice a sharp distinction between its probability of occurrence and degree

of impact. The reason for this could be linked to the previous assertion that there has been a significant improvement in the level of safety awareness on site as a result of continuous research on safety challenges associated with tower crane working environment thereby, reducing the probability of occurrence which is a function of the probability of occurrence and the degree of impact. The result of this was then measured against a standard risk rating developed by [23] so as to come up with their risk levels. Σα (probability risk score), Σβ (degree of impact risk score), ΣRS (combined risk score), N (population), RSIS (relative significance index score). The fracture of a wire rope during dismantling had the highest RSIS of 15.6 and implies a high risk factor which requires a high level of control put in place to forestall danger and make the working environment safer. The factors ranked from 2nd to 15th as shown in Table 5.4 had RSIS of 13.2 - 9.0 respectively, and as such implies that they are moderate risk factors that is acceptable but, requires suitable controls to maintain a safe working environment.

Those ranked from 16th to 21st had RSIS of 7.9 – 6.4 respectively, which implies low risk factors that are acceptable with no further action required. The factor "workers (erectors, dismantler) are leaving the work often due to hard working condition" had the lowest RSIS of 6.4 and does not really pose any treat to safety. This could be attributed to the high rate of unemployment in the country as reported by [24] thereby making the assertion in the factor false because, those who managed to be gainfully employed instead of leaving would rather do everything possible to keep their jobs so as to continue sustaining themselves. The fear that losing their job might make them become unemployed for the rest of their lives makes people stick to the ones they have irrespective of the working condition. It is widely recognised that poor maintenance culture is lacking in both private and public sectors in Nigeria as stated by [25]. This could therefore be the reason why "fracture of a wire rope during dismantling" closely followed by "Abrasion (wear and tear of components such as bolts, nuts or pins) had high RSIS of 15.6 and 13.2 respectively. Routine maintenance of the tower cranes could help to minimize the risk level.

S/No	Safety Risk Factors	Frequency						Σfx (Σβ)	Mean
		1	2	3	4	5	Σf		
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
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

Table 4: Degree of impact

S/No.	Safety Risk Factors	Σα	Σβ	ΣRS	N	RSIS	Rank	Risk Level
1	Fracture of a wire rope during dismantling.	128	176	22528	1444	15.6	1st	High
2	Abrasion (wear and tear of components such as bolts, nuts, or pins).	138	138	19044	1444	13.2	2nd	Moderate
3	Lack of workers competence.	119	153	18207	1444	12.6	3rd	Moderate
4	Inexperienced tower crane operators.	121	148	17908	1444	12.4	4th	Moderate
5	Not following work procedures in manuals for the installation/climbing/dismantling of tower cranes.	110	161	17710	1444	12.3	5th	Moderate
6	Deterioration of tower cranes part (components).	125	141	17625	1444	12.2	6th	Moderate
7	Frequently omitting required safety procedures or rules for various reasons.	111	156	17316	1444	12	7th	Moderate
8	Trying to finish the work earlier than the time required for safe work.	116	149	17284	1444	12	8th	Moderate
9	Unreasonable sites condition (working space, ground conditions and restrictions).	99	152	15048	1444	10.4	9th	Moderate
10	Buckling of a telescopic cage.	112	132	14784	1444	10.2	10th	Moderate
11	Falling items.	111	126	13986	1444	9.7	11th	Moderate
12	Failure of working platforms.	111	123	13653	1444	9.5	12th	Moderate
13	Contractors do not recognise the need to ensure the safety of tower crane installation and dismantling.	110	124	13640	1444	9.4	13th	Moderate
14	Overloading with objects exceeding the tower crane load limit.	84	159	13356	1444	9.2	14th	Moderate
15	Malfunction of a tower crane.	95	137	13015	1444	9	15th	Moderate
16	Insufficient number of workers to perform the work correctly and safely.	103	111	11433	1444	7.9	16th	Low
17	Incompatibility of components.	82	134	10988	1444	7.6	17th	Low
18	Time constraints requested from employer/principal contractor.	99	105	10395	1444	7.2	18th	Low
19	Instruction and supervision at construction sites are insufficient.	89	116	10324	1444	7.1	19th	Low
20	Workers attitude (installation/dismantling workers).	94	104	9776	1444	6.8	20th	Low
21	Workers (erector, dismantler) are leaving the work often due to hard working condition).	104	89	9256	1444	6.4	21st	Low

Table 5: Safety risk evaluation

8.1 MAINTENANCE

There are a number of equipment maintenance management techniques that can be employed, including “Breakdown Maintenance” where maintenance is only carried out after faults or failures have occurred, and “Planned Preventive Maintenance” which involves routine inspection replacing parts and consumables or making necessary adjustments at present intervals, so that risks do not occur as a result of the deterioration or failure of the equipment.

In the case of tower cranes the “Breakdown” approach is inappropriate, as any failure presents an immediate risk. The Best Practice Guidance is therefore the “Planned Preventive Maintenance” management technique. Maintenance of tower cranes should be managed in the same way as any other business activity as, if not carried out effectively, it can have severe financial and safety implications for a business. An effective management structure is required to ensure that everyone involved in the maintenance activity is aware of their responsibilities, properly briefed on their duties and that systems are in place to enable effective feedback, including the monitoring of maintenance data. Tower crane maintenance activities should be carried out, as a minimum, at the intervals specified in the tower crane manufacture’s maintenance manual. Varying circumstances on site may however require the frequency to be increased. Once a tower crane has been erected on a site, the user of the crane has a duty to ensure that it is adequately maintained. The actual undertaking of the maintenance is often delegated to the crane owner by the user; the user however, retains the responsibility for ensuring that the maintenance is carried out. Clear lines of responsibility for maintenance operations should be established from Board level downwards, ensuring that those appointed and responsible have sufficient knowledge and experience to carry out their duties in a way which will ensure that risks are properly controlled. Each tower crane should have a documented preventive maintenance schedule which is targeted at the parts of the equipment where failure or deterioration could lead to health and safety risks and which specifies the frequency of inspection and test of relevant parts, taking account of the manufacturer’s instructions, the age of the crane and its in-use history.

Tower crane owners may not have access to expert professional engineering advice in-house. If this is the case arrangements should be made for securing such advice externally where this is necessary for the purposes of health and safety and clear guidelines should be established for when this advice should be sought. For a preventive maintenance system to be fully effective it is essential that comprehensive records of daily checks, intermediate inspections, breakdown reports, maintenance work sheets (including details of parts replacement) and reports of thorough examination are kept. These should be filed in an individual machine history file which should be kept for the life of the crane. An extremely important aspect of a planned preventive maintenance system is the continuous and systematic review of all maintenance records, inspection reports and reports of thorough examination to ensure that the maintenance is effective, defects are found and worn components are replaced well in advance of any possible failure. Should this review indicate that

maintenance is not fully effective, the frequency may have to be increased and maintenance practices amended. Maintenance should only be carried out by those who are competent and have adequate training and information to carry out the work required. A number of general maintenance training courses and qualifications are available for personnel carrying out and supervising maintenance operations. Training is offered by a number of training providers including the National Construction College, whilst qualifications are available through the NVQ/SVQ scheme. All maintenance personnel should have received machine specific training, traceable to the tower crane manufacturer, before carrying out maintenance tasks on any tower crane. Maintenance operations on tower cranes require adequate facilities and equipment to enable them to be carried out effectively, efficiently and safely. The size and sophistication of the facilities will depend on the degree of maintenance tasks to be carried out.

8.2 THOROUGH EXAMINATION

Thorough examination of lifting equipment is a fundamental requirement of the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER). Regulation 9 of the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) requires employers to ensure that tower cranes are thoroughly examined at prescribed intervals. In the case of a hired-in tower crane the actual undertaking of thorough examinations is often delegated to the crane owner by the user. The user however, retains the legal responsibility for ensuring that thorough examinations are carried out. The primary purpose of a thorough examination is to ensure that a tower crane or climbing frame is safe to be taken into, or to continue in, use. It is in addition to any inspection carried out as a part of the maintenance regime and is a statutory requirement. Tower cranes operate in a high risk environment which includes lifting loads over people and with the operator in an elevated position. These factors must be taken into account by the competent person when determining the scope and nature of the thorough examination. As with maintenance, the thorough examination of tower cranes should be managed effectively, irrespective of whether thorough examination is carried out in-house or by a third party. An effective management structure is required to ensure that everyone 4 involved in the thorough examination activity is aware of their responsibilities, properly briefed on their duties and that systems are in place to enable effective feedback, including the monitoring of thorough examination outcomes. If thorough examination is carried out by the organisation owning or supplying the tower crane steps must be taken to ensure that the competent persons carrying out the thorough examinations have, as LOLER requires "the genuine authority and independence to ensure that examinations are properly carried out and that the necessary recommendations arising from them are made without fear or favour." This guidance describes a number of ways in which this requirement may be met. Thorough Examination of tower cranes should only be carried out by those who are assessed as competent and have adequate training and information to carry out the task. Competent persons should be selected through a formally documented assessment process and any shortfalls in their knowledge or ability addressed through formal or on the job training. All assessment and training must be recorded in an individual training record, together with the ongoing Continuing Professional Development that should be undertaken by all Competent Persons. Competent Persons carrying out Thorough Examinations of tower cranes should be provided with adequate information to enable them to carry out their duties effectively and safely. The Competent Person may specify supplementary tests to be carried out prior to or during the Thorough Examination. These may include such tests as: - • Overload test following erection; • RCI/RCL calibration and functional test; • Hoist brake and luffing brake test; • Pre-delivery inspections; • Non Destructive Examination of individual components. The results of the thorough examination must be reported in writing as required by LOLER. This includes the reporting of safety critical defects to the Enforcing Authority (Normally the Health and Safety Executive)

8.3 AVAILABILITY OF TOWER CRANES FOR MAINTENANCE AND THOROUGH EXAMINATION

Tower cranes, when erected on a construction site, are often pivotal to the construction process and Site Managers may be reluctant to release a tower crane to the owner to allow maintenance or thorough examination to take place. It is essential that adequate downtime is built into the construction programme to allow effective maintenance and thorough examinations to be carried out and to ensure that personnel do not feel under pressure to skimp the work. The activities should always be carried out during the hours of daylight and the crane operator should be in attendance to operate the tower crane as required.

6.4 OTHER ISSUES

In addition to the issues summarised above the guidance also addresses - site issues, management review of records, spare parts, work at height, safe systems of work and checklists for checks and inspections. This Guidance may be used by Principal Contractors when undertaking vendor assessment as required by the CDM Regulations.

7. CONCLUSION

The study concludes that abrasion (wear and tear of components such as bolts, nuts, or pins) was the most probable factor and fracture of a wire rope during dismantling had the highest degree of impact. In evaluating the safety risk factors, "fracture of a wire rope during dismantling and abrasion (wear and tear of components such as bolts, nuts, or pins) which could both be seen as a maintenance management issue as looked at by previous research is a highly affecting factor on safety during installation and dismantling. Adoption of a preventive maintenance strategy or routine check on the tower crane parts and components could help minimize the probability of occurrence and impact of the safety risk factors on site during installation and dismantling of tower cranes

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