

A Study on Human Factor That Lead to Tower Crane Accident at Construction Site in Malaysia

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Abstract: Tower crane act as the lifeline in the construction industry, but accidents that related to tower crane operation still often occur. Loss of life, death, and harm to the property are the implications that will arise if the crane handling processes and standards are not properly performed. There are several factors that affect the safety of tower crane operation in construction that can be put into four main factors that are project condition, environment, human factor and safety management. From those factors, the human factor is the most common reason for the accident that related to tower crane operation to occur. Human error such as lack of communication, inexperienced worker, disobeying the safety procedure that provided and lack of supervision has been the contributor to this accident happened. This research, therefore, addressing the issue about the most common causes of tower crane accidents that happen on the construction site. This research further examine the human factor that causes tower crane accident and propose recommendation in minimizing human-related error in a tower crane accident. All information and data were obtained by using Pilot study and questionnaire surveys in Google form that were distributed to the professionals such as tower crane operator, site engineer, site safety supervisor, safety officer and further studies of crane accident cases in Malaysia. The responses achieved shows that majority of the respondents strongly agree that tower crane shall be operated by a competent person who holds a valid competency certificate issued by DOSH Malaysia and the recommendation to reduce tower crane accident is each tower crane operator shall carry out daily the pre-operation safety inspection checklist to avoid further problem during tower crane handling process.

Keywords: Construction, Tower Crane, Human Factor

1. Introduction

The utilization of crane in all types of construction has improved the efficiency rate of building projects globally. Generally, there are two types of crane that are mobile crane and tower crane. Ironically, when large numbers of cranes are deployed to a construction site, the vulnerability to danger frequently increases for construction workers employed with, around or under the cranes. The severity of the hazardous event is evaluated by the levels of work-related fatalities, compensation for employees, injury and death. Workplace safety is an active topic and a subjective study field. That is because workplace health has undergone major changes over the last decade [2]. The accident involving a crane occurred on the construction site and reported the accident that happened outside the building sites such as highways, public housing, and many other [6]. Even if fitted with advanced safety equipment, accidents such as blind lifting and poor communication can lead to machine failure and death [12]. Based on the interview and survey studies, there are 21 factors that affect the safety of tower crane operation in construction that can be put into four main factors that are project condition, environment, human factor and safety management [15]. From those factors, the human factor is the most common reason for the accident that related to tower crane operation to occur. This research, therefore, was addressing the issue about the most common causes of tower crane accidents that happen on the construction site. This research further examine the relationship between human that contribute to workplace accidents and suggested recommendation for a solution to those issues. Further analysis of the previous study, legislation and literature review was done to show that the human factor plays an important role in the tower crane accident.

2. Materials and Methods

Many research pieces have been conducted on tower crane safety, which involves incident analysis, construction site interviews and surveys, and modelling analysis [17]. Argued by [13], claimed that human contribution is around 80 to 90% in all major accidents. Several studies widely accepted that human error accounts for up to 80% of all incidents and accidents in diverse high-risk processes in the aviation, petrochemical, healthcare, manufacturing, mining and nuclear industries [5]. Described by [9] the commonly known phrase human factors as describing problems affecting people's performance at work or recognizing possible contributors to the causes of injuries or incidents. Human factors are likely to contribute to this problem at various levels, including human factor, work design, and organizational factor [8]. This theory explores human's likelihood to make mistakes under multiple circumstances and environmental conditions, with the blame primarily on the human unsafe characteristics and act [1]. The Department of Standard Malaysia has issued some guidelines for the safe handling of tower cranes that the construction industry should obey (MS 1803:2008 Cranes Safety Tower Crane and MS ISO 4310:2014 Cranes Test Code and Procedures. So far as legal responsibility is concerned, the Department of Occupational Safety and Health (DOSH) is the federal agency that enforces statutory tower crane protection provisions in legislation such as Factory and Machinery Act 1967 [4], Occupational Safety and Health Act 1994 [11] and other relevant regulations. Those regulation need to be strictly followed because it is important in order to reduce the probability of tower crane accidents, as mentioned in human theories most of the accident happen due to human error.

2.1 Duties and Requirement of Personnel

Each person should do their duties and tasks to make sure any accident event can be deflected from the construction site. Based on OSHA 1994 Section 15, Section 16, Section 17 and Section 18 of Part IV (General Duties of Employers and Self-Employed Persons) state that each employer and every self-employed person need to ensure the safety, health, and welfare at work of all his employees. The employer of the self-employed need to do provision and maintenance of plant and systems of work, giving information or training supervision to make the working environment is safer for everyone and establish a health and safety policy.

2.2 Tower Crane Operation

Based on FMA 1967 Part II (Certificates of Fitness) and Regulation 10 (Machinery Requiring Certificate of Fitness), tower crane operators need an appropriate degree of competency to ensure secure execution of the lifting job. Department of Occupational Safety and Health (DOSH) offers a certificate of competence to qualified individuals and companies to ensure that laws and regulations provide the training, experience, knowledge and skills in tower cranes operations.

2.3 Tower Crane System

The system is structured, consisting of interconnected and interacting elements or components and having a certain form and purpose [7]. System components included three major parties that are the tower crane stakeholders, equipment, and staff. Each of the parties plays an important role in making the accident event reduced from time to time.

2.4 Tower Crane Stakeholder

Tower crane stakeholders consist of the manufacturer, the main contractor for the project, and the subcontractor. Thus, the manufacturer needs to construct tower cranes in compliance with design guidelines and the list of manual and residual risks for crane instructions. The main contractor needs to ensure a functional working area for the subcontractor, establish a safety plan, and ensure supervisory support for protecting the tower crane. A subcontractor needs to fulfil the task of supplying tower crane work and equipment, making supervision at regular intervals on the construction site.

2.5 Tower Crane Equipment

There will be needed for maintenance and repair to ensure the tower crane will run smoothly. Provide a schedule for maintenance inspection and operation, and the operation report is retained for record-keeping at the site office.

2.6 Tower Crane Staff

Operator proficiency is the foremost ingredient in determining safety level of crane work and surroundings [10]. The Tower crane operation consists of numerous staff that is the tower crane operator, signalperson, and slinger (Table 1). Each party needs to have good communication and proper teamwork to reduce the probability of an accident. Supervision and guidance of supervisors from the main contractor and subcontractor are important in this operation.

Table 1: Human factors affecting safety on construction sites with tower cranes [15]

Factor	Definition	Description	Safety Risk
Operator proficiency	Experience and proficiency of crane operator	Operator proficiency is the foremost ingredient in determining safety level of crane work and surroundings. Objective measures of operator skills are formal training and certification, accumulated experience and safety record. Experience is measured first and	Operator proficiency plays a decisive role in making errors, preventing dangerous situations before they develop and responding to others errors once a dangerous situation has developed and preventing an accident or lessening its damages. The shorter and less variegated the operator's experience and the lower their proficiency, the higher the safety risk.

		foremost by the number of crane operating years but also by the variety e.g., crane types and models, project types and dimensions to which the operator has been exposed over the years.	Operator experience is also critical for “feeling” the crane instinctively “by the seat of his pants”.
Operator character	Behavioral patterns and mental capacity of the crane operator	Measures of operator character that may affect the operator’s conduct are: levelheaded/impulsive, disciplined/defiant, tenacious/ submissive, vigilant/sluggish; and focused easily distracted.	As in any man-machine system, in the operator-crane system the character of the operator and its bearing on the operator’s conduct have a great effect on the chances of accidents.
Employment source	Crane operator is on the construction company’s staff or is outsourced	Depending on local cultures, on the construction company policy, and on supply and demand, crane operators can either be on the permanent staff of the company, moving from one company’s project to the next, or outsourced from a manpower company, usually for the duration of one project only and often for a shorter-term service.	Outsourced operators, who have no direct employment contracts with the construction company, are often exploited and discriminated compared with permanent company employees, which may hamper their work and have negative implications on safety. On their part, outsourced operators tend to work overtime particularly if paid by the hour and “cut corners” so as to please their temporary employers.
Superintendent character	Behavioural patterns and mental capacity of the superintendent	In addition to generally being in charge of safety on site, the superintendent often has direct contact with crane work, the latter being a critical element of the production chain on site. Superintendent characteristics that may	In the likely possibility of conflict between speed and productivity on the one hand, and safety on the other hand, the superintendent’s character may play an important role in maintaining or neglecting safety as far as crane work is concerned. We do not, however, claim that safety

		affect their contact with crane work and crane operators are, for example, authoritativeness, accountability, sensibility, and alertness.	and productivity are essentially in conflict with each other.
Signalperson experience	Experience of workers employed for signalling and rigging	Signalpersons, commonly also in charge of slinging, are referred to by many as “the operator’s eyes and ears.” But although they fulfil a critical function, they are usually undertrained and their service is often too short to gain adequate experience.	The situation that prevails in many cases, of undertrained and inexperienced signalpersons, increases chances of accidents in general. The situation is particularly riskier in cases of poor visibility and a great extent of blind lifts.

3. Methodology

In order to systematically analyze the tower crane safety at the construction site, this research intends to achieve research objectives through two phases. For the first phase of this research, the influencing factors related to the tower crane safety system have been determined systematically by further analyzing the previous study, legislation, and literature review to show that the human factor plays an important role in the tower crane accident. The result gained from the first phase will be the research basis for the second phase. The second phase of this research is carried out by using a quantitative method. Whether a researcher chooses either a quantitative or qualitative research method depends on the researcher's epistemologically focused beliefs [3]. Quantitative research can be defined by collecting quantifiable data and performing statistical, mathematical, or computational techniques to investigate phenomena systematically. In this phase, the primary data were gathered from questionnaire surveys sent to professionals such as tower crane operator, site engineer, site safety supervisor, and safety officer that related to the construction industry as the main respondent.

3.1 Pilot Study

A pilot study is one of the important stages of a research project. It is conducted to identify potential problem areas and deficiencies in the research instruments and protocol before implementation during the full study [19]. An in-depth discussion is required to define issues that need to be addressed in a large-scale survey. Pilot Study can also help to determine possible practical problems in the execution of the whole research process. It may also help the researcher more familiar with the study procedures and help to understand between two opposing methods of analysis, such as using interviews instead of a self-administered questionnaire [18]. Likewise, in this research, an experienced worker or a lecturer related to the construction field could lend guidance and assistance to check the validity and reliability of the constructed questionnaire before the actual survey. Later, the finalized questionnaire were distributed to the respondents for data collection.

3.2 Quantitative Research Questionnaire

In quantitative research, conventionally, the presumption of determinism indicates that one or more causes fully determine all occasions. There are several methods for data collection in quantitative research that are survey and interview. A survey was implemented to gather data to investigate the main dimensions and contributing components related to the tower crane safety system. The term survey is primarily spelled out as a mode of data collection from an individual sample [14]. This research was using a survey as a method for data collection. A survey was implemented to gather data to investigate the main dimensions and contributing components related to the tower crane safety system.

3.3 Research Flowchart

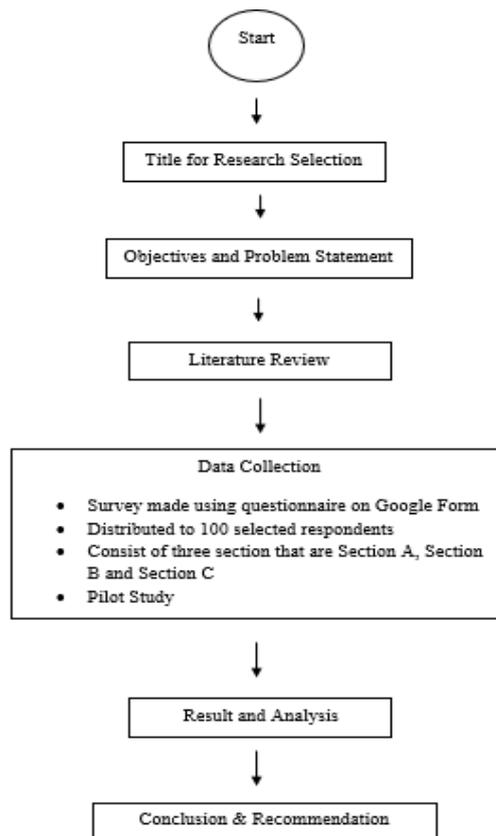


Figure 1: Research Flowchart

4. Result and Findings

A total of 100 respondents from the different backgrounds were involved in the survey questionnaire. In the survey questionnaire, three sections consist of the respondent's background, a human factor contributing to tower crane accident and recommendation to reduce human-related error in tower crane operation.

4.1 Result for human error that related to tower crane accident (Table 2)

These section of the survey questionnaire include several questions and statements related to the human error that lead to a tower crane accident. Respondents need to answer the question based on experience and their knowledge to obtain this study's first objective. This section was using a likelihood range from strongly disagree to strongly agree.

Table 2: Result for human error that related to tower crane accident

Statement/Question	Likert Scale (%)				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Good communication and proper teamwork is important to reduce the probability of an accident to happen	0	0	1	7	92
Miscommunication between worker can affect safety during the operation process	0	0	1	8	91
Each worker needs a good behavioral pattern and sufficient mental capacity to perform well in any task given	0	0	1	16	83
When I worked overtime, I tend to be less focused and easily distracted	1	6	28	21	44
Supervision and guidance of supervisors from the main contractor and subcontractor is important in tower crane operation	0	0	1	14	85
Lack of experience and expertise in handling tower crane can lead to tower crane accident	0	0	3	4	93
Do you think that it is important to have a competent worker for tower crane handling?	0	0	1	6	93
Tower crane shall be operated by a competent person who holds a valid competency certificate issued by DOSH Malaysia	0	0	1	4	95
Do you know the tower crane used is already maintenance and inspected or not?	1	1	10	13	75
A competent person must do the inspection on the tower regularly that is before, during and after the tower crane utilization	0	0	1	10	89

4.2 Result of the recommendation to reduce human related error (Table 3)

This section asks the recommendation to reduce and lower the probability of human-related error in tower crane operation. This section comprises seven recommendations that the respondent needs to answer to fulfill the second objective of this study.

Table 3: Result of the recommendation to reduce human related error

Statement	Likert Scale (%)				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It is important for a construction worker to undergo training in order to stimulate the employee to follow safety regulations	0	0	1	9	90
Crane should be operated by a competent person that has been trained, qualified and have experiences	0	0	1	6	93
Any operation regarding tower crane handling need to be regularly supervised by an expert and experienced supervisor	0	0	2	7	91
Tower crane operator shall carry out daily the pre-operation safety inspection checklist to avoid further problem during tower crane handling process	0	0	3	2	95
All worker needs to be brief and notified with a tower crane operation hazard before starting the job	0	0	1	9	90
All personnel involved in tower crane operation need to attend training provided by CIDB or other agencies to improve skills	0	0	2	6	92
Disciplinary action is used in the company for infractions to safety rules or practices	0	1	2	6	91

5. Conclusion and Recommendation

In order to obtain this study's objectives, further analysis of the previous study, legislation, and literature review was done to show that the human factor plays a vital role in the tower crane accident. A pilot study and a survey questionnaire were done to obtain information from selected respondents to achieve this study's objectives. By referring to the data gathered from a survey questionnaire, lack of experience or expertise in handling tower crane may lead to tower crane accident. Besides, the tower crane needs to be operated by a competent and qualified worker only. A competent operator has capabilities that play an important role in stopping hazardous situations from emerging and reacting to other errors until a hazardous circumstance has occurred, and preventing an accident or reducing its impact. The shorter and less varied the operator's experience and the lower their skill, the higher the safety risk. Next, to reduce the probability of a tower accident, the tower crane must be inspected regularly by the employee who qualified for the inspection. The inspection consists of pre-operational, weekly or monthly, and annual inspections that need to be performed. Provide a schedule for maintenance inspection and operation, and the operation report is retained for record-keeping at the site office. Any problems that have been discovered will have to be addressed before starting the crane operation.

This study has attempted to investigate the human error that contributes to the tower crane accident and recommend best practices on preventing the incident from occurring accordingly. Even though there were plenty of safety devices, procedures, and strategies currently available for any personnel related to tower crane operation, the extent to which this issue occurs remains unsolved. Additional research is essential to evaluate the function and validity of present safety strategies to recognize and correct the flaws to reduce the probability of construction injuries resulting from working around cranes. It will be useful to perform surveys on the challenges faced when enforcing these strategies on construction sites and the degree of enforcement attained. Details and information may be obtained from various sources from various positions, including project managers, foremen, and signalperson.

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