

## Risk Assessment of Tower Crane Operation in High Rise Construction

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### ABSTRACT

Construction in Malaysia is rapidly increase nowadays especially involving high rise construction. As tower cranes also extensively used for hoisting materials in high rise construction, its operation also increasingly involved in a high rise construction. The usage of tower crane at construction site also created several of risk and hazard that will cause the accident toward the construction workers and public surrounding. This paper is to identify the operation hazard that occurred during tower crane operation and to propose a safe operation guideline for tower crane operation. The study began with collecting relevant tower crane hazard through conducting survey questionnaire for respondents at selected 3 numbers of high rise construction project. Through the survey and site observation, it was found that a several type of accident and hazard involved during the operation of tower crane. From the result, risk rating has been conducted to establish a safe operation guideline for the tower crane operation.

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## 1. Introduction

Tower cranes are the heartbeat of progress on today's typical building construction sites. Tower cranes hoist and transport a variety of loads in the high rise building construction [1, 2] in Malaysia. The usage of tower cranes in construction are inevitable, thus the risk of the operation is exist. Risk assessment on tower crane operations are vital in identifying the hazard and the assessment will allow management to take necessary action to mitigate the risk. Current situation in high rise construction is that the construction's management failed to identify the specific hazards towards tower crane operation. Even though identifying hazard is a crucial process in construction, still many the management failed to conduct it properly as they solely depends on safety personnel. When the risk assessment are not conducted, project team will not identify the hazard occurred during tower crane operation thus the hazard continuously exist until the accident happened.

Recently, many accident cases reported involving tower crane operation in Malaysia. A several accidents caused by tower crane operation recorded by DOSH Malaysia is shown in Table 1.

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**Table 1**  
Type of Accident involving tower crane operation

Date	Location	Accident Description
February 2016	Taman Molek Johor Bharu	Luffing rope were snap and caused the tower crane (Luffing Type) collapsed
October 2016	Cheras, Kuala Lumpur	Fatal accident caused by Tower crane's hook block loose and hit a construction workers
February 2016	<i>Lumut Perak</i>	Load entangled with scaffolding during high speed lifting and causing the tower crane (hammerhead type) mast twisted and collapsed
August 2016	Kuala Lumpur	Fatal accident involving public caused by loose hook block
Julai 2017	Tg.Kupang, Johor Bharu	Fatal Accident, one construction workers hit by falling hook block

Due to that matters, the current hazard identification and risk assessment on the lifting operation would require urgent review to assure inherent safety are met and risk of unwanted event are control at all safety critical point to prevent dangerous occurrence [3]. Also, the hazard identification and risk assessment will reduce failure of the system and thus it will eliminate any unwanted event that may cause injury to the construction workers[4], operators, and public operation as mentioned in Occupational Safety & Health Act 1994 (Act 514). This accident happened due to no specific risk assessment for tower crane operation at construction by Malaysia's Department of Occupational Safety & Health (DOSH), and no any risk assessment has been conducted by organization. A guideline from Department of Occupational Safety & Health (DOSH) [5] only covered the requirement of the tower crane operation but not providing specific risk assessment on the tower crane operation. There is a several guideline or code of practices in other countries that related to tower crane operation but again it is not specified the risk assessment for the tower crane operation and these guidelines are Code of practice for safe use of Tower Crane In Hong Kong, Code of practice 2006 Tower Crane in Queensland, Australia and Code of Practice for safe use of Lifting equipment in UK.

Thus, this paper will proposing a risk assessment and guidelines for tower crane safe operation in high rise construction. Beforehand, the paper will discussing on identification of the operation hazard during hoisting then the risk assessment of current standard procedure for tower crane operation will be determined. The risk assessment on obtaining the risk rating and the risk level will be using Likelihood and Severity Rating as shown in Figure 1.0. Assessing the Likelihood and Severity rating are based on worker experience in tower crane operation, worker individual's health, surrounding environment and properties at construction site. Next, the causes of the hazard present during hoisting operation will be ranked. A set of questionnaire has been developed and conducted towards 20 respondents. Only respondents with an experience in tower crane operation have been selected. These all respondents are project manager, safety and health officer, tower crane technician, tower crane operator, signalmen, site engineer, site supervisor and DOSH Officer. 3 of high rise construction site were included during the process which is comprises a total of 6 tower cranes.

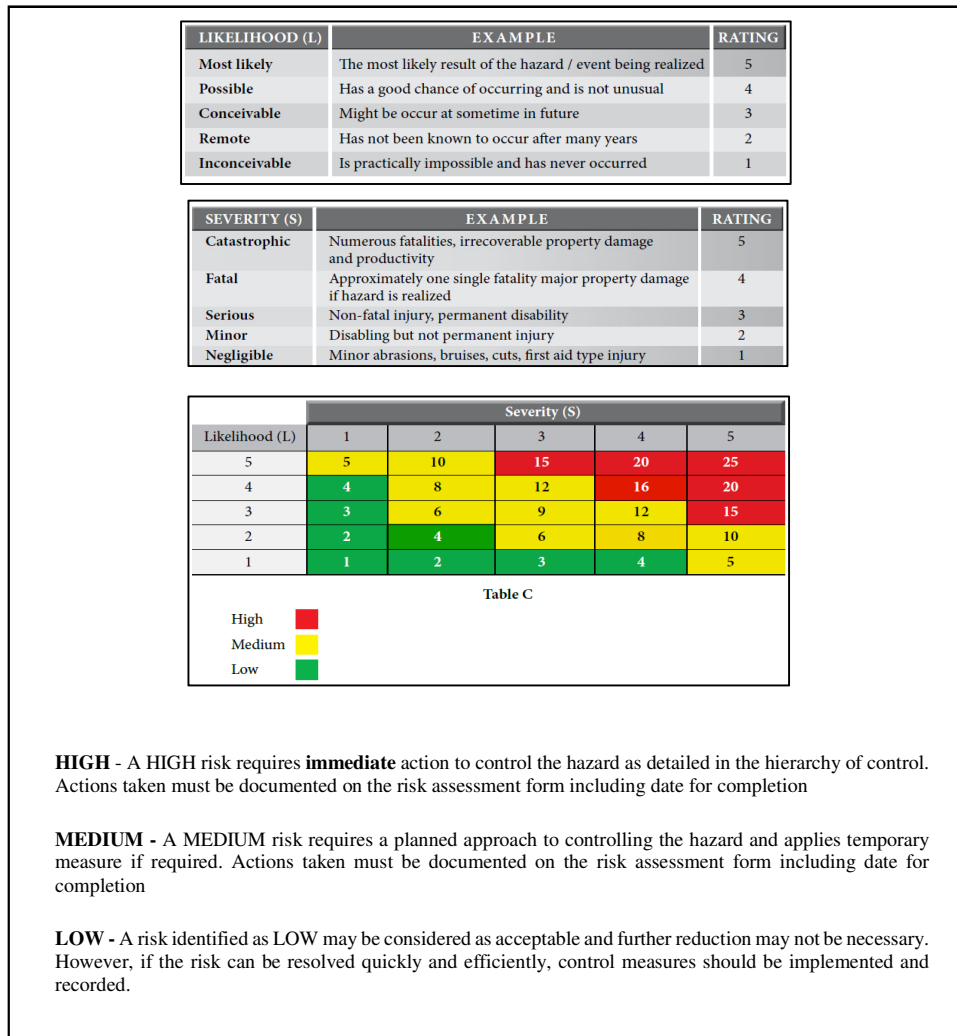


Fig. 2. Likelihood and Severity Rating [6]

## 2. Operation Hazard that Occurred during Hoisting Operation

Tower crane accident is the one of frequent recorded accident that occurred in construction and it is not only hazardous to workers in construction but also to the public [3]. Risk assessment is important in order to identify the hazard at early stage of construction[4], as this will allowed an organization to construct a preventive action to minimize or to eliminate the hazard [7]. Many type of accidents involving tower crane operation in high rise construction as such loss of load, collision between crane, collapse of crane or part of the crane, falls from height, caught in between and struck by moving object [8, 9]. All those identified accident were cause by human errors, technical errors, and some of the accident caused by the nature. In the Tower crane safety in the construction industry: A Hong Kong study mentioned that human error is the main factor that contributed to tower crane operation accidents [3]. However, In the “A ‘normal accident’ with a tower crane? An accident analysis conducted by the Dutch Safety Board emphasized that the human error cannot solely blamed to the incident occurs during the operation [10]. Technical error such as the design or any structural failure need to be identified first before blaming the human errors as a finding. The nature incidents also contributes to the tower crane operation accidents[11]. There are 12 major hazards that contributing towards tower crane accident [3, 10-12]. These major hazards are defective lifting tools,

improper method of rigging, poor communication among signalman and operator, moving load, incompetent tower crane operator, structural failure, insufficient clearance, overload, working at height, nature due to storm and heavy rain, operator and signalman error.

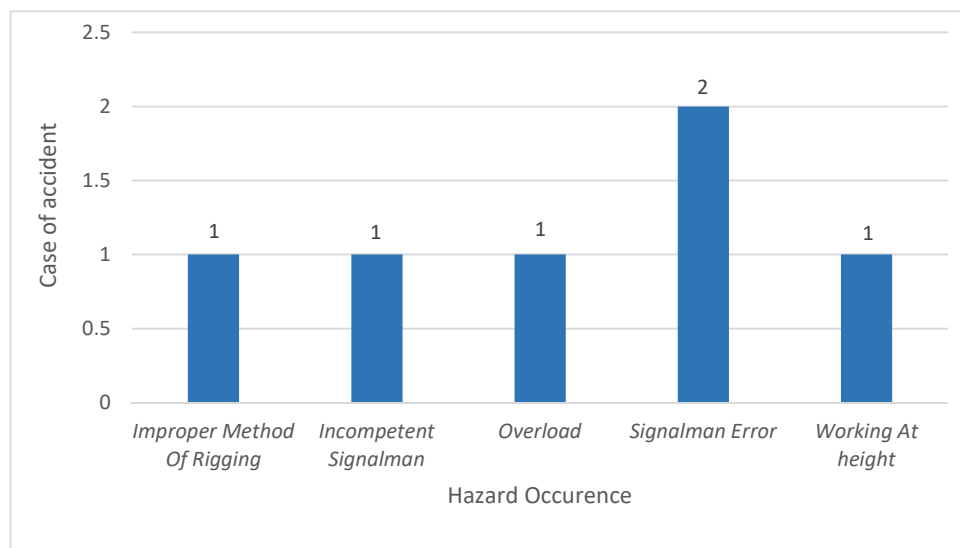
In order to access and ranking the causes of the hazard during hoisting operation. A guideline for hazard identification, risk assessment and risk control (HIRARC) [6] will be used and current control establish by DOSH for tower crane operation [5] will effecting the risk rating. By using this HIRARC format, it is possible to identify the highest hazard and control measure can be made at one time.

### 3. Results and Discussion

The results and discussion will focusing on the hazard occurrence during tower crane operation which is crucial and requires immediate action. The risk rating will be assessed using the Likelihood and Severity Rating as shown in Figure 1.0.

#### 3.1 Hazard Occurrence

Figure 2.0 shows 5 out of 12 hazards which are working at height, signalman error, overload, incompetent signalman and improper method of rigging are contributing to the risk and requires immediate and effective action.

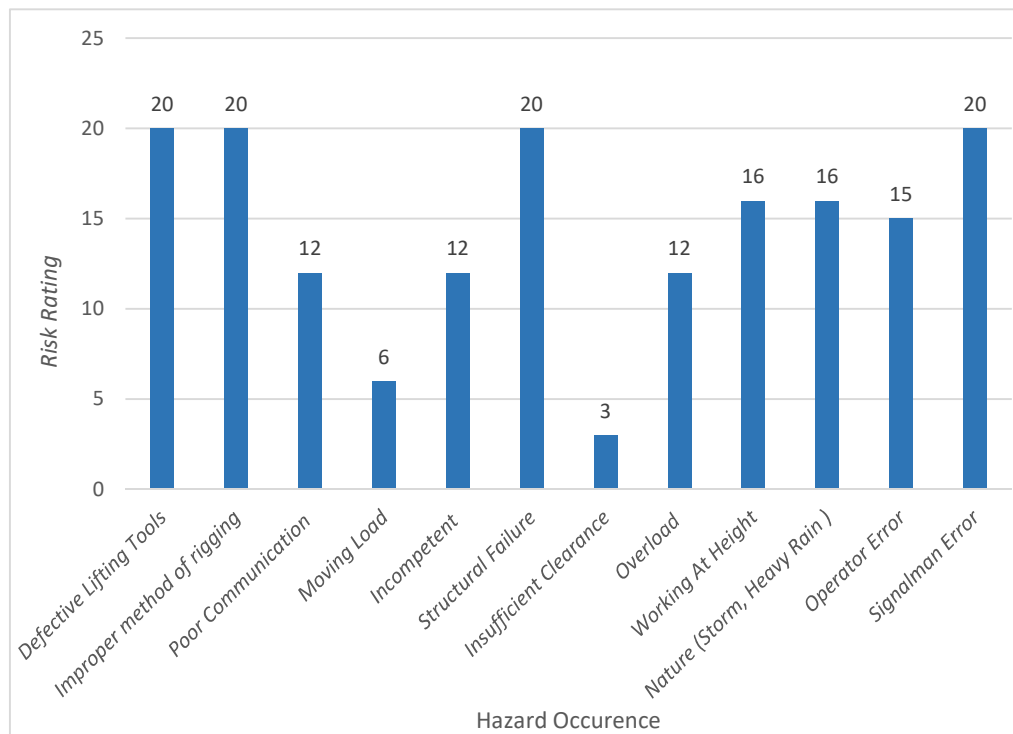


**Fig. 2.** Hazard Occurrence during Tower Crane Operation

From the Figure 2, it shows that the signalman error contributes to two cases of tower crane accidents. This is due to no competency needed to become signalman, the random workers will be selected with no any training or competency to become a signalman. Thus, it will lead to language barrier among signalman and tower crane operator during giving instruction during the operation of tower crane. In order for them to become competent, they must acquire knowledge on figurative language by attending all compulsory training by DOSH and a set of test need to be conducted for them. This system is similar to scaffolder, safety officer, and many more competency that endorsed by DOSH Malaysia. Continuous training for signalman need to be conducted and a merit point system need to be introduced for them to renew their competency.

### 3.2 Risk Rating

Figure 3 shows 12 of hazards during tower cranes operation has been ranked. A total of 7 risk has been identified as a high risk according to Livelihood and Severity in Figure 1. All of them were signalman error, operator error, nature, working at height, structural failure, improper method of lifting and defective lifting tools. These of identified hazard need immediate action to control the hazard during the operation. While the rest of hazards required a planned approach to control the hazard and only 1 of hazard which is insufficient clearance has been identified as low risk in the rating.



**Fig. 3.** Risk Rating

The highest risk rating were signalman error, structural failure, improper method of lifting and defective lifting tools. For the hazard of signalman error, the control measure has been explained in subsection 3.1. The hazard of structural failure contributes due to the designated technician which a person that appointed by the crane maintenance company without proper competency. The other issue is after inspection for PMA (*Perakuan Mesin Angkat*), DOSH does not know what happened to the tower crane after the inspection, and when the accident occurred, the term of *safe during inspection* will be used. Recommendations action to control the hazard are the appointed technician must be a competent person registered with DOSH and they must have a certain years of experience. However, a total of 2 unregistered technician under the competent technician can be appointed. Next, during maintenance, repair and jacking-up activities of tower crane, the company need to provide a report to DOSH for reporting on any maintenance activities that have been done on the tower crane. Lastly, DOSH need to conduct a frequent periodic inspection towards the tower crane instead of just 15 months as scheduled.

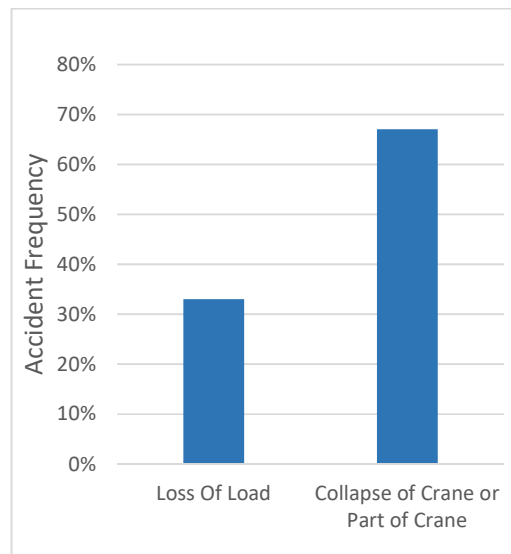
The hazard of improper method of rigging/hoisting contributes to the highest rating due to no specific requirement for safe rigging method in any DOSH guideline. Therefore a rigging training and a test need to be conducted for signalman before allowing them to become a competent signalman.

Next a continuous education program for the competent signalman need to be done in order to renew their competency.

Lastly the highest recorded hazard is defective lifting tools. This highest hazard is due to nobody willingly to inspect the hoisting tools, even the safety personnel is not competent in the hoisting inspection and the workers using wrong hoisting tools for the wrong task thus damaging the hoisting tools. Recommendations action for this hazard are a logistic supervisor must be assigned to inspect all the hoisting tools as to ensure it is safe to be used. The logistic supervisor need to determine the suitable hoisting tools to be used. Also, they must attend a special training that related with all hoisting matters. This training must be endorsed by DOSH in order to ensure the quality of the training.

### 3.3 Reported Frequency of Accident

Figure 4 shows only two types of accidents have been reported during operation. 67% of respondents agreed that the collapse of crane contributes to the incident of the crane tower's accident while only 33% believed that the incident is caused by the loss of load during operation. This respond is supported by the accident investigation reported by DOSH (2015-2017).



**Fig. 4.** Reported frequency of accidents

The highest frequency of accident in the figure is reported on collapse of crane or part of tower crane. The cause of this accident always contributed by many factors, but the most contribute factors is overload of the crane. When the crane is overloaded, it will causing the crane structure failed to coupe the load thus the crane will be collapsed. Overload usually due to hoisting of the construction material and the accident occurred during hoisting operation and dismantling the tower crane. For this accident and hazard involved due to overload, it is rating as medium risk as referred in Fig. 3 and Fig. 1 thus it requires a strategy approach to control the hazard and applies temporary measure if required. To prevent overload, a cut-off limit is compulsory device to install for the tower crane. This device must be installed before the tower crane erected and operated. It will cut-off the tower crane power supply automatically when the crane is overloaded. Load monitor indicator is another device that must install for tower crane operation. This device allow the tower crane operator to know the total weight of the load that he will hoist, as this will prevent from overload.

### 3.3.1 Loss of load

Due to improper method of rigging and hoisting, it caused the loss of load accident. This accident usually will causing fatalities accident. This accident will occurred during the tower crane hoisting the material. Several loss of load accident reported occurred on evening. Based on risk rating, this accident and hazard are categorised as high risk, thus requires immediate action to control the hazard. In construction, signalman is the person that are responsible to rig the material, therefore signalman need to be competent in proper method rigging. Attending continuous rigging training is a must in order to allow them to become signalman.

## 4. Conclusion

This paper identified the operation hazard that occurred during tower crane operation, and it found 6 type of accident caused by the tower crane which are loss of load, collision between cranes, collapse of crane or part of crane, falls from height, caught in between and struck by moving object. Survey questionnaire and site physical observation conducted in order to get the hazard related. Signalman error is the most frequent hazard that contribute to two type of tower crane accident and most of accident occurred during hoisting the material. It is noticeable that most of the accident occurred during evening due to several factor. Recommendations for improving safety performance related to tower crane operations were also discussed.

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