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Increase Safety in High-Rise Building Construction with Innovation on Cranes

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Abstract

Rapid development of the construction industry and decrease in land space have resulted in the development of high-rise buildings. This makes the usage of cranes inevitable. However, usage of cranes has often caused accidents which result in deaths and also varies injuries. This paper aims to increase the level of safety for high-rise building construction when using crane. Literature and empirical data were obtained in this study. Review of related literature was conducted to identify problems associated with the use of cranes in high-rise building constructions. Questionnaire survey was carried out on industry players to recognize the current practice in the industry. Document analysis was then implemented to highlight the existing flaws of the current crane design. An innovation was then proposed to try counteract the problems highlighted earlier. It is expected that the innovation proposed will have a huge impact to the level of safety in crane usage for high-rise building construction. Being simple and economical, it is targeted that the innovation is easily adopted by construction players.

Keywords: Crane, High-Rise Building Construction, Safety, Accident, Camera, Sensor

Introduction

Background

Construction is one of the industries that contribute to the development of a nation (Wibowo, 2009). As such, many developed countries compete to construct buildings which are either the largest, tallest or even both. Numerous innovations in the construction industry have been carried to enhance the buildability of amazing vertical structure. An example of an innovation in construction is the crane, which facilitate builders to achieve construction of high-rise buildings to reach almost 1 kilometre in height. However, some problems still exist. One of it is safety (Hinze, 2008). Safety on construction sites is an important aspect that must not be overlooked in any construction works.

Problem Statement

Limited eye vision of a crane operator is one of the most inconveniencing problems faced with tower crane. Crane operators often operate the cranes without the ability to see right beneath the cabin (Koumboulis et al., 2016). As the crane gets higher up, the blind spot increases. To address this problem, an innovation will be proposed.

Aim and Objectives

Due to the increasing number of accidents on construction sites caused by crane, it is imperative to study on innovative technique for crane control, to reduce the occurrence of such accidents. Use of mechanical equipment undoubtedly help in carrying out on-site activities. However, due care must be taken to ensure that the works are carried out safely. The aim of this study is to identify a method to safely carry out the construction works of high-rise buildings utilizing cranes. To reach the aim of the study, a few objectives were formulated as follows:

1. to identify the causes of accidents involving cranes in construction sites;
2. to analyse the problems leading to the problems; and
3. to propose a solution that can overcome the problems discovered.

Research Questions

In order to achieve the abovementioned objectives, research questions were formed. They are:

1. What are the causes of accidents involving cranes on construction sites?
2. What are the problems that lead to these accidents?
3. How can crane-related accidents be avoided/minimised?

Scope and Limitation

This research only looks at the usage and causes of crane-related accidents for high-rise buildings that are constructed on Malaysia construction sites.

Literature Review

Background

In any country, construction contributes to the development in general and also in its economy (Khan, 2012). Not only does it provide buildings and infrastructure, construction activities also provide employment to the people – local and from abroad. Construction may be of many natures and sizes, ranging from simple renovation works of a residential building to development of townships, complete with buildings and relevant infrastructure.

High Rise Building

With rapid development occurring throughout the country, land space is decreasing (Fazal, 2000). This results with the construction of high-rise buildings. Construction of high-rise buildings is becoming a trend especially in states and countries where land is limited (Ahmad et al., 2017). High-rise buildings are those buildings which are beyond 75 metres in height (Yankovskaya et al., 2018). Examples of high-rise buildings are usually for residential and office buildings where the floor plan from one level is the same or similar to another level.

Industrialised Building System

With the same or similar layout of floor plan between each floor of the building, repetitive building components may be utilised. This is where the Industrialised Building System (IBS) method of construction, in some circumstances, become a preference. The building components including wall panels, door and window units, and floor slabs are mass-produced in the fabrication yard before being transported to the construction site for assembly (Thanoon et al., 2003). This method, although is high in capital cost due to the need of plants for fabrication, saves a lot of time and wastes during the assembly of the components on site. It also reduces the dependency on general labour to construct the building elements from scratch, therefore indirectly reduces problems of sub-standard quality or workmanship, and in the long-run, prolongs the lifespan of the building (Oliewy et al., 2009).

Crane

When using pre-fabricated components, the panels are manufactured off-site and assembled on the construction sites. Cranes are being utilised to place the panels into positions. Usage of cranes is crucial as it assists in the lifting of the panels. Basically, there are two types of cranes i.e., mobile cranes and tower cranes. Mobile cranes, as its name suggests, are mobile and can reposition itself by the operator to move around the site. However, its height capability is limited. For buildings that are higher, tower cranes are being used. This type of cranes needs to be assembled and they are fixed to that one particular spot until they are dismantled.

Methodology

For this study, both literature and empirical data were gathered. For the first objective, findings were gathered through literature review on reputable journals related to studies on crane incidents to find the major causes. For the second objective, empirical data were gathered from respondents who are involved directly in the construction work activities in Malaysia. The third objective was achieved through proposal of an innovation in order to achieve the aim of the study.

Review of Literature

In this study, a review of literature was conducted to study the current scenario of the construction industry, especially those involving high-rise buildings construction, cranes, and accidents on site. It was found that the number of accidents leading to fatalities, disabilities and injuries were fluctuating between years for projects involving cranes in Malaysia. Between the years 2009 and 2015, the highest number of incidents happened in 2015 where there were 138 temporary disabilities, 11 permanent disabilities, and 88 fatal cases in the construction sector. Among those, six fatalities and two injury cases involved cranes (Abdul Hamid et al., 2019).

Questionnaire Survey

Once the problems have been identified, a potential cause of the problem is investigated. Questionnaire surveys were carried out onto construction workers and/or professionals of various levels in Malaysia construction sites, to support the findings and provide an insight on the construction activities happening on site, especially when involving high-rise building construction and crane.

Results and Discussion

Demographic Information

A total of 27 respondents successfully completed and returned the questionnaire survey. The questionnaire survey was done online using the Google Form platform. Out of the 27 respondents, 25 were from the construction organisation, while the two others were a supplier and a manufacturer respectively. Between them, they have experience working in various projects including housing, public facility, commercial, and education purpose buildings, as illustrated in Table 1. Some of the questions asked in the questionnaire were regarding the use of crane, their perception on the current level of safety when cranes are used, their personal experience of being in crane related accidents or incidents, and whether or not improvement on the existing crane may impact the level of safety on site positively.

Table 1. Type of project involved

Current or Latest Type of Project	Total Number of Respondent	Percentage (%)
Housing	10	37.0
Public Facility	8	29.6
Commercial	8	29.6
Education	1	3.7
Total	27	100

Current Issue

Based on the responses gathered, the majority of them were involved in construction projects involving cranes and they do think that cranes can be improved in order to increase the level of safety on site, as summarised in Table 2. Working forward from this, ways on improvement for the crane is researched.

Table 2. Responses on cranes

Crane Issue in Construction Industry	Yes	No	Maybe
Is crane the most used machinery in the site?	20	4	3
Is crane important in precast construction?	27	0	0
Does crane have a high-risk in accident?	20	0	7
Can handling and installation failure affect the quality of precast components?	22	2	3

From the total number of 27 respondents, six of them have experience as crane operators and command assistant. Even though most of respondents agreed that the incidents were mostly caused by misled on code of practice and lack of proper supervision before handling the crane, there is no doubt that one of their difficulties was an obstruction on total vision, where sometimes this factor may also be caused by bad weather at a particular time, as displayed in Table 3.

Table 3. Causes of crane mishandling

Factors of miss operating	Yes	No	Maybe
Lifting of the excessive load which are higher than the load allowed by safe code of practice.	13	14	0
Crane operator's low visibility	18	0	9
Hazardous and weather conditions	20	2	5
Inadequate work supervision and weak communication between crane operators and site foreman	16	6	5

Camera and Sensor Based Crane

Next, a desk study was carried out to study the potential innovation towards the crane to try minimize the problems earlier highlighted. Before finding out how to improve, the existing problems involving cranes were identified. From the literature, human error contributed to 25% of the accidents involving cranes in construction sites in Malaysia between years 2009 to 2016 (Abdul Hamid et al., 2019). It was understood that one of the problems involving crane is to do with inadequate supervision and weak communication (Zaini et al., 2020). This is due to the physical nature of the crane being so high up that the crane operator could not see the area directly beneath him. With both reference on data obtained as in Table 3 and results from desk study, an innovation was seen to be needed in this aspect of sight problems when operating the crane.

Proposed Innovation

The problem identified involving cranes is to do with limited sight of the crane operator due to blind spots. To try reduce the number of accidents involving use of crane in the construction of high-rise buildings, an innovation of a camera and sensor-based crane is proposed. This innovation makes use of the standard crane with addition of sensor and camera linked to a control panel located in the control room for supervisor to monitor remotely, away from the building being constructed.

A camera and sensor are attached underneath the crane operator carriage as shown in Figure 1. This provides extra sets of eyes, not only for the operator, but also for the supervisor observing through the control panel in the control room located away from the building being constructed. The image is projected in real time wirelessly between the camera and sensor and the control panel in the control room. This is possible as the geographical distance between them is not so high.

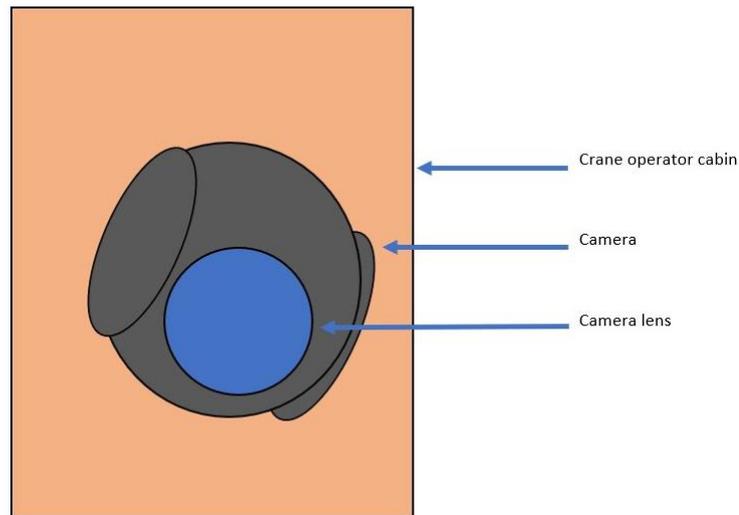


Figure 1. Camera mounted underneath crane operator cabin

Having extra sets of eyes help the crane operator to navigate safely and avoid any potential risks of danger that could provide harm to people or damage to plants, equipment, and buildings. The supervisor and crane operator communicates by using a two-way radio (walkie-talkie) as a medium of fast communication. Should the supervisor foresee any danger, he/she can immediately notify the crane operator to halt the activity before any danger progresses. This will drastically increase the chance of the danger being stopped from happening and indirectly, avoids any unwanted accidents. This is seen to help improve the sight problem and can indirectly be successful in reducing the number of accidents related to cranes as shown in Figure 2.

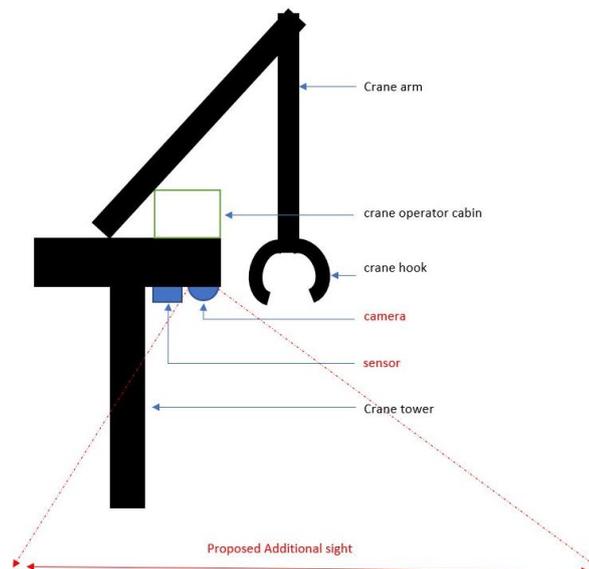


Figure 2. Additional sight gained from camera mounted underneath crane operator cabin

The proposed innovation was then presented to the same questionnaire respondents for validation. The results are summarised in Table 4.

Table 4. Respondents feedback on proposed innovation

Question on the marketability	Total Number of Respondents				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The concept of the proposed innovation idea is unique	0	0	0	15	12
The concept of proposed innovation idea is practical	0	0	5	19	3
Camera on crane helps improve the vision for the crane operator	0	0	2	19	6
This innovation idea will be able to reduce the accidents that occur on the construction site involving crane	1	1	0	15	10
The proposed innovation idea can benefit the precast industry	0	1	2	7	17
The proposed innovation idea has market potential.	0	0	3	15	9

Marketability

It is anticipated that this innovation will drastically help reduce the number of accidents involving crane on construction sites. The simple steps to adopt this innovation makes it marketable and feasible for construction players to implement on their construction projects.

Conclusion

With the ever-increasing demand of high-rise buildings where limited land is available, cranes are important in the construction works. Therefore, the need of increasing the level of safety to try prevent accidents resulting with deaths and injuries is demanded. This innovation is seen to be able to provide a higher level of safety when cranes are utilised.

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The empirical data used in this paper was collected by a bachelor's degree students for an innovation project course. The findings were submitted as part of the student's assessment only. No publication was ever made using the same data to any publishers locally and internationally.

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