CAUSES OF THE TOWER CRANE ACCIDENTS AND SAFETY
PERFORMANCE PRACTICES AT CONSTRUCTION SITE IN MALAYSIA:
PERSPECTIVES FROM TOWER CRANE OPERATOR

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Dedication...

"...a special dedication to my family

best father
Muhamad Zaini Bin Ahmad

lovely mom
Rashidah Bt Mohd Nor

wonderful siblings
Muhamad Khairul Zairani Bin Muhamad Zaini
Nurmahliana Zairani Binti Muhamad Zaini and Mohd Shahdan Bin Mokhtar
Nurmahliani Zairani Binti Muhamad Zaini

lovely cheerful nephew
Muhammad Azzikr Irfan Bin Mohd Shahdan
Muhammad Atheef Irfan Bin Mohd Shahdan

best friend thick and thin
Mohamad Ariff bin Mat Salleh

special one
Kamarul Nazrin bin Kamarudin

Thank you for love, guidance, and encouragement..."

Alhamdulillah

THANK YOU ALLAH

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ABSTRACT

The evolution of the construction industry in this twenty-first century is seen flourishing, with the use of cutting-edge machinery like tower cranes. As a pivotal transportation option and lifting at construction sites, tower cranes are now dominating precedence. The tower crane operations safety and health must be handled carefully to prevent any accidents in order to ensure that the work at the construction site runs briskly. Consequently, this research is conducted to identify the causes of tower crane accidents with the weakness of safety performance practices at a construction site in Malaysia. The research focused on building and civil construction sites around Peninsular Malaysia. Respondents for the research are focusing entirely to tower crane operator as they are the pillar during tower crane operations. The quantitative method was adopted and the data were analysed using Statistical Package for the Social Sciences (SPSS); frequency analysis, descriptive statistics (mean analysis) and correlation coefficient analysis (Spearman analysis). The findings of this research indicate that the major tower crane accident was caused by poor safety management which is tower cranes operated by unskilled and uncertified tower crane operators. Furthermore, respondents have the highest level of agreement for the safety performance implemented on the construction site, with the weaknesses originating from management categories which are the management never provide safety training programs for signalman and tower crane operators. Lastly, the finding of research was selected and integrated into a fishbone diagram, which is a novelty for this research. The establishment of the fishbone diagram was created using empirical data gathered in the field, and as an important tool to recognise the root cause of the problem and weakness of safety performance practices at site. This research also allows authorities and management to have a better understanding of the root causes of accidents, and to help in taking systematic precautions steps to enhance safety performance practices when operating tower cranes. In conclusion, the findings of this research will help further research as well as industry players to mitigate tower crane accidents in Malaysia.

ABSTRAK

Evolusi industri pembinaan pada abad ke-21 ini dilihat berkembang pesat, dengan penggunaan jentera canggih seperti kren menara. Sebagai pilihan pengangkutan dan pengangkatan penting di tapak pembinaan, kren menara kini mendominasi keutamaan. Keselamatan dan kesihatan operasi kren menara mesti dikendalikan dengan berhati-hati bagi mengelakkan sebarang kemalangan serta memastikan kerja di tapak pembinaan berjalan dengan lancar. Sehubungan itu, penyelidikan ini dijalankan untuk mengenal pasti punca kemalangan kren menara dengan kelemahan amalan prestasi keselamatan di tapak pembinaan Malaysia. Penyelidikan tertumpu pada bangunan dan tapak pembinaan awam di sekitar Semenanjung Malaysia. Responden bagi penyelidikan ini tertumpu sepenuhnya kepada pengendali kren menara kerana mereka merupakan tunggak utama semasa operasi pengendalian kren menara. Kaedah kuantitatif telah diterima pakai dan data dianalisis menggunakan Asas Statistik Untuk Sains Gunaan (SPSS); analisis kekerapan, statistik deskriptif (analisis min) dan analisis pekali korelasi (analisis Spearman). Dapatan kajian ini menunjukkan bahawa punca kemalangan kren menara yang utama adalah disebabkan oleh pengurusan keselamatan yang lemah iaitu kren menara dikendalikan oleh pengendali kren menara yang tidak mahir dan tidak bertauliah. Tambahan pula, responden juga mempunyai tahap persetujuan tertinggi terhadap prestasi keselamatan yang dilaksanakan di tapak pembinaan, dengan kelemahan yang berpunca daripada kategori pengurusan iaitu pihak pengurusan tidak pernah menyediakan program latihan keselamatan untuk juru isyarat dan pengendali kren menara. Akhir sekali, dapatan kajian telah dipilih dan diintegrasikan ke dalam gambarajah tulang ikan, yang merupakan sesuatu yang baru untuk penyelidikan ini. Penubuhan gambarajah tulang ikan telah dibuat menggunakan data empirikal yang dikumpul di lapangan, dan sebagai alat penting untuk mengenali punca masalah dan kelemahan amalan prestasi keselamatan di tapak. Penyelidikan ini juga membolehkan pihak berkuasa dan pengurusan mempunyai pemahaman yang lebih baik tentang punca kemalangan, dan membantu dalam mengambil langkah

berjaga-jaga yang sistematik untuk meningkatkan amalan prestasi keselamatan semasa mengendalikan kren menara. Kesimpulannya, dapatan kajian ini akan membantu penyelidikan lanjutan serta pemain industri untuk mengurangkan kemalangan kren menara di Malaysia.

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LIST OF SYMBOLS AND ABBREVIATIONS

(α)	-	Cronbach's Alpha
n	-	the sample size
N	-	the population size
H_O	-	null hypotheses
H_a	-	alternative hypotheses
CIDB	-	Construction Industry Development Board
DOSH	-	Department of Safety and Health Malaysia
KLCC	-	Kuala Lumpur City Centre
NIOSH	-	National Institute of Occupational Safety and Health
OSH	-	Occupational Safety & Health
PERKREMA	-	Persatuan Pekerja Mahir Kren Menara Malaysia
PPE	-	Personal protective equipment
SOCSO	-	Social Security Organization

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CHAPTER 1

INTRODUCTION

The general introduction of this thesis is covered in this chapter. It begins by explaining the purpose of the research by highlighting the main issues under exploration and providing a background to explain it. This aspect culminated in the problem statement. The next important section describes the research objectives. Then, the research scope and the significance of this research are determined in the last section of this chapter.

1.1   Background of Research

The construction industry is one of the world's fastest-growing industries. This industry has a lot of impact on a country's economy through investments made by foreign investors and provides various incentives to society by increasing job opportunities and improving quality of life. In 2007, Malaysia was recorded as the 3rd largest economy in Southeast Asia (Waris *et al.,* 2014). Generally, the Malaysian construction industry are divided into two areas, which are building and civil engineering construction. Furthermore, the construction industry is also a generator and determinant of a country's success. The Malaysian government is aware that this construction industry will provide many advantages and help to develop other industries in the future (Ibrahim *et al.,* 2010).

The construction industry is an industry that uses a lot of heavy machineries in its work. The use of machinery is crucial to assist with work productivity and minimise

a construction project's schedule. Heavy machineries such as tower cranes, crawler cranes, mobile cranes, backhoes, bulldozers, and excavators are frequently employed on construction projects due to their versatility. Tower cranes are regularly used to construct high-rise buildings as machinery for lifting construction materials such as reinforced iron, concrete, bricks, and others in large loads (Shapira and Simcha, 2009). The tower crane can move and lift construction materials horizontally or vertically from one location to another, depending on its type and ability.

Nowadays, the construction of high-rise buildings in Malaysia is increasing and directly affects the demand for tower cranes. This activity becomes a dangerous situation when it lacks of safety management on the tower crane. In order to alleviate this situation, it is very important to improve the tower crane safety performance practices at the site to avoid an accident. Accidents on a construction site can affect the progress and delay of the project. It is common to hear of tragic accidents at construction site that result in injury, death, or illness to workers and surrounding people (Manu *et al.,* 2018).

The safety performance practices of the tower crane should be taken seriously by every party involved in the construction of high-rise buildings to avoid serious accidents. All management levels need to ensure the safety performance practices of the tower crane is at maximum level.

1.2 Problem Statement

According to research on the rate of work-related fatalities, workers' compensation, injuries, and deaths, the construction sector are classified as one of the most dangerous and biggest industries in the world (Chong and Low, 2014). According to the Department of Occupational Safety and Health Statistics (2021), over five years since 2016, the total number of workers has died was 535, and many others were injured while working on the construction industry. The highest number of deaths among construction workers was 118 in the year 2018, the most since 2016. Moreover, the occupational accident statistics by sector on 2021, as reported to DOSH, the highest number of fatalities is from the construction industry. These statistics demonstrate that Malaysia's construction industry is one of the critical industries that need more

attention to create a much safer workplace. Implementing safety and health standards is commonly recognised. in the construction industry as a viable technique for managing occupational safety and health because a priority on these factors may prevent or decrease dangers in the workplace (Saifullah and Ismail, 2012).

Past literature indicates that frequent accidents happen at a construction site due to falls from heights, crane, or hoist accidents, slips and falls, gas leaks, fires, explosions, electrocutions and machinery accidents (Winge and Albrechtsen, 2018). The construction industry also frequently uses cranes, mainly tower cranes, to assist expedite building construction. Cranes are one of the essential assets used at construction sites for lifting operations. The standard types of cranes used in Malaysia are mobile cranes, tower cranes, and telescopic cranes. The tower crane is mostly used in high-rise building construction. Therefore, the construction industry of Malaysia represents the epicentre of growth of the country and has been propelled by demand for high-rise building projects. High-rise buildings are the current trend in construction nowadays because of its convenience, advantages, architectural design, grade and luxury. The demand of high-rise projects continues to grow due to the reducing of usable land area in Malaysia. Meanwhile, the rapidly development of high-rise projects has leaded to the rise of fatalities and accidents. According to Manzoor *et al.,* 2021, every year many people working in high-rise building construction became the victim of injury, death and harm caused by accidents compare to low-rise building construction. Despite this, this research are focuses on high-rise buildings in Malaysia.

Referring to research by UKM Pakarunding, (2017), 70 tower crane accidents were reported from the year 2000 until October 2017, and the cases are found to be increased every year, as shown in Figure 1.1. In year 2000, 2001, 2004 and 2007 the tower crane accidents data are unrecognised by DOSH. From the 70 accidents, 34 cases involved luffing tower cranes, 14 cases for hammerheads and 22 cases were unidentified (data unavailable). Next, for the latest updated of tower crane accident stated by DOSH is in year 2018 with only one cases contributed to fatalities. DOSH statistic is only listed the accident involving fatalities neither than an accident relating of injury. The latest statistic for active tower cranes in Malaysia on 2020 is 1533 (Ab Rahman, M. F., personal communication, March 20, 2021). As the number of tower cranes in Malaysia rising every year, the accident rate may rise if safety aspects and standard regulations/codes on crane operation are neglected.

Every year, an accident due to a tower crane operation is repeatedly reported.

Related to this accident on 2nd January 2018, a foreign worker was killed while three others were seriously injured after being struck by a component from a falling crane in Section 7 Shah Alam (Muhamad Zaini *et al.,* 2020). DOSH statement pointed out the reason behind the death as the failure in the crane structure. On July 11th, 2017, a tower crane accident was reported in Johor, and the victim died after being struck by a hook block. This case happened when the tower crane's hook block broke and fell onto workers on the ground. During the incident, he was doing housekeeping under the crane operation area (DOSH, 2021). Then, an accident involving a tower crane was also reported in 2014 at the construction site in Pulau Pinang (DOSH, 2021). The victim, a civilian, was crushed to death by a tower crane. The victim, who was sleeping, died when the crane, in a free-standing condition, suddenly collapsed onto the shop house inhabited by the victim. After an investigation by DOSH, it was found that the accident was caused by a failure in the crane foundation.

Based on these scenarios, a solution to tower crane accidents is still unsatisfactory; crane injuries are still happening, and the number of accidents and death rates have increased. There are several issues involved with the tower crane operation at the construction site in Malaysia. Tower crane accidents are categorised as technical accidents, such as mechanical failure, crane overturn, and momentum loss, which would trigger more liability loss. According to Arunkumar and Gunasekaran (2018), an accident does not necessarily result in an injury. It can be in terms of time lost, project execution, firm reputation, workers mental illness, and productivity loss. Construction projects that require tower cranes as heavy machinery need to be handled efficiently and carefully.

Despite this, current research only focuses on general cranes without specifically unclear what type of crane was involved in the accident. This is because each type of crane has different tasks, functions and components according to the conditions of the construction project. This research is more comprehensive and incorporated all aspects of the causes and safety performance at the construction site compare to previous research only focuses on certain aspects (i.e.: mechanical aspects).

Therefore, to overcome this problem, this research focuses on the causes of tower crane accidents with the safety performance practices at a construction site in Malaysia. The causes of tower crane accidents should be considered in order to reduce the probability of an accident. Consequently, safety issues should tackled immediately during tower crane operations in order to make these activities safe and secure.
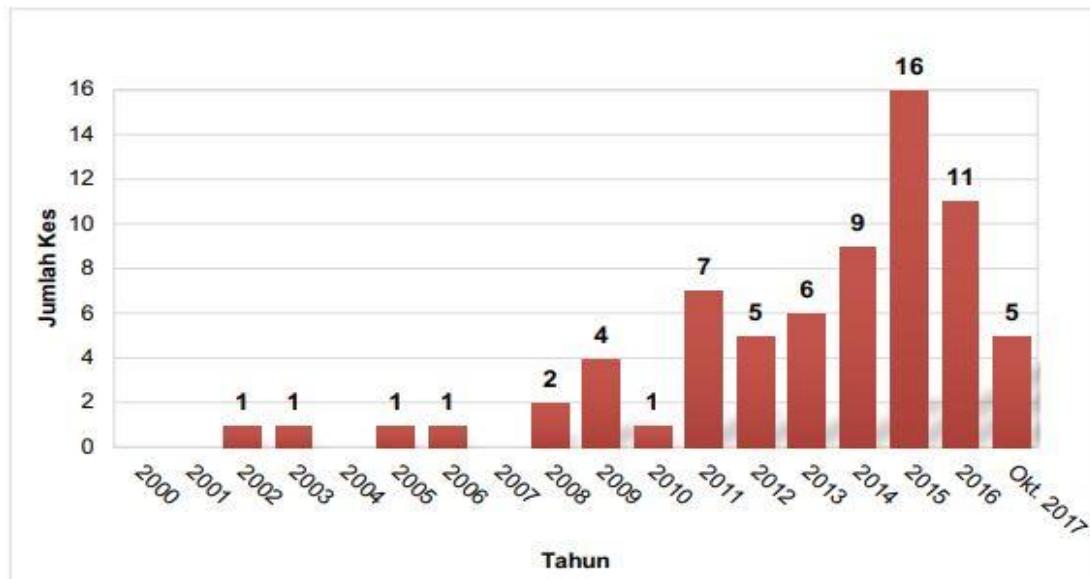
Figure 1.1: Statistics of accidents involving tower cranes (UKM Pakarunding, 2017)

1.3 Objective of Research

This research aims to identify the causes of tower crane accidents and safety performance practices at construction site in Malaysia. In order to achieve these aims, the objectives of this research are:

1. To identify the causes of accidents on construction sites at tower crane operation.
2. To determine the safety practices in tower crane operation that will lead to increase safety performance.
3. To propose and validate a diagram of accident causes and safety performance in a tower crane operation.

1.4 Scope of Research

The research scope will focus on the causes of tower crane accidents and safety performance practices at construction site in Malaysia. This research focuses on a building and civil construction site where activities are carried out by private and government departments. A questionnaire is distributed to the relevant tower crane

operator around Peninsular Malaysia. The method of data collection is based on quantitative approaches. Then, the data is analysed using frequency analysis, mean analysis and correlation coefficient analysis to determine the causes of tower crane accidents and safety performance practices at construction site in Malaysia.

1.5   Significance of Research

The construction industry in Malaysia and other developing countries faces a wide range of challenges, one of which is the frequent occurrence of accidents in the working areas. This research focuses on identifying the causes of tower crane accidents with the safety performance practices at the construction site in Malaysia. During the last few years, several accidents have occurred on various construction projects all over the country and involved worker fatalities. This problem has made the construction industry one of the high-risk industries in Malaysia regarding worker safety.

In view of this flow of events, some strategies must be implemented to reduce the number of construction site accidents. This research significance will assist and guide all parties involved in tower crane operations, such as contractors, safety practitioners and tower crane operators. Moreover, this research can also improve the safety performance practices related to tower crane operations and develop more effective regulations in the future. Besides that, this research will increase the awareness of all management levels about the importance of safety and health to reduce tower crane accidents at construction site.

1.6   Outline of Research

In a summary, Chapter 1 explain on background of tower crane, the problems occur regarding tower crane operation in Malaysia, the objective and significance of this research. Tower crane component and other element in this research were discussed briefly in Chapter 2. In Chapter 3, this chapter were discussed regarding the analysis method to analyses collected data. Next, Chapter 4 are more focused on data analysis and the outcome of this research and Chapter 5 focused on discussion and conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter was to discuss about the Malaysian construction industry, type of tower crane, parts of tower crane, issues related to tower crane operation, tower crane accident, causes of accident, safety performance practices and others. This chapter is essential to achieve the first objective of the research which is to identify the causes of tower crane accident with safety performance practices at construction site in Malaysia.

2.2 Malaysian Construction Industry

The construction industry is defined as activities or production work from the beginning until the finale. The activities include designing, planning, construct, demolition, repair, and maintenance. This industry plays an essential role as one of the contributors to economic development of the country (Abas *et al.,* 2020). The "Economic Outlook" by Ministry of Finance Malaysia (2020), shows that the construction industry contributed to 3% of economic growth in 2020. Since independence, Malaysia has begun to develop its construction industry, and more than half of capital formation consists of work in construction. Malaysia is also one of the countries that has skyscrapers buildings. The global trend of skyscraper construction indicates the growing impact of global competitiveness on the growth of the world's

largest cities. These cities competed on a global scale for the title of tallest skyscraper, which serves as a symbol of their developing economies confidence and global significance. An prominent towering skyscraper improves the city's global image (Ali and Al-Kodmany, 2012). For example, the KLCC building explains it is a landmark, and the outside community will recognize Malaysia when people see the building. The KLCC building 'sells' Malaysia's name to the whole world and most importantly, the existence of the building also explains that Malaysia is a developed and high technology country (Mat Hayin, 2017). The building will be a great legacy to the country and future generations. The idea of construction 452m high Petronas Twin Towers (KLCC) are from the 4th Prime Minister of Malaysia, Tun Dr. Mahathir bin Mohamad which became the pinnacle of national pride when it was recorded as the tallest skyscrapers in the world from 1998-2004 (Naidu, 1995). The upcoming two tallest skyscrapers of The Exchange 106 and Merdeka PNB118 with 492m and 630m height will be another symbolic of Malaysia construction success. The construction of Merdeka PNB118 are considered as 'megatall skyscraper' with the height ≥600m/1,968 ft. (Merchant, 2021). The Malaysian government commit more attention and focus on the construction industry for future development. Table 2.1 shows the list of tallest skyscrapers and upcoming skyscrapers in Malaysia.

Table 2.1: Tallest building information in Malaysia (Merchant, 2021)

No.	Building	State	Height (m)	Height (ft)	Building Floor	Year
1	Merdeka PNB 118	Kuala Lumpur	644 m	2,113 ft	118	Under Construction
2	Petronas Twin Tower 1	Kuala Lumpur	451.9 m	1,483 ft	88	1998
3	Petronas Twin Tower 2	Kuala Lumpur	451.9 m	1,483 ft	88	1998
4	The Exchange 106	Kuala Lumpur	445.5 m	1,462 ft	95	Under Construction
5	Coronation Square Tower 1	Johor	370 m	1,214 ft	78	Under Construction
6	Four Seasons Place	Kuala Lumpur	342.5 m	1,124 ft	74	2018
7	Oxley Tower 1	Kuala Lumpur	338.6 m	1,111 ft	84	Under Construction

REFERENCES

Abas, N. H., Yusuf, N., Suhaini, N. A., Kariya, N., Mohammad, H., & Hasmori, M. F. (2020). Factors Affecting Safety Performance of Construction Projects: A Literature Review. *IOP Conference Series: Materials Science and Engineering,* 713(1). https://doi.org/10.1088/1757-899X/713/1/012036.

Abdelhamid, T. S., & Everett, J. G. (2000). Identifying Root Causes of Construction Accidents. *Journal of Construction Engineering and Management,* 126(1), 52–60. https://doi.org/10.1061/(asce)0733-9364(2000)126:1(52).

Abdul, H., Naim, M., Mohd, A., Amir, M., Lokman, A., & Shaari, N. (2015). An Overview of the Management Commitment to Safety Elements for Mitigating Accidents in the Construction Industry. *Jurnal Teknologi Full Paper 2*, 1–8.

Abdul Rashid, I., Bassioni, H., & Bawazeer, F. (2007). Factor affecting safety performance in large construction contractor in Egypt. *In Proceedings of 23rd Annual ARCOM Conference, 3-5 September 2007, Belfast, UK, Association of Researches in Construction Management,* pp.661-670.

Abdullah, D. N. M. A., & Wern, G. C. M. (2011). An Analysis of Accidents Statistics in Malaysian Construction Sector. *International Conference on E-Business, Management and Economics,* 3, 1–4.

Agwu, M. O., & Olele, H. E. (2014). Fatalities in the Nigerian construction industry: a case of poor safety culture. *British Journal of Economics, Management & Trade*, *4*(3), 431-452.

Ahad, N. A., Yin, T. S., Othman, A. R., & Yaacob, C. R. (2011). Sensitivity of normality tests to non-normal data. *University Sains Malaysia*, 40(6), 637–641.

Ahmad Shukri, F. A. (2010). Malaysia construction experience in deployment of crane services for construction project. *University Teknologi Malaysia.*

Ahmed, S. (2019). Causes and effects of accident at construction site: A study for the construction industry in Bangladesh. *International Journal of Sustainable Construction Engineering and Technology*, 10(2), 18–40. https://doi.org/10.30880/ijscet.2019.10.02.003.

Ahmed, S. (2019). Causes of Accident at Construction Sites in Bangladesh. *Organization, Technology and Management in Construction: An International Journal,* 11(1), 1933–1951. https://doi.org/10.2478/otmcj-2019-0003.

Ahn, S., Kim, T., Park, Y. J., & Kim, J. M. (2020). Improving Effectiveness of Safety Training at Construction Worksite Using 3D BIM Simulation. *Advances in Civil Engineering, 2020*. https://doi.org/10.1155/2020/2473138.

Ali, M. K. A. M., & Mohamad, M. I. (2014). Crane failure and accident in construction. *Malaysia: Universiti Teknologi Malaysia*. 136–149.

Ali, M. M., & Al-Kodmany, K. (2012). Tall buildings and urban habitat of the 21st century: a global perspective. *Buildings*, *2*(4), 384-423.

Arunkumar, K., & Gunasekaran, J. (2018). Causes and effects of accidents on construction site. *International Journal of Engineering Science and Computing*, 8(6), 18102-18110.

Au Yong, C.P. (2013). The Relationship between Preventive Maintenance Characteristic and Maintenance Performance of High-Rise Office Building in Malaysia. *PhD Thesis, University of Malaya*.

Bamfo-Agyei, E., & Atepor, L. (2018). Assessing the safety use of tower cranes on construction sites in central region of Ghana. *Advances in Intelligent Systems and Computing,* 604(July), 486–496. https://doi.org/10.1007/978-3-319-60525-8_50.

Binding, S., & Extent, S. (2016). *Mastering Research Methods, 2e*. *June*, 1–11.

Boyd, P. (2012). Sampling Concepts. *MBA Faculty Conference Papers & Journal Articles*, *2002–2012*. https://doi.org/10.1201/9781420035636.ch3.

Carmona, I. G., & Collado, J. (2016). Control of a two wired hammerhead tower crane. Nonlinear Dynamics, *84(4), 2137–2148.* https://doi.org/10.1007/s11071-016-2634-3.

Chen, Z., & Wu, Y. (2010). Explaining the causes of construction accidents and recommended solutions. *2010 International Conference on Management and Service Science*, 1–5. https://doi.org/10.1109/ICMSS.2010.5576704.

Cheng, C. W., & Wu, T. C. (2013). An investigation and analysis of major accidents involving foreign workers in Taiwan's manufacture and construction industries. *Safety Science,* 57, 223–235. https://doi.org/10.1016/j.ssci.2013.02.008.

Chim, B. L. H., Chun, C. J., & Wah, F. K. (2018). Accidents in Construction Sites: A Study on the Causes and Preventive Approaches to Mitigate Accident Rate. *Inti Jurnal*, *1*(3), 1–12. http://eprints.intimal.edu.my/1136/

Chinniah, Y. (2015). Analysis and prevention of serious and fatal accidents related tomoving parts of machinery. *Safety Science,* 75, 163–173. https://doi.org/10.1016/j.ssci.2015.02.004.

Chong, L. H., Ibrahim, S. H., Affandi, R., Rosli, N. A., & Mohd-Nasrun, M. N. (2016). Causes of fall hazards in construction site management. *International Review of Management and Marketing*, 6(Special Issue), 257–263.

Chong, H. Y., & Low, T. S. (2014). Accidents in Malaysian construction industry: statistical data and court cases. *International journal of occupational safety and ergonomics*, *20*(3), 503-513.

Couto, J. P., Santos, F. J. B., & Rabbani, E. R. K. (2017). How time constraints affect safety conditions at construction sites: Analysis of the perception of Portuguese construction participants. *Electronic Journal of Geotechnical Engineering,* 22(02), 563-576.

CIDB Statistic. (2022, August 8). *Construction Industry Statistic (open data)*. Construction Industry Development Board. Retrieved February 13, 2022, from https://www.cidb.gov.my/en/construction-info/construction-statistic/construction-industry-statistic-open-data.

Dodge, R.B. (2012), Patterns of root cause in workplace injury. *International Journal of Workplace Health Management,* 5(1), 31-43.

Dorman, P. (2000). The Economics of Safety, Health, and Well-Being at Work: An Overview. In Focus Program on SafeWork, *International Labour Organisation, The Evergreen State College,* 1–41.

Djamba, Y. K., & Neuman, W. L. (2002). Social Research Methods: Qualitative and Quantitative Approaches. *In Teaching Sociology.* (Vol.30, Issue 3) https://doi.org/10.2307/3211488.

DOSH. (2022). Department of Occupational Safety and Health. *Official Website Department of Occupational Safety and Health Statistic*. https://Www.Dosh.Gov.My/. Retrieved 2022, from https://www.dosh.gov.my/index.php/statistic-v/occupational-accident-statistics/occupational-accident-statistic-2022.

DOSH. (2021). Department of Occupational Safety and Health. *Official Website Department of Occupational Safety and Health Statistic*. https://Www.Dosh.Gov.My/. Retrieved 2021, from https://www.dosh.gov.my/index.php/statistic-v/occupational-accident-statistics/occupational-accident-statistic-2021

DOSH. (2018). Department of Occupational Safety and Health. *Official Website Department of Occupational Safety and Health Statistic*. Https://Www.Dosh.Gov.My/. Retrieved 2021, from https://www.dosh.gov.my/index.php/statistic-v/occupational-accident-statistics/occupational-accident-statistic-2018.

DOSH. (2017). Department of Occupational Safety and Health. *Guidelines of Occupational Safety and Health in Construction Industry (Management) 2017 Messages from the Director General*.

DOSH. (2011). Department of Occupational Safety and Health. Guidelines on Occupational Safety. *Guidelines on Occupational Safety and Health Management Systems*, 1–24.

DOSH. (2007). Department of Occupational Safety and Health. Guidelines for Public Safety and Health. In *Guidelines for Public Safety and Health* (Vol. 1, pp. 1–24). Ir. Haji Mohd Hatta Zakar and Technical Committee.

Fung, I. W. H., Tam, V. W. Y., Sing, C. P., Tang, K. K. W., & Stephen, O. (2016). Psychological climate in occupational safety and health : the safety awareness of construction workers in South China. 3599 (March). https://doi.org/10.1080/15623599.2016.1146114.

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 10(2), 486–489. https://doi.org/10.5812/ijem.3505

Gillen, M., Goldenhar, L. M., Hecker, S., & Schneider, S. (2013). Safety Culture and Climate in Construction : Bridging the Gap Between Research and Practice. 1–60.

Goh, K. C., Goh, H. H., Omar, M. F., Toh, T. C., & Mohd Zin, A. A. (2016). Accidents preventive practice for high-rise construction. *MATEC Web of Conferences*, 47, 3–8. https://doi.org/10.1051/matecconf/20164704004.

Górny, A. (2017). Identification of occupational accident causes by use the Ishikawa diagram and Pareto principles. *Economics and Management Innovations (ICEMI),* 1(October 2017), 384–388. https://doi.org/10.26480/icemi.01.2017.384.388

Halim, N. N. A. A., Jaafar, M. H., Kamaruddin, M. A., Kamaruzaman, N. A., & Jamir Singh, P. S. (2020). The causes of malaysian construction fatalities. *Journal of Sustainability Science and Management*, *15*(5), 236–256. https://doi.org/10.46754/JSSM.2020.07.018.

Hoła, B., Nowobilski, T., Szer, I., & Szer, J. (2017). Identification of factors affecting the accident rate in the construction industry. *Procedia engineering*, *208*, 35-42.

Mat Hayin, N. A. (2017, August 18). Pencakar langit. *Harian Metro.(online)* Available at: <https://www.hmetro.com.my/nuansa/2017/08/254884/pencakar-langit>.

Hamid, A. R. A., Abd Majid, M. Z., & Singh, B. (2008). Causes of accidents at construction sites. *Malaysian journal of civil engineering*, *20*(2).

Hamid, A. R. A., Azhari, R., Zakaria, R., Aminudin, E., Jaya, R. P., Nagarajan, L., & Yunus, R. (2019). Causes of crane accidents at construction sites in Malaysia. *IOP Conference Series: Earth and Environmental Science* (Vol. 220, No. 1, p. 012028). IOP Publishing.

Hanapi, N. M., Kamal, M. M. M., Ismail, M. I., & Abdullah, I. A. P. (2013). Identifying Root Causes and Mitigation Measures of Construction Fall Accidents. *Gading Business Management Journal,* 17(1), 65–79. http://www2.pahang.uitm.edu.my/upena/docs/5. Normardiana (pp. 65-79).pdf.

HSE. (2012). Health and Safety training: A Brief Guide. *Government Leaflet*, 1–6. http://www.hse.gov.uk/pubns/indg345.pdf

Hussain, H. (2017). Reliability And Correlation Of Multimedia Element And Tablet Interface In Digital Storytelling. *Asia Pacific Journal of Educators and Education,* 31, 27–45. https://doi.org/10.21315/apjee2016.31.3

Ibrahim, A. R. Bin, Roy, M. H., Ahmed, Z., & Imtiaz, G. (2010). An investigation of the status of the Malaysian construction industry. *Benchmarking*, 17(2), 294–308. https://doi.org/10.1108/14635771011036357.

Ibrahim, M., (2010). Analisis Data Penyelidikan. 1st ed. *Kuantan: Bandar Ilmu*, pp.32-88.

Ismail, H. B., & Ghani, K. D. A. (2012). Potential Hazards at the Construction Workplace due to Temporary Structures. *Procedia - Social and Behavioral Sciences,* 49(December 2012), 168–174. https://doi.org/10.1016/j.sbspro.2012.07.015.

Ismail, Z., Doostdar, S., & Harun, Z. (2012). Factors influencing the implementation of a safety management system for construction sites. *Safety Science*, 50(3), 418– 423. https://doi.org/10.1016/j.ssci.2011.10.001.

Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science & Technology,* 7(4), 396–403. https://doi.org/10.9734/bjast/2015/14975

Kabir, S. M. S. (2016). Methods of data collection. *Plastic Surgical Nursing*, 14(2), 109–110. https://doi.org/10.1097/00006527-199406000-00014

Kemei, R. (2016). Occupational Accident Patterns and Prevention Measures in Construction Sites in Nairobi County Kenya. *American Journal of Civil Engineering,* 4(5), 254. https://doi.org/10.11648/j.ajce.20160405.17.

Kelloway, E. K., Kelloway, E. K., & Cooper, C. L. (Eds.). (2011).Occupational health and safety for small and medium sized enterprises. *Edward Elgar Publishing. Retrieved from http://QUT.eblib.com.au/patron/FullRecord.aspx?p=807375.*

Khahro, S., Ali, T., Talpur, M. A. H., Akhund, M. A., & Siddiqui, F. (2016). Occupational Health Problems in Construction Industry: A Case Study. *Sindh University Research Journal*, 48(December), 737–740.

Krejcie, R. V., & Morgan, W. D. (1970). Using methods of data collection. Advanced Public and Community Health Nursing Practice: Population *Assessment, Program Planning and Evaluation, Second Edition, 38*, 127–153. https://doi.org/10.1891/9780826138446.0006

LearnWithBel, P. (2020, July 8). Adverbs and expressions of frequency. *Cursos de Ingles - Underground English Institute*. Retrieved August 12, 2022, from https://www.undergroundenglish.cl/institute/?p=1962

Lee, D., Lim, H., Cho, H., & Kang, K. I. (2015). Optimization of luffing-tower crane location in tall building construction. *Journal of Construction Engineering and Project Management*, 5(4), 7-11.

Long, T. Y. U. E., Jun, Z. H. U. H., Hai, L. U., Toh, A., Chiah,(2019). Best Practices on Occupational Safety and Health in Construction Industry 2019.

Manu, P., Mahamadu, A. M., Phung, V. M., Nguyen, T. T., Ath, C., Heng, A. Y. T., Kit, S. C. (2018). Health and safety management practices of contractors in South East Asia: A multi country study of Cambodia, Vietnam, and Malaysia. *Safety Science*, 107, 188–201. https://doi.org/10.1016/j.ssci.2017.07.007.

Manzoor, B., Othman, I., & Manzoor, M. (2021). Evaluating the critical safety factors causing accidents in high-rise building projects. *Ain Shams Engineering Journal*, *12*(3), 2485-2492.

McGettigan, T. (2021) *World-wide tower crane accident statistic 2000 – 2009* http://towercranesupport.com/tower%20crane%20accidents%202.php.

Ministry of Finance Malaysia, (2020). Economic Outlook in 2020. 1–26. https://www.mof.gov.my/portal/arkib/economy/ec_Main.html.

Misnan, M. S., Hakim, A., Yusoff, W., & Mahmood, W. (2008). Development of Safety Culture in the Construction. *23rd Annual ARCOM Conference, Icbedc*, 1902–1920.

Merchant, C. (2021, June 10). *Malaysia now officially has a new 'tallest building' Champ*. ExpatGo. Retrieved April 13, 2022, from https://www.expatgo.com/my/2021/06/10/malaysia-now-officially-has-a-new-tallest-building-champ/.

Mohammadi, A., Tavakolan, M., & Khosravi, Y. (2018). Factors in fluencing safety performance on construction projects: A review. *109*(December 2017), 382–397. https://doi.org/10.1016/j.ssci.2018.06.017.

Muhamad Zaini, N. Z., Fikri Hasmori, M., Mat Salleh, M. A., Norazam Yasin, M., & Ismail, R. (2020). Crane Accidents at Construction Sites in Malaysia. *IOP Conference Series: Earth and Environmental Science,* 498(1). https://doi.org/10.1088/1755-1315/498/1/012105.

Mukaka, M. (2012). Statistics Corner: A Guide to Appropriate Use of Correlation Coefficient. *Malawi Medical Journal,* 24(3), 69–71. https://pubmed.ncbi.nlm.nih.gov/23638278/

Nagapan. S., Abdul Rahman. I., & Asmi. A.. (2011). A Review of Construction Waste Cause Factors. Conference of Real Estate: Sustainable Growth Managing Challenges, Johor Bahru, Malaysia. http://eprints.uthm.edu.my/2665/.

Naidu, K. G. (1995). The Petronas Tower: The World's Tallest Building. *CPAC Seminar*. http://www.jtkconsult.com.my/pdf/CPAC95.pdf.

Nawi, M. N. M., Ibrahim, S. H., Affandi, R., Rosli, N. A., & Basri, F. M. (2016).

Factor affecting safety performance construction industry. *International Review of Management and Marketing*, 6(8), 280-285.

O'Toole, M. (2002). The relationship between employees' perceptions of safety and organizational culture. *Journal of Safety Research,* 33(2), 231–243. https://doi.org/10.1016/S0022-4375(02)00014-2.

Othman. T., (2015). *Tajuk 706 SPSS dan Normality SV pun jadi tak normal !!.* [online] Drotspss.blogspot.com. Available at: <http://drotspss.blogspot.com/2015/01/tajuk-706-spss-dan-normality-sv-pun.html> [Accessed 30 September 2021].

Omar Alrehaili. (2016). Assessing Safety Culture Among Personnel In Governmental Construction Sites At Saudi Arabia: A Quantitative Study Approach. *Journal of Chemical Information and Modeling,* 53(9), 1–702.

Othman, I., Majid, R., Mohamad, H., Shafiq, N., & Napiah, M. (2018). Variety of accident causes in construction industry. *MATEC Web of Conferences* (Vol. 203, p. 02006). EDP Sciences.

Peng, B., Flager, F. L., & Wu, J. (2018). A method to optimize mobile crane and crew interactions to minimize construction cost and time. *Automation in Construction*, 95(July 2017), 10–19. ttps://doi.org/10.1016/j.autcon.2018.07.015.

Prabhaker Mishra, Chandra M Pandey, Uttam Singh, A. G., Sahu, C., & Keshri, A. (2019). Descriptive Statistics and Normality Tests for Statistical Data. *Annals of Cardiac Anaesthesia*, 20(4), 456–458. https://doi.org/10.4103/aca.ACA_36_17.

Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting and Management,* 8(3), 238–264. https://doi.org/10.1108/11766091111162070.

Rabun, M. N., & Ladisma, M. (2021). Statistical Note for SPSS Exercises *ADS651 / ADS511*.

Raviv, G., Fishbain, B., & Shapira, A. (2017). Analyzing risk factors in crane-related near-miss and accident reports. *Safety Science,* 91, 192–205. https://doi.org/10.1016/j.ssci.2016.08.022.

Rosli, M. F. (2016). Keselamatan Dan Kesihatan Operasi Kren Menara di Malaysia *[Master's thesis]. UTM Dissertations*. *16* (May), 1–81.

Saifullah, N. M., & Ismail, F. (2012). Integration of occupational safety and health during pre-construction stage in Malaysia. *Procedia-Social and Behavioral Sciences*, zaka*35*, 603-610.

Salim, S. M., Romli, F. I., Besar, J., & Aminian, N. O. (2017). A study on potential physical hazards at construction sites. *Journal of Mechanical Engineering,* SI 4(1), 207–222.

Sarkam, S. F., Shaharuddin, L. S., Zaki, B. M., Masdek, N. R. N. M., Yaacob, N. J. A., & Mustapha, M. (2018). Factors Influencing Safety Performance at the Construction Site. *International Journal of Academic Research in Business and Social Sciences,* 8(9), 1057–1068. https://doi.org/10.6007/ijarbss/v8-i9/4680.

Septiawan, D. B., & Bekti, R. (2016). Analysis of Project Construction Delay Using Fishbone Diagram at PT Rekayasa Industri. *Journal of business and management*, *5*(5), 634-650.

Sekaran, U. (2000). Research Methods for Business: A Skill-Building Approach *(3rd ed.). John Wiley and Sons*, New York, NY.

Sedgwick, P. (2012). *What is sampling error? BMJ (Online)*, *344*(7863). https://doi.org/10.1136/bmj.e4285

Shapira, A., & Simcha, M. (2009). AHP-Based Weighting of Factors Affecting Safety on Construction Sites with Tower Cranes. *Journal of Construction Engineering and Management,* 135(4), 307–318. https://doi.org/10.1061/(asce)0733-9364(2009)135:4(307)

Shi, R., & Conrad, S. A. (2019). Correlation and regression analysis. *Annals of Allergy, Asthma and Immunology*, 103(4 SUPPL.). https://doi.org/10.1016/s1081-1206(10)60820-4

Shin, I. J. (2015). Factors that affect safety of tower crane installation/dismantling in construction industry. *Safety Science,* 72, 379–390. https://doi.org/10.1016/j.ssci.2014.10.010,

Sleet, D. A., Dahlberg, L. L., Basavaraju, S. V., Mercy, J. A., McGuire, L. C., & Greenspan, A. (2011). Injury prevention, violence prevention, and trauma care: building the scientific base.

SOCSO. (2019). *2018 Annual Report* (8th ed.). Social Security Organization. https://www.perkeso.gov.my/images/laporan_tahunan/LAPORAN%20TAHUNAN%20_ANNUAL%20REPORT%202018.pdf.

Soriano, B. J. N., Duarte, S. G., Alonso, A. M. F., Perales, A. B., & Carreño, T. P. (2020). Validation of a questionnaire developed to evaluate a pediatric ehealth website for parents. *International Journal of Environmental Research and Public Health,* 17(8). https://doi.org/10.3390/ijerph17082671.

Swuste, P. (2013). A "normal accident" with a tower crane? An accident analysis 142 conducted by the Dutch Safety Board. *Safety Science*, 57, 276–282. https://doi.org/10.1016/j.ssci.2013.03.002.

Taherdoost, H. (2018). Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. *SSRN Electronic Journal*, September. https://doi.org/10.2139/ssrn.3205040

Tam, C. M., Zeng, S. X., & Deng, Z. M. (2004). Identifying elements of poor construction safety management in China. *Safety Science*, 42(7), 569–586. https://doi.org/10.1016/j.ssci.2003.09.001.

Tam, V. W. Y., & Fung, I. W. H. (2011). Tower crane safety in the construction industry: A Hong Kong study. *Safety Science,* 49(2), 208–215. https://doi.org/10.1016/j.ssci.2010.08.001.

The Sun. (2016, October 17). *Bernama staffer almost killed when two-metre pipe fell from crane. TheSun.Com.* Retrieved July 23, 2021, from https://www.thesun.com/news/359399.

Thode, H. C. (2011). Normality Tests. *International Encyclopedia of Statistical Science,* 1954, 999–1000. https://doi.org/10.1007/978-3-642-04898-2_423.

Upendar, S. (2018). Design and analysis of a crane hook. *International Journal of Current Engineering and Scientific Research,* 5(4), 10–15.

UKM Pakarunding, (2017). Training Module for Operator (Tower Crane). *Jabatan Keselamatan Dan Kesihatan Pekerjaan*, 1(August), 225. https://www.dosh.gov.my/index.php/construction-safety-v/research/tower-crane-1/training-module/3975-module-crane-operator-bi/file.

UKM Pakarunding, (2017). Tower Crane Accident Profile. *Jabatan Keselamatan Dan Kesihatan Pekerjaan*, 30(October), 125. https://www.dosh.gov.my/index.php/construction-safety-v/research/tower-crane-1/accident-profile.

UTM Unbox. (2021a). *Lifting Operation at Night.* (Webinar). (2021, September 5).

UTM Unbox. (2021b). *Lifting Gear Inspection and Maintenance.* (Webinar). (2021, October 17).

UTM Unbox. (2021c) *Safe Lifting Operation Practices (SLOP)* (Webinar). (2021, October 3).

Vitharana, G. H. M. J. Subashi D. S., and Sudhira D. S. (2015) "Health Hazards, Risk and Safety Practices in Construction Sites"Vol. XLVIII, No. 03, pp[35- 44].

Waris, M., Liew, M. S., Khamidi, M. F., & Idrus, A. (2014). Investigating the awareness of onsite mechanization in Malaysian construction industry. *Procedia Engineering,* 77, 205–212. https://doi.org/10.1016/j.proeng.2014.07.018.

Win, K. N., Trivedi, A., & Lai, A. S. (2018). Workplace fatalities in Brunei Darussalam. *Industrial Health*. 566–571.

Winge, S., & Albrechtsen, E. (2018). Accident types and barrier failures in the construction industry. *Safety Science,* 105(February), 158–166. https://doi.org/10.1016/j.ssci.2018.02.006.

Xu, S., Zhang, M., & Hou, L. (2019). Formulating a learner model for evaluating construction workers' learning ability during safety training. *Safety Science,* 116(March), 97–107. https://doi.org/10.1016/j.ssci.2019.03.002.

Yakubu, D. M., & Bakri, I. M. (2013). Evealuation of safety and health performance on construction sites (Kuala Lampur). *J. Mgmt. & Sustainability*, *3*, 100.

Younes, A., & Marzouk, M. (2018). Tower cranes layout planning using agent-based simulation considering activity conflicts. *Automation in Construction,* 93(September 2017), 348–360. https://doi.org/10.1016/j.autcon. 2018.05.030.