Original Article

Safety Competency on Heavy Machinery: A Comparison Study Between the Importance and Practices from Site Supervisor Perceptions

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ABSTRACT: *There is an increase in awareness of employee competency and relation to accidents that occur during operations and maintenance of heavy machinery. The competence level of operators and supervisors are one of the critical factors related to safety in the workplace. A survey was developed to assess the comparison of perceptions between the practice and the level of importance regarding safety for heavy machinery. Respondents consisted of supervisors and operators of heavy machinery. In this paper, the discussion will focus on the supervisor's perception and practice when managing and maintenance of heavy machinery. The results found that the percentage of the level of 'Importance' more than the percentage of 'Practice' for all elements. These results further indicate that the need for training is very important for improving the competence of handling heavy machinery.*

Keywords: *Competency, Heavy Machinery, Operator, Safety, Supervisor*

1.0 INTRODUCTION

A heavy machinery management system and competent workers are important to ensure the safety of all parties. Work involving the use of heavy machinery requires skills and knowledge in terms of operation and maintenance so that the machinery can operate safely. Employees who operate the machinery must also be competent and skilled in various aspects such as safety and technical problems of the machinery used. They need to attend courses offered by NIOSH or relevant external parties to increase their competence in the use of heavy machinery. However, there are still risks and require monitoring, standards, safe work practices, good training modules, and proper maintenance to prevent accidents.

The construction industry contributes to around 6% of Malaysia's GDP in recent years (Trading Economics, 2020). Heavy machinery is part of the important assets for different land works and material handling activities in the construction industry. Since construction is one of the major industry, accidents often occur, and it will impact the overall project flow and cost. And the root cause of the accident is always related to less precaution regarding safety procedures and the level of competencies of the heavy machinery operators and supervisors. Therefore, a correct safety precaution to minimize the accident occurrence regarding heavy machinery will benefit the industry (Zaini, 2020; Lee, 2020; Bedi, 2021).

The most common type of accident in Malaysia is one involving heavy machinery. Due to physical interaction with powered machinery without proper safeguarding and control, heavy machinery can be a threat and cause serious injuries. Backhoe injuries, rollover accidents, struck-by accidents, faulty machine components, and electrocution are all causes of heavy machinery operator accidents (Cordeiro, 2005; Duarte, 2021; Kazan, 2018).

To minimise workplace accidents, it is proposed that heavy machinery operators need specialised skills (Permana, 2010). To minimise heavy machinery accidents, heavy machinery operators must have a thorough understanding of the necessary competencies. Furthermore, although the majority of those who work with heavy machinery, such as operators and safety supervisors, have completed a competency course, not all of them have put their training into practice while handling the projects (Yin, 2017; Kecojevic, 2004; Md-Nor, 2008).

This paper aims to compare the value of safety and existing safety practices among safety supervisors working on construction sites with heavy machinery. The findings of this study will help to clarify the difference between knowledge and practice for people who work with heavy machinery.

2.0 METHOD

A survey among the construction workers, including project managers, health, safety, and environmental (HSE) officers, site supervisors, training instructors, heavy machinery operators, general workers were conducted to identify and gather data on the safety practices. A total of 63 respondents have answered the survey questions with the site supervisors contributing 38% of the respondent. This paper focuses on the comparison between 'Level of Importance' and 'Current Practice' of safety by the site supervisor based on the collected survey data.

Fig. 1 shows the distribution of respondents in which 38% are working as supervisors who are closely or directly related to users/operators of heavy machinery which represents 25% of the respondents. Other distributions showed 18% as HSE officer, 8% as heavy machinery management, 6% as heavy machinery instructors, 3% as general workers, and 2% as enforcers. Fig. 2 shows 46% of the site supervisors never attend any heavy machinery training.

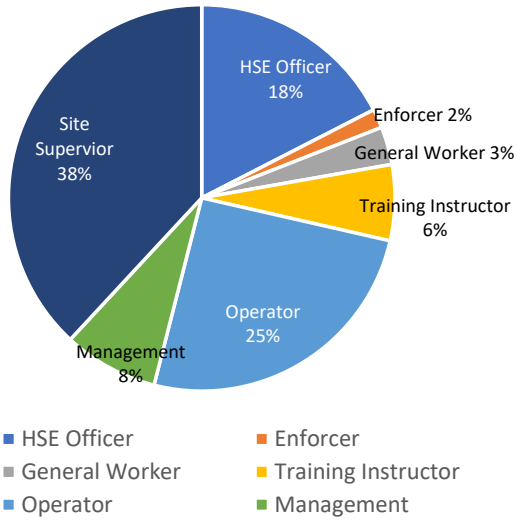

Figure 1 Distribution of Respondents Based on Occupation

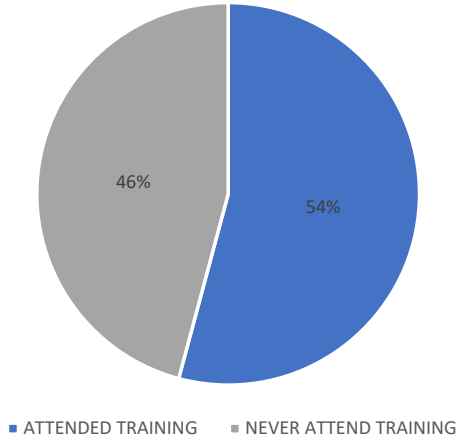

Figure 2 Percentage of Site Supervisor Attended Heavy Machinery Training

The discussion of the findings of this questionnaire is divided into the following order such as the profile of the respondents, operations & monitoring and technical knowledge. The measure for “Level of Importance” and “Current Practice” used in this analysis was the percentage of respondents. This questionnaire requires respondents to answer "Yes" or “No” to a question that requires a yes or no answer. For questions requiring answers on a 5-point Likert scale, respondents were asked to state the level of importance for questions requiring answers “Very Important, Important, Neutral, Not Important, Very Unimportant” and were asked to state the frequency level for questions requiring answers "Always, Very Often, Sometimes, Rarely, Never".

A total of four main types of heavy machinery were classified in this study. Based on the results of the questionnaire, there are six types of lifting machinery, five types of transport machinery, six types of construction machinery, and five types of loading machinery operated or supervised by respondents. This distribution is shown in Fig. 3.

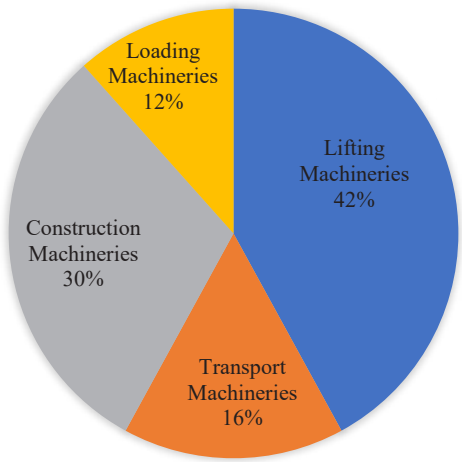

Figure 3 Types of Heavy Machinery Operated or Supervised by Respondent

3.0 RESULTS AND DISCUSSION

Fig. 4 shows the frequency of heavy machinery used or supervised by respondents. A total of 14.7% of respondents have experience in operating or supervising the use of excavators, 11.8% backhoe loader, 9.4% carrier trucks, 6.2% mobile cranes, 5.9% steamroll, 5.6% bulldozers and cement mixer trucks, 5.3% use tractors, 5.0% use front loaders, 4.7% piling machinery, 4.4% tank trucks, 3.8% forklift, 3.5% using drilling rigs, plough machine and garbage trucks, 3.2% grader, 2.9% skid steer loader and tower cranes, 2.4% sky lifts, 0.6% gantry cranes, and finally, 0.3% each represented bored piles, cargo trailers, loaders, log trucks, low loaders, roller compactor, and side loaders.

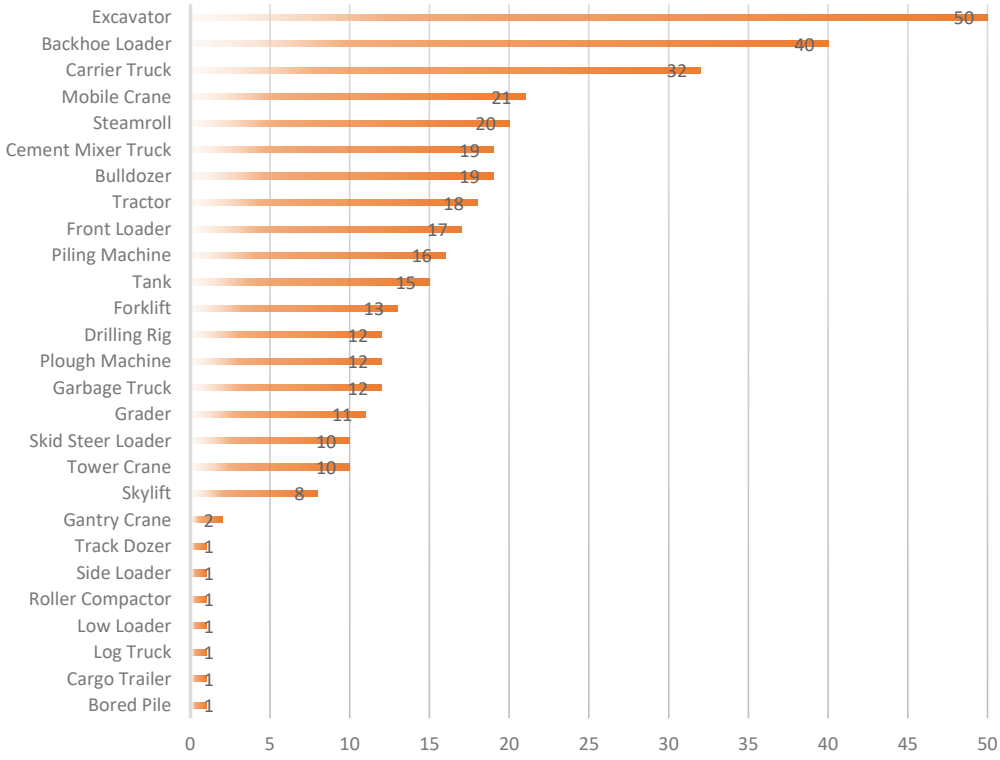

Figure 4 Breakdown of Heavy Machinery Used or Supervised

3.1 Level of Importance and Current Practices Regarding Safety in the Workplace

This section discusses the level of importance and current practices regarding safety in the workplace and it is divided into seven items on the importance and current practices in the workplace such as: Able to identify or detect site hazards and barriers such as power lines, underground cables/pipes, and other hazardous systems (B1), able to identify areas allowed to public access (B2), have current knowledge of safety rules in the workplace (B3), responsibility for safety and health limited to work in the workplace (B4), responsibility for safety and health other than work in the workplace (B5), trained in first aid skills (B6), and able to provide an appropriate response in the event of an emergency or case of an accident at work (B7).

Fig. 5 shows that all respondents response between "very important" and "important" but in terms of current practice, there are many shortcomings, especially for sections "B1: Able to identify or detect site hazards and barriers such as power lines, underground cables/pipes, and other hazardous systems", "B3: Have current knowledge of safety rules in the workplace", "B4: Responsibility to maintain safety and health at the workplace" and "B6:Trained in first aid skills".Overall, for all elements asked, as discovered the percentage of 'Level of Importance' for all questions asked was greater than outcome obtained by the 'Current Practice'. The difference is due to only half of the site supervisors in this survey have attended heavy machinery training as mentioned in Fig. 2. By attending training on heavy machinery, it is convinced that knowledge from questions B1, B3, and B6 can be further enhanced. These results show that the need for training is very important for the improvement of heavy machinery handling and competencies.

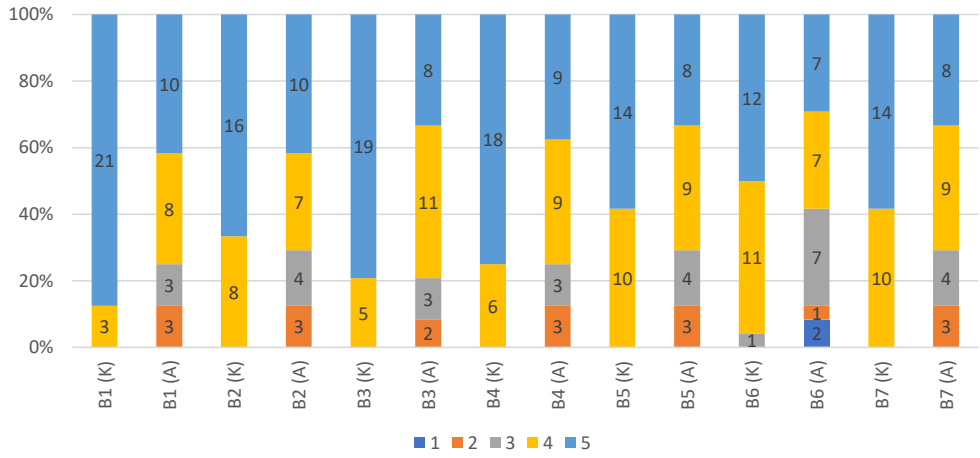

Figure 5 Level of Importance and Current Practices Regarding Safety in the workplace: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.2 Level of Importance and Current Practices During Operations

This section discusses each nine 'Level of Importance' and 'Current Practices' during the operation of heavy machinery, namely knowing the emergency response procedure in the event of an accident while operating heavy machinery (C1), the emergency response procedure in the event of heavy machinery failure (C2), the emergency response procedure for fire control (C3), emergency response procedures in the event of contact with electrical power sources (C4), how to inspect heavy machinery to ensure machinery is always in the best condition (C5), complete records or forms of handling of heavy machinery (C6), how to safely operate heavy machinery (C7), the appropriate time to communicate with supervisors and management (C8), how best to communicate with supervisors and management (C9).

Based on Fig. 6, almost all respondents make a selection between “very important” and “important” for the ‘Level of Importance’ questionnaires. In terms of current practice, almost all have chosen the lower level answer and some respondents select "Never" for the question "C5: Know how to inspect heavy machinery to ensure the machinery is always in the best condition", "C6: Complete records or forms of operation of heavy machinery”, “C7: Know how to safely operate heavy machinery” and “C8: Know the appropriate time to communicate with supervisors and management”. This information is believed because the respondents have never conducted training but operated heavy machinery on a freelance basis. The appropriate communication time between the operator and the supervisor can also be seen as a key issue and shall be included in the training module at a later stage. Overall, the percentage of ‘Level of Importance’ for all questions asked was greater than what was obtained by the percentage of ‘Current Practice’. The results have shown that the need for training is very important for the improvement of heavy machinery handling competencies.

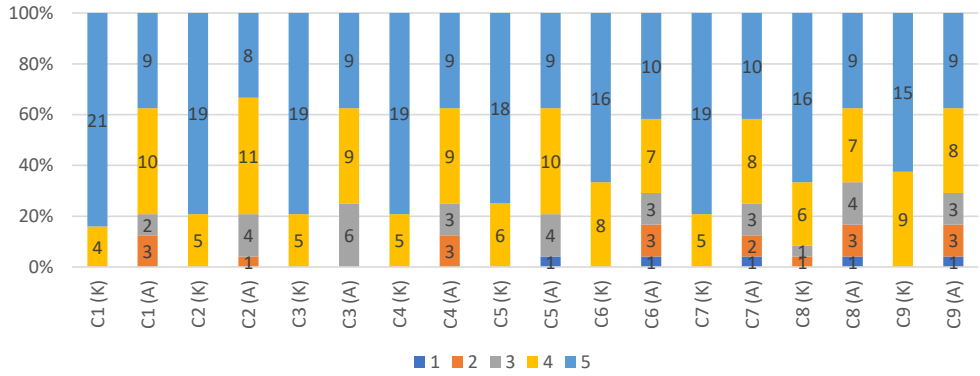

Figure 6 Level of Importance and Current Practice During Heavy Machinery Operation: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.3 Level of Importance and Current Practices During Monitoring

This section discusses fourteen ‘Level of Importance’ and ‘Current Practices’ during heavy machinery monitoring to assess the knowledge and practice on how: To perform basic heavy machinery maintenance (C11), to stop operation and keep heavy machinery safe when left (C12), to use operator aids and limiting devices for forklifts and skylifts (C13), to operate safely based on recommendations from manufacturers (C14), know the original project schedule (C15), aware of any changes to the project schedule (C16), attend safety training (C17), attend heavy machinery operation training (C18), aware of current weather conditions (C19), aware of site safety conditions (C20), aware standard operating procedures for retrenchment during emergencies (C21), safety is a priority topic at pre-construction and construction meetings (C22), knowing the correct or allowable maximum working day period (C23), and know the working period overtime and the rate of payment (C24).

Fig. 7 shows the respondents chose “very important” and “important” indicating the Level of Importance but in terms of practice, there are many shortcomings. In terms of current practice, almost all chose the low level, especially for questions “C13: Know how to use operator aids and limiting devices for forklifts and skylifts”, “C16: Aware of any changes to the project schedule” and “C23: Know the correct or allowable maximum working day period”. For the question “C13: Knowing how to use operator aids and limiting devices (for forklifts and skylifts)”, a low result in practice was expected because there are respondents who do not operate or supervise this type of heavy machinery compared to others. Overall, for all elements that have been questioned on the percentage of ‘Level of Importance’ for all questionnaires, as discovered, the outcome was greater than what has been obtained from the percentage of ‘Current Practice’.

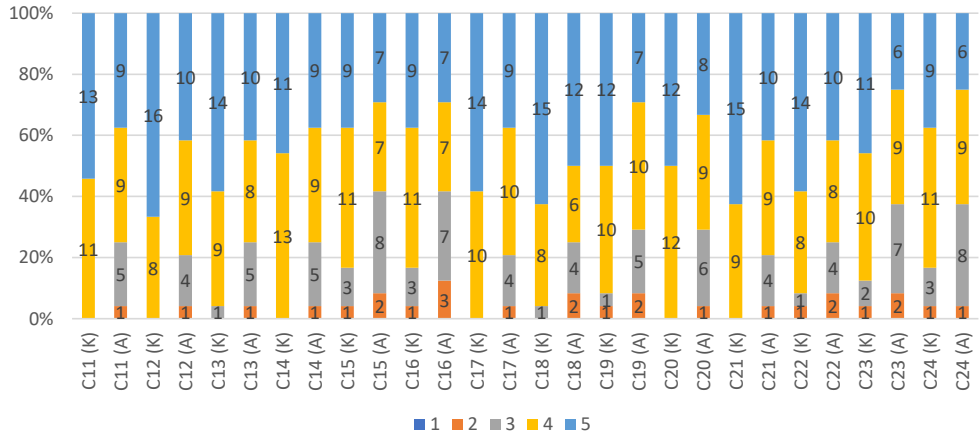

Figure 7 Level of Importance and Current Practice During Heavy Machinery Monitoring: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.4 Technical Knowledge for Pre-Operational Activities

Based on Fig. 8, all heavy machinery operators and supervisors agreed they need to be alert to heavy machinery accident situations (D1), know the standards, rules, and laws that can be applied in the workplace (D2), know and understand the basic nomenclature of heavy machinery (D3), know the basics of maintenance and inspection criterion for heavy machinery (D4), understand the basic systems of machine power flow of mechanical, electrical, hydraulic and their combination (D5), know how to check structural integrity (D6), know the documents required in the operation of heavy machinery (D7), and understand the safe operating procedures (D8). But in terms of practice, almost 30% felt that they were still at a medium and low level despite feeling the importance of technical knowledge about heavy machinery.

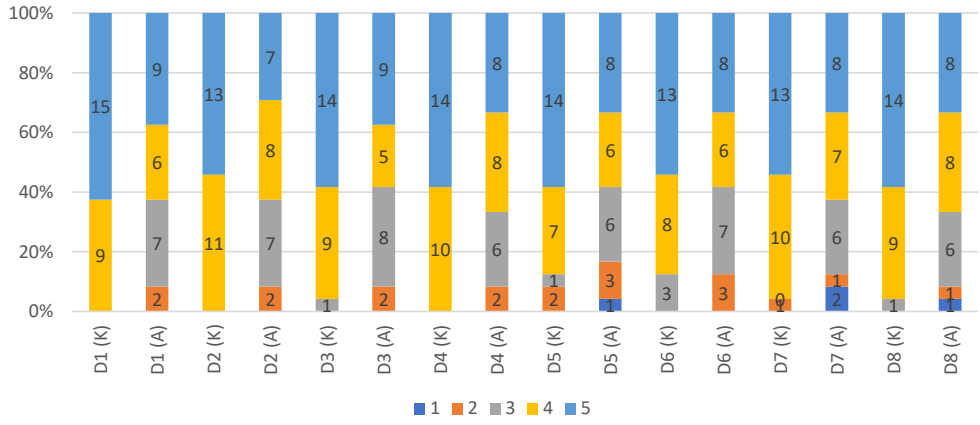

Figure 8 Technical Knowledge of Heavy Machinery Pre-Operational Activities: (K) is a Level of Importance and (A) is Current Practice, with Scale 5 for (K) is Very Important and (A) is Always

3.5 Training and Safety Management Systems Reduce Risk

This section discusses two main issues on the management of safety systems and hazardous incidents and accidents involving heavy machinery. Fig. 9 shows that 20% of the respondents did not undergo specific construction-related training (E2), but almost all companies have safety management systems in their respective companies (E3). Fig. 10 shows that some respondents feel that there is a possibility of accidents based on the existing risk management in their respective workplaces. There were also 48 near-miss accidents and 25 accidents at work when the respondents were operating or supervising the heavy machinery at the workplace. Of these 48 near-miss accident incidents, there are still 6% that were not investigated. As for the accident, 100% of the respondents stated that the accident had been investigated.

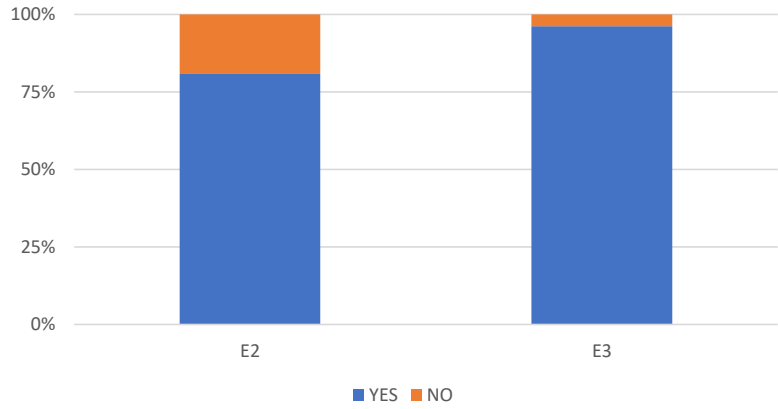

Figure 9 Site-Specific Training and Workplace Management Systems

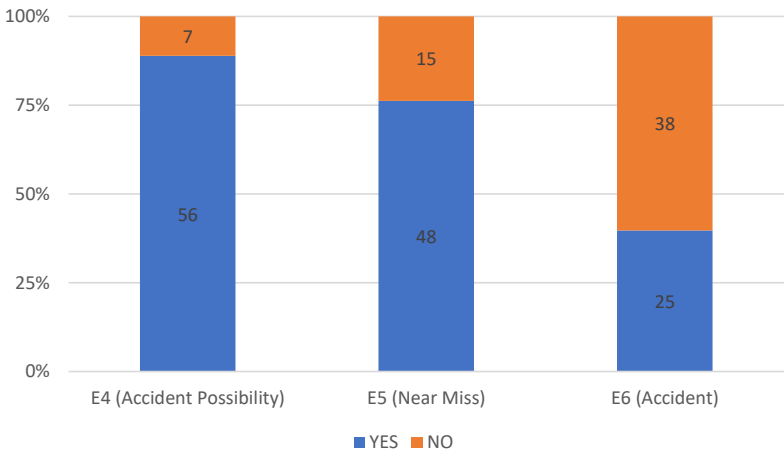

Figure 10 Accidents and Near Misses while Operating Heavy Machinery

4.0 CONCLUSION

Based on the questionnaire of the survey conducted, it can be concluded that the level of importance and practices in the workplace for operations and monitoring; technical knowledge, pre-operation, training, certification, and registration; accidents; needs to be understood and implemented properly by the supervisor and operators of heavy machinery to ensure safe operation of machinery. Overall, for all elements being questioned, the percentage on 'Level of Importance' on responses found was greater than what was obtained by the percentage of 'Current Practice'. According to survey outcome, responses gathered from questions being asked on knowledge, the majority of site supervisors believe knowledge is essential but still lacking in practice. This is because they must expand their knowledge and skills until they can become competent. The finding indicates that the demand for training is very important for improving the level of competence of handling heavy machinery.

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REFERENCES

Bedi, J.K., Rahman, R.A., & Din, Z. (2021). Heavy Machinery Operators: Necessary Competencies to Reduce Construction Accidents. *IOP Conference Series: Earth and Environmental Science*, 641,012007.

Cordeiro, R., & Dias, A. (2005). Stressful Life Events and Occupational Accidents. *Scandinavian Journal of Work, Environment & Health,* 31, 139–148.

Duarte, J., Marques, A.T., & Santos Baptista, J. (2021). Occupational Accidents Related to Heavy Machinery: A Systematic Review. *Safety, 7*(1),21.

Kazan, E. & Usmen, M.A. (2018). Worker Safety and Injury Severity Analysis of Earthmoving Equipment Accidents. *Journal of Safety Research*, 65.73-81.

Kecojevic, V., & Radomsky, M. (2004). The Causes and Control of Loader-and Truck-Related Fatalities in Surface Mining Operations. *International Journal of Injury Control and Safety Promotion*, 11,239–251.

Lee, J.Y., Yoon, Y.G., Oh, T.K., Park, S., & Ryu, S.I. (2020). A Study on Data Pre-Processing and Accident Prediction Modelling for Occupational Accident Analysis in the Construction Industry. *Applied Sciences, 10*(21), 7949.

Md-Nor, Z., Kecojevic, V., Komljenovic, D., & Groves, W. (2008). Risk assessment for Loader-and Dozer-Related Fatal Incidents in US Mining. *International Journal of Injury Control and Safety Promotion*, 15,65–75.

Permana, H. (2010). Risk assessment as a Strategy to Prevent Mine Accidents in Indonesian Mining. *Review Mining,* 4, 43–50.

Trading Economics. Malaysia GDP from Construction. Retrieved October, 2020, from Economic website, https://tradingeconomics.com/malaysia/gdp-from-construction

Yin, W., Fu, G., Yang, C., Jiang, Z., Zhu, K., & Gao, Y. (2017). Fatal Gas Explosion Accidents in Chinese Coal Mines and the Characteristics of Unsafe Behaviors: 2000–2014. *Safety Science,* 92,173–179.

Zaini, N.Z.M., Hasmori, M.F., Salleh, M.A.M., Yasin, M.N., & Ismail, R. (2020). Crane Accidents at Construction Sites in Malaysia. *IOP Conference Series: Earth and Environmental Science,* 498,012105.