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IDENTIFICATION OF FLOOD IMPACTS ON CONSTRUCTION SITES

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ABSTRACT

Flooding is an unexpected phenomenon that happens throughout the year in Malaysia and has become very common. The yearly recurrence of floods has had a significant influence on the lives of humans and other living beings specifically at the construction sites. Due to the negative impact of floods, awareness must be given careful consideration. The purpose of this research is to identify the impact of the flood occurrence on the construction sites. The initial research begins with a literature review from various scholars on key areas of flood and the impact of flood on construction sites. The next stage was of obtaining the data was though primary data. The research instrument was a set of questionnaires. The questionnaires were divided into two sections A – Demographic Questions and B – The impacts of flood. Questions for Section B used five Likert Scales strongly agree to strongly disagree. All the data were analysed using SPSS software, on the frequency and descriptive analysis. The respondents were contractors in Grade 7 (G7) registered with the Construction Industry Development Board (CIDB) in Selangor state. A total of 146 respondents participated in this research. This research identified five impacts of flood occurrence in construction sites.

There are reconstruction and maintenance of the building structure, safety of labour, the cost of reconstruction, the defects to the building structure, and construction delays. All the construction stakeholders need to be aware and prepared with the flood occurrence to avoid from losses and delays to construction project.

Keywords: *Flood, Construction industry, Impact, Construction site*

INTRODUCTION

Recently, floods are the most regular natural disaster in Malaysia. Based on NADMA report 2021, flood has been categorised as the common hazard in Malaysia with the highest likelihood of happening and extreme impacts that may directly or indirectly affect the country over the next five years. According to Luino (2016), flooding is a natural process that occurs when the level of a body of water rises until it overflows its natural banks or artificial levees and submerges areas that were usually dry. Along a watercourse, a flood can manifest itself annually. Usually, high water flow is contained between the natural banks or artificial levees, but when the volume of the flood waters can no longer be contained within those natural or artificial confines, waters expand into the surrounding areas. Specifically, there are two types of flooding that usually occur in Malaysia which are monsoon flood and flash flood. Monsoon flood normally occurs around the month of May until August (Southwest Monsoon) and around the month of November until February (Northeast Monsoon). The differences between these two floods are Flash floods take a few hours to return to the normal level of expression compared to monsoon floods which can sometimes take up to a month to go to normal levels (Saad et al., 2023).

On the other hand, flash flood usually occurs in busy cities. Heavy or prolonged raining cause a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise during a stream or creek above a predetermined flood level within six hours of the causative event. If it rained heavily or for an extended amount of time, the water will flow quickly and excessively high, raising the water in normally dry areas. Alternatively, the water level in a river or stream will increase quickly, surpassing the flood level established within the typical six-hour timeframe.

This is caused by the uncontrolled human activities such as infrastructure development near the river areas and uncontrolled littering causing clogged drains and waterways. This situation is definitely worrying to the public as it has a negative impact on life, property, infrastructure, agriculture, human health and economic status which are affecting the community quality of life (Yusoff, Ramli, Alkasirah & Nasir, 2018).

Recently in Malaysia, phenomenon of flood cannot be predicted and will happen regardless throughout the year. As reported by the Department of Statistic 2023, in 2022 almost 14 states were affected by floods compared to 12 states recorded last year. The affected states were Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Pulau Pinang, Perak, Perlis, Selangor, Terengganu, Sabah, Sarawak and W.P. Kuala Lumpur. The overall value losses were Ringgit Malaysia 622 million (DOSM, 2023). Sometimes the result from heavy rainfall almost over from one hour also cause flood. This is especially in developed area for example Kuala Lumpur and Johor Bahru including construction site. This phenomenon is known a flash flood. In early November 2017, the construction of a new highway interchange in Kuala Lumpur experienced severe flooding due to continuous heavy rainfall. The site was part of a major infrastructure project (Bhuiyan, Reza, Choy & Pereira, 2018). Additionally, about 70 percent of the construction work at Sections 1 and 2 of the East Coast Rail Line (ECRL), covering 82km from Tunjong in Pasir Puteh to Setiu in Terengganu, was affected by the floods. Locations affected by the flood involved preliminary works, such as forest clearing the forest, and are in the low-lying area (Ishak, 2022). Hence, it is crucial to identify the impact to the construction site because of the flood occurrence.

THE IMPACT OF FLOOD ON CONSTRUCTION SITES

The impact of floods can be devastating to the construction sites and all the operational work often need to be stopped for several days. This is to make sure all the sites are free from waterlogged. Some construction projects involve working with water or other liquids, which can create risks if the site was not properly equipped to contain them. Workers who are involved in construction may be at risk of injury due to exposure to unsafe working conditions. Besides, construction workers are at risk of slipping

on wet surface or being struck by flying debris kicked up from tools like hammers and excavators. These hazards increase when areas are prone to flooding or excess rainwater cannot be drained away properly, leading to waterlogged in the construction sites. This research only described five flood impacts which are safety, cost of reconstruction, reconstruction and maintenance of building structure, defects to the structure of the building and delay in construction. In the next section, all the five flood impacts are comprehensively discussed.

Safety

Why safety is so important?. Safety are always priority everywhere especially at construction site (Vladkova, 2020). Construction is always labelled as dirty, dangerous and difficult works area (Zulkefle & Said, 2023). All the stakeholders need to be prepared in any situation including flood. Thus, well preparation to prevent the flood, especially in high-risk area of a construction site should be considered. Sometimes flash flood occurrence is difficult to predict. Heavy rains over a one hour resulted a flash flood. If there was a flood at the construction site everyone needs to cooperate to ensure that all the works can proceed without delay. In addition, flash flooding occurs sometimes, when rain falls fast that the underlying ground cannot cope, or drain it away fast enough where sites can become like rivers with devastating consequences. Safapour and Kermanshachi (2019) mentioned that one of the differences between post-disaster recovery procedures and typical construction projects is that disasters frequently generate large amounts of debris. As the debris consisted of construction materials, damaged or destroyed building fragments, sediments, green waste (e.g., trees, branches, leaves, and shrubs), white goods (i.e., utensils), asphalt, oil, chemicals, and other substances, the removal of the debris would result in multiple fatalities (Schierow, 2014).

Since it is dangerous to inform material, size and type, thus workers who are involved in cleanup and reconstruction as part of the post-disaster recovery play crucial roles in maintaining the safety of others. Their safety and health frequently come second to the site recovery and cleanup because they frequently work in hazardous environments and under extreme conditions. Workers are exposed to numerous injuries as a result of the significant volumes of debris that disasters frequently produce, including

construction materials, damaged or destroyed building materials, sediments, green waste (tree limbs, leaves, and shrubs ring), the process of post-disaster reconstruction. Workers could fall from an unprotected edge, open spaces, ladders, and scaffolds. Additionally, while repairing structures, the workers are exposed to chemical risks from welding fumes, as well as from grinding and cutting in confined spaces.

Cost of Reconstruction

The Finance Minister, Tengku Datuk Seri Zafrul Tengku Abdul Aziz, said the Ministry of Finance (MoF) allocated a total of RM200 million to address the impact of floods and activation of all disaster networks (MoF, 2021). Relief Web (2022) reported that flooding and landslides in eight states in December 2021, killed about 50 people, while over 40,000 people were displaced. The Malaysian Department of Statistics estimated that overall flood losses totalled RM6.1 billion (USD1.46 billion) (Rahman, 2022). In the aftermath of a flood disaster, the facilities or structure may require additional cleaning or longer drying time, adding to the expense of clearing process.

Therefore, the contractor needs to think about ways to improve their financial and financial resources to prevent losses. Williams (2016) pointed out that effective project cost management can lead to many other beneficial project outcomes. It can significantly contribute to the business success of project-based organisations and the sustainable development of trading/ business as well as economy in organization-located locations. It should not be surprising that an accurate preliminary estimate of construction costs is essential in the early phases of a construction project (Mahamid, 2015). Budget, feasibility, and investment choices are usually based on preliminary cost estimates. Sridarran et al. (2017) concurred that it is challenging to generate an accurate estimate of the initial cost of a project. It should also be mentioned that the importance of unrealistic initial estimations is disputed (Andersen et al., 2016). Cost estimates, which can substantially impact a project's success (Rahikkala et al., 2015), should include contingencies when information is insufficient for more accurate forecasting. Contingencies are supplementary allowances that serve as buffers for unforeseen (or unanticipated) and uncertain project features (Yi et al., 2016).

Reconstruction and Maintenance of Building Structure

The planned recovery following a flood event is an important tool in flood risk management. Emergency warning, and evacuation in conjunction with the construction of the most resilient vital infrastructure and buildings is a planned method for minimising the need for recovery and reconstruction. Yet, some damage will inevitably occur, necessitating reconstruction. Nevertheless, post disaster reconstruction projects face challenges that go beyond standard construction issues and are less likely to result in adequate building solutions. Despite the fact that these circumstances are well known, Celentano et al. (2019) claimed that the necessary strategies to overcome these challenges appear to be less clear. The following are the main bottlenecks in reconstruction projects: (i) a dysfunctional supply chain, (ii) a lack of resources, (iii) corruption, (iv) a lack of coordination among agencies, (v) poor construction skills, and (vi) infrastructure breakdown.

According to Ahmed (2011), the first step to carry out reconstruction on buildings is gaining access to flooded areas, as contractors and those affected require access to the affected areas. After the floodwaters recede, it is likely that access problems will persist due to the large amounts of debris, as well as the collapse of structures in situ, destruction of roads and other transportation routes. Therefore, waste removal is a top priority during recovery in order to facilitate access and the commencement of reconstruction efforts. Ahmed (2011), also added that a rapid assessment of the condition of critical infrastructure will help to determine the extent and scale of damage and inform plans for restoring the infrastructure on a national scale. With this, coordination of recovery efforts across all sectors is most easily achievable.

Defects to the Structure of the Building

According to the research findings of Merz et al. (2010), the effects of floods can cause significant damage to a variety of materials, structures, and services. In a flood disaster, the floodwater will find the path of least resistance into a building, including any cracks, gaps, or openings in the masonry or the construction itself. The statement is supported by Sia et al. (2022), that rising groundwater levels from floods or intense rainfall pose a threat of collapse and heavy damage to many low-rise constructions. Two to

three times as much settlement occurs when clay's moisture content increases by 10%, and the degree of saturation increases with a rising groundwater table. Modern construction strategies and conventional building materials are not equipped to endure prolonged submersion in floodwater (Escarameia et al., 2012). Most floodwater is contaminated with various materials, including chemical and biological pollutants, sewage, and silt. These contaminants can damage the way buildings work and the health of the labour (Taylor et al., 2013).

Delay in Construction

After a flood disaster, the facilities or building may also need more cleaning or drying time, which can add to costs and slow construction work. This claim can be supported by similar research done by Aminorlah et al. (2023), which demonstrated that project delays in the construction industry have a significant impact that it slows down the implementation of projects, particularly those initiated by the government. In addition, construction project delays can be classified into two main categories, namely internal and external causes. Internal factors are from the contracting parties, such as contractors, developers, and consultants, while external factors are from things beyond the contracting party's control, such as natural disasters (Fateh, 2022). This statement is supported by Ashworth et al. (2022), who said that two categories of factors could contribute to delay in building projects: external and internal factors. There were four different parties involved in that project, each contribute to one of the internal causes of the delays. The Owner, Designers, Contractors, and Consultants are considered part of these parties.

Other delays, which do not come from these four parties, are based on external causes such as the government, material suppliers, or the weather. Besides, construction contracts typically extend the construction period when a delay occurs during construction that is not the contractor's fault. This event is referred to as a time extension (EOT). In writing, the contractor notifies the contract administrator of the relevant event that caused the delay if it becomes reasonably evident that one exists or that one is likely to exist that could justify a deadline extension. If the contract administrator agreed that a relevant event was to blame for the delay, they may grant a deadline extension and change the completion date. Ashworth

et al. (2022), pointed out that a contract clause dealing with time, schedule, suspension of work, or default will usually outline the events that qualify the projects for a time extension. A typical clause provides time extensions for unforeseeable events beyond the company's control and not resulting from the company's fault or carelessness. In other words, it can also be called force majeure. Examples of force majeure include flood disasters or unusually severe weather. However, the contractor is responsible for avoiding or minimising the delay and any loss that may arise due to the delay, even if the contractor did not cause the delay.

RESEARCH METHODOLOGY

The research was carried out through a literature review as secondary data. The literature sources were obtained from journals, articles, websites, and the work of previous researchers. This research employed a quantitative survey method using a questionnaire form for data collection (Collins, 2021; Bhat, 2020). Initially, the questions in the questionnaires were developed based on the objective of the research. The questionnaire was structured into two sections. The section A: Personal or demographic detail of respondents. Section B: The impacts of the flood on construction sites.

The data analysis that was used was Likert Scale. The respondents were asked to answer the question using the five rating Likert scale (from 1= “strongly disagree” to 5= “strongly agree”) for section B. Data analysis was done using computer software Statistical Package for Social Science (SPSS). The data then were analyzed using the frequency analysis and average Index Analysis, whereas, the Average Index was calculated by means of the following formula: Average Index (A.I.) = $\sum$ (aX), where X = n / N, a = Value weight that was prescribed for variable (1 to 5), N = Total respondents and n = Respondent frequency. The classifications for the rating scale were grouped as follows is $1.00 \leq$Average Index<1.50 (not important or strongly disagree), $1.50 \leq$Average Index<2.50 (less important or disagree), $2.50 \leq$Average Index<3.50 (neutral), $3.50 \leq$Average Index<4.50 (important or agree) and $4.50 \leq$Average Index≤ 5.0 (very important or strongly agree) (Fassin, 2020).

FINDINGS AND ANALYSIS

A total of 300 questionnaires were distributed to the respondents; only 146 questionnaires were duly answered and returned. The questionnaires were distributed to the respondents via emailed and WhatsApp application. Many challenges and difficulties faced in retrieving back the questionnaire. The researchers need to follow-up the respondents by telephone to make a confirmation on receiving the questionnaire. This was to ensure that the respondents had completed the questionnaire and returned it back. The respondents were contractors Grade G7 registered with Construction Development Board (CIDB) around Selangor state. Selangor is Malaysia's most developed state located on the west coast of Peninsular Malaysia, it consists nine districts and covers about 125,000sqkm. Based on the history stated by Ishak, Dali and Razak (2014), Selangor experienced floods since 1911 and 1917 at Kuala Kubu. In addition, research done by Muhamad and Shaidin (2022) revealed that almost 150 flood occurrences had happened in Selangor from 2012 until 2021. Selangor often experiences disasters, especially in urban areas. In 2021, Selangor was reported to be the highest state to incur losses Ringgit Malaysia 3.1 billion due to floods compared with other states in Malaysia (DOSM, 2021).

Most of the respondents have been working in the construction industry from 7 to 9 years which is 29.5%, followed by 28.1% ranging from 4 to 6 years. In addition, there are also 25.3% respondents who have experienced working for 1 to 3 years. There was a respondent who has been in the construction industry for more than 10 years which contributed to 17.1%. The duration of working experience in the construction industry is important to ensure that the quality of the data obtained from the survey meet the requirements of the research (Table 1). 75.3% of the respondents had experienced floods during construction in progress, while another 24.7% had never experienced flood during construction phase. This indicates that majority of the respondents in this research have experienced with floods at the construction site (Table 2).

Table 1. Working Experience

Working experience	Frequency	Percentage (%)
1-3 years	37	25.3
4-6 years	41	28.1

7-9 years	43	29.5
10 years and above	25	17.1
Total	146	100.0

Source: Author

Table 2. Experience with Floods at Construction Sites

Description	Frequency	Percentage (%)
Yes	110	75.3
No	36	24.7
Total	146	100.0

Source: Author

Table 3 shows the result of frequency of Likert scale, mean, and rank of the overall five (5) variables. Most of the variables have an average mean above 4.00. The results demonstrated that most of the respondents viewed the listed variables as mostly agree in the questionnaire. Five (5) impacts of flood in construction site as variables are the buildings' structure require the reconstruction and maintenance, safety of labour, defects to the building structure, the cost of reconstruction, and delay in construction.

Table 3. Impact of Flood in Construction

Variables	Frequency of Likert Scale					Mean Score	Perception level	Rank
	1	2	3	4	5			
1.Safety of labour	0	3	10	31	66	4.45	Strongly Agree	2
2.The cost of reconstruction	0	1	5	59	45	4.35	Strongly Agree	3
3.Require the reconstruction and maintenance of the building structure	0	0	6	40	64	4.53	Strongly Agree	1
4.Defects to the building structure	1	1	6	56	48	4.32	Strongly Agree	4
5.Delay in construction	1	3	12	46	48	4.25	Strongly Agree	5

Source: Author

The findings revealed that structure of building will require the reconstruction and maintenance scoring the highest mean value of 4.53. The majority (44%) of the respondents strongly agree with this assertion due to the construction sites can be a dangerous environment, particularly

after a disaster. In placing more emphasis, Safapour et al. (2019) claimed that workers involved in post-disaster reconstruction are usually at high risk of unknown hazards that can cause short- and long-term disability or be fatal. Thus, rebuilding and maintaining the structure of buildings on construction sites is critical to ensure the safety of workers and also can minimise or eliminate the safety risks. This was followed by safety of labour with the second highest mean score 4.45. In addition, flooding can pose several physical hazards that pose a direct threat to worker's safety. Kim and Lee (2019) argued when it comes to safety, it is difficult to predict construction accidents and emergency situations during construction work. These hazards may include fast-moving water streams, debris carried by floodwaters, collapsed structures, submerged hazards (such as tree branches or utility lines), and unstable ground conditions. These conditions increase the risk of injury, drowning and other accidents.

Next, cost of reconstruction was in the third rank with a mean score 4.35. This is probably because it did not have much impact on the contractor. The contractors do not have to spend a lot of money on reconstruction because there are other sources to repair damage from a flood disaster. For example, CAR insurance. According to Delalay (2019), flood insurance companies participated in measures to prepare for flood hazards as well as to cope with flood disasters and reconstruction. The provision of insurance products may be more relevant to flood risk reduction than flood risk assessment models, although flood risk assessment models could still be used to inform decisions on the design and implementation of flood insurance schemes. In addition, the analysis underscores the multifaceted impact of floods on construction projects, ranging from safety risks and financial burdens to structural vulnerabilities and schedule delays. Addressing these challenges requires a holistic approach encompassing proactive risk management, resilient design practices, and effective crisis response mechanisms to enhance the resilience of construction projects in flood-prone areas.

CONCLUSION

In conclusion, overall flooding significantly impacts construction projects in multiple ways, disrupting progress and often necessitating a halt in work for

cleaning and repair efforts. This leads to project delays, increased costs and safety issues. This paper has identified five flood impacts on construction sites. The most critical impact is the need for reconstruction and maintenance of building structures. The other four impacts need a budget to continue the site activities such as for safety works and it will delay the timeline of work. Every decision and action are vital in making sure the impact of flooding is reduced. Reducing the impact of flooding is the responsibility of everyone. As stipulated by the National Disaster Management Agency (NADMA), for disaster management in Malaysia they should continuously implement various improvement initiatives to reduce the risk of disasters and to enhance the disasters preparedness. To minimize the impact of flooding on construction sites, it is suggested from the previous research it is crucial to employ preventive measures such as installing water management and detection devices, maintaining regular inspections and creating detailed water damage risk management programs. Additionally, collaboration with experienced flood specialists and engineers can aid in minimizing risks and managing the consequences of flooding.

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All authors contributed equally to the conceptualisation, literature review, data analysis, and writing of the manuscript. Finally, all authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

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