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EXPLORING OF THE FACTORS INFLUENCING THE HOLISTIC FORMULATION OF CONSTRUCTION DURATION ESTIMATION

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Graphical abstract

Abstract

Construction duration is defined as the time required to complete all activities in a construction project, from start to finish. Whilst the time objective is invariably a critical criterion for measuring construction project performance and effective time management is always a priority, project delays remain common. Among the many contributing factors, inadequate project planning and scheduling is a significant cause, highlighting the importance of establishing an accurate and realistic schedule from the outset. As most available scheduling techniques available focus on activities' time estimation to build up the construction duration, the study took on holistic view to project time planning where potential issues or delays are identified and reviewed at early planning stages of construction duration estimation. The study analyses a set of 123 public projects from the Public Works Department in Sarawak, Malaysia and seeks to understand the patterns and factors influencing the formulation of overall construction duration estimation. The paper reviewed on the project case studies' original time objectives, actual final construction durations and their causes of delays and duration of delays through the studies of project documents such as extension of time applications and approval, correspondences, site records and minutes of meeting. The findings reveal that out of 123 projects, 111 projects did not meet their time requirement due to factors such as exceptionally inclement weather, project size and complexity, project geographical location and the related location conditions and obstructions by external parties and other regulatory requirement authorities. These factors will be as incorporated into a systematic formulation of construction duration estimation as a preemptive approach time management in order to provide project managers a strategic overview to setting project time objective, forming a stronger and more reliable project scheduling.

Keywords: Construction Duration, Scheduling, Factors, Formulation, Duration Estimation.

1.0 INTRODUCTION

Olawale and Sun [1] explained that construction duration is the actual time taken to complete a construction project, including any delays or disruptions that occurred during the project. Construction duration is generally defined as the time required to complete all activities in a construction project, from start to finish [2]. This definition focuses on the time required to complete only the construction activities in a project, excluding activities such as design, planning, and procurement. According to Khaled [3], construction duration is the length of time it takes to complete all the planned activities in a construction project, including any time extensions given due to delays caused by weather, labor disputes, or other factors outside the control of the project team.

Time planning has always been a critical aspect of project management that involves both estimating the duration of individual activities and the overall project timeline. Meeting project time objective has always been a measurement and criterion for project success from the perspective of all the stakeholders involved. Williams [4] identified timely completion as a critical success factor for construction projects together with

cost and performance of the project. Albtoush et al [5] also found that delays in construction projects can result in increased costs, reduced profitability, and decreased customer satisfaction. According to Alshihre et al [6], timely project completion is essential to meeting customer expectations and ensuring customer satisfaction, which could be equates to the organization reputation and goodwill. The review also identified the negative consequences of project delays, including increased costs and reduced quality in the works and final product.

Nguyen [7] found that project managers who placed a high priority on meeting the project time goal were more likely to implement effective time management practices, such as developing a detailed project schedule, monitoring progress, and taking corrective actions when necessary. This highlights the importance of effective time planning, monitoring, and management throughout the project lifecycle. Typically, construction duration planning focuses on the scheduling techniques that calculate and define the time duration for each activity to be build up to the final overall duration. Traditionally construction duration estimation methods include Gantt Charts are useful for visualizing the project schedule and identifying the duration of each activity [8]; CPM, which involves identifying the critical activities in the project schedule and determining the longest path of activities that must be completed to finish the project [9]; PERT involves using three estimates of the activity duration (optimistic, pessimistic, and most likely) to calculate the expected activity duration and project duration) [10]; Monte Carlo simulation, which is a statistical method that involves generating multiple scenarios using probability distributions for various project parameters such as activity duration, resource availability, and weather conditions [11].

However, despite the available techniques and methods available, the completion of construction project in timely manner remains elusive. According to a report by the PMI [12], project delays continue to be a prevalent issue for organizations worldwide. The report states that 33% of projects fail to meet their original goals or business objectives, with 44% of those projects experiencing delays. In the Global Construction Disputes Report for 2021, it was found that delays were the most common cause of disputes in the construction industry. The report found that the average value of disputes related to delays was $34 million, with an average delay of 8 months. While statistical data may vary across countries and regions, project delays remain a significant challenge for organizations in the construction industry that leads budget overruns, poor quality products and construction disputes.

Studies carried out globally including but not limited Hwang et al. [13] for Singapore; Wang et al, [14] for China; Romzi and Doh [15] for Malaysia, Mpofu et al. [16] for the United Arab Emirates; Sweis et al. [17] for Jordan; Ballesteros-Pérez et al., [18] for Chile and Santoso and Soeng [19] for Cambodia on causes of delays in construction projects point towards delay mitigating strategies that include effective project planning, incorporation of risk management, effective communication, and stakeholder engagement to reduce delays and improve project performance. The focus of the paper is on effective project duration planning.

It is hypothesized that setting the overall duration for a project construction duration and then refining it through activities' duration estimation is more effective for the fulfilment of project time goal. The formulation of a construction duration estimation represents a proactive strategy and preemptive approach to project scheduling and time management. The conventional approach of determining construction duration by estimating the duration of individual activities is often reliant on the estimator's personal experience and judgment regarding the variables that influence time estimation. Studying the individual time duration of each activity can be a time-consuming and arduous task, leading to a propensity to make estimations with a greater degree of subjectivity. Hence, in the event that an initial mistake is made, subsequent results derived from the same set of assumptions or methods are also likely to be erroneous. Conventional techniques, such as the Gantt chart, which rely on estimating the duration of each activity to construct a project duration, have exhibited limited effectiveness due to persistent delays. The study advocated for a comprehensive approach to time management by devising a global estimation of the construction duration. The holistic strategy involves setting an initial direction to expedite the accurate computation of construction duration and employing it as a framework for subsequent activity duration estimates.

The aim of this study to explore the factors that can overall affect the estimation of construction duration. The objectives of the study are as follows.

a) To review on factors affecting for construction projects' scheduling
b) To study how these factors, affect the final project duration.
c) To categorize the factors into major category based on the cause and effect.

2.0 METHODOLOGY

The research method engaged here is method of multiple case studies, which provide an in-depth analysis with patterns, themes, and underlying relationships identified. The multiple case study method allows researchers to gather rich and detailed data from multiple sources, which can provide a deep understanding of the phenomenon under investigation. According to Mishra [20], multiple case studies provide a comprehensive view of the research problem, which can help researchers to develop a holistic understanding of the issues being studied. This method can increase the external validity of the study by providing a basis for generalization across cases, which can lead to the development of new theories and hypotheses [21].

Also mentioned by Flyvbjerg [22], multiple case studies can provide a deep understanding of the complexity of the research problem, which can help to identify the underlying causes and mechanisms that contribute to the problem. Triangulation can improve the credibility and validity of the study by reducing the risk of bias and increasing the reliability of the findings [23].

The case studies were all governmental contracts related to public infrastructure obtained from the Sarawak Public Works Department. The Sarawak Public Works Department has documented a total of 123 completed projects spanning from 2014 to 2019. From this dataset, a total of 111 projects were chosen as case studies based on specific selection criteria. These criteria include the overall project start date and end date, original construction duration, final construction duration and instances where the overall contract duration was extended, which indicates the occurrence of delay events and associated

period of delays. The data collected for these case studies were sourced from project files, as well as documentations such as project correspondences, extension of time application and approval/rejection, on-site instructions, and minutes of meetings. The following presents the results and analysis of the case studies.

2.1 Case Studies Information

A dataset comprising 111 project records that were granted Extension of Time (EoT) was obtained from JKR. Descriptive statistics were utilized to gain a better understanding of each case study. Based on the sample collected through the checklists, in terms of project type, building projects outnumber roadwork projects, accounting for 34.2% (38 projects) as against 24.3% (27 projects) as shown in Figure 1. Projects that are categorized under 'other projects' includes agriculture sub-station (2 projects), airport (2 projects), earthwork (1 project), electrical system (1 project), gate (1 project), jetty (3 projects), playground (2 projects), RC pontoon (2 projects), riverine terminal (1 project) and seashore works (1 project). Other projects ranked third with 16 projects in total representing 14.4%, followed by roadwork and bridge project category with 15 projects (13.5%), 8 projects under bridge only category (7.2%) and 7 projects (6.3%) under the waterworks category respectively, as shown in Figure 1

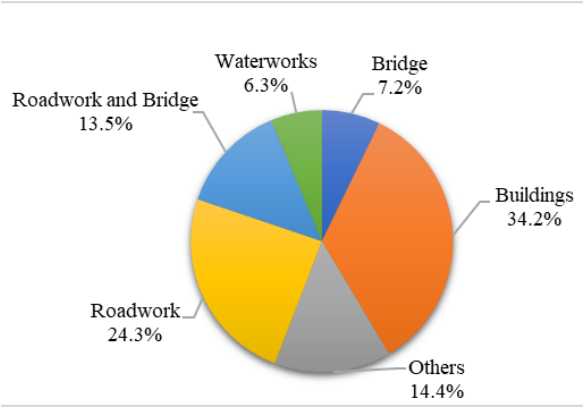

Figure 1 Distribution of project categories by percentage

Majority of projects with that fail to meet their time objective, i.e., 34 projects or 30.6%, occurred in the year of 2016. This is followed by project of year 2017, with 25 projects representing 25.6% in this research. Year 2015 projects are ranked third with 21 projects with failure to meet the original construction duration (18.9%). This is followed by project of year 2018 with 16.2% (18 projects), 2014 with 9.9% (11 projects), and 2019 with 1.8% (2 projects). During the data collection phase, it was observed that only a limited number of projects in 2019 failed to meet the predetermined time objectives. This can be attributed to the fact that a majority of the projects were either still in progress or had just commenced construction work at the time of data collection. Figure 2 presents the number of projects that fail to meet its time objectives in the respective year of 2014 to 2019.

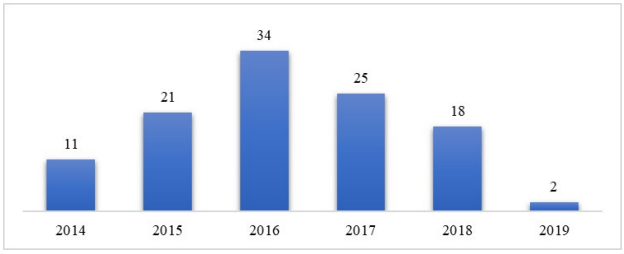

Figure 2 Distribution of projects that fail to meet time objectives by year

3.0 RESULTS AND DISCUSSION

An extensive literature review was conducted to develop a comprehensive list of potential causes of delay, which in this study are treated as potential risk factors influencing construction duration, as they directly contribute to its extension. This list served as the fundamental reference for examining over 111 project case studies. Through this systematic approach, the actual causes of delay in each project were identified and analysed. The results from the case studies, summarised in Table 1, present the key factors affecting construction duration as evidenced by the findings.

Table 1 Factors affecting the Construction Duration of Project Case Studies

No.	Factors Affecting Construction Duration	No of Project Affected
1	Exceptionally Inclement Weather	92
2	Site Possession	17
3	Contractor Related Issues – lack of performance, reworks, repair, misalignment	13
4	Changes and Errors in Design	8
5	Late Site Instructions by Engineer	8
6	Client Related Issues such as changes in design, schedule, material requirements	4
7	Suspension of Work due to disputes	6
8	Regulatory requirements, coordination with other authorities/agencies	14
9	Obstructions by third party	3
10	Relocation of existing facilities	4
11	Land blocked by other structures/properties	3
12	Unforeseen circumstances such as flooding,	3
13	Environmental issues such as haze, air pollution, soil erosion, extremely low water level/high water level	17
14	Unforeseen site conditions	9
15	Late material delivery	4

The data analysis revealed several factors that can influence the final duration of a construction project. Of these factors, exceptionally inclement weather was found to have the highest occurrence rate in the case study projects, affecting 92 projects (82%) of the 111 projects that met the predetermined construction duration. The projects encompassed a wide range of works, including structural projects such as RC pontoons, jetties, buildings, bridges and substations, as well as civil works such as roadworks, waterworks, airports, earthworks,

playgrounds, fencing and electrical system installations. The impact of this factor ranges from 1% to 160% of deviation from the original construction duration. Depending on the type and complexity of the project, most projects are significantly impacted. Only 23 projects out of the 111 projects has a less than 10% deviation from its original construction duration.

Lu et al. [24] defines exceptionally inclement weather as "extreme weather events" as events that are outside the normal range of weather patterns for a specific location, such as heavy rainfall and extreme heat or cold waves. Similarly, Adeyeye et al. [25] refers to "adverse weather conditions" as conditions that are severe or extreme and can cause delays and disruptions to construction projects, such as hurricanes, storms, and heavy snowfall. In general, exceptionally inclement weather refers to weather conditions that go beyond the normal range of weather patterns for a specific location and are severe enough to cause significant damage or delays to construction projects. For the study, only the daily rainfall intensity exceeds 10mm, will be recognized as exceptionally rainfall. Rainfall data for this purpose will be obtained from the Malaysia Hydrological Yearbook, published by the Malaysian Meteorological Department (MMD).

The following factor that influences construction duration is the issue of site possession. Site possession is a crucial aspect of construction projects that refers to the transfer of possession of the construction site from the client to the contractor. This transfer enables the contractor to commence construction activities and execute the project as per the contract terms. Site possession is a contractual obligation that outlines the specific date on which the contractor is permitted to begin construction activities and the period within which they must complete the project. Site possession issues can have significant implications for the construction contract, particularly with respect to time and cost. The inability to obtain site possession as per the contract terms can lead to project delays, which can result in additional costs for the contractor. In some cases, the contractor may be entitled to an extension of time (EoT) to account for the delay caused by the site possession issues.

The site possession factor has impacted five (5) different types of project, namely building, playground, roadwork, coastal, and bridge projects. Site possession issues are responsible for over 17 (15%) out of the 111 projects, with the highest delays frequently occurring in road and highway projects and bridge projects. Most projects affected by the site possession issues has high percentage of days deviating from original construction timeline. Percentage of delays can go as high up as 88% of deviation of original construction duration.

Another factor that significantly impact the project construction duration is the contractor's performance. A contractor in a construction project is a person or a company that is hired by the project owner or the developer to perform specific tasks or services related to the construction project. Even though completing the job is their foremost responsibility to the contract, client and end-users, they are responsible for managing and executing the project according to the specifications, timeline, and budget agreed upon in the contract.

The results of the present study indicate that a total of 13 projects, representing 12% of the sample of 111 projects under investigation, were found to be encountering difficulties in meeting their overall timeline commitments. The data further reveal that approximately 70% of the delay observed in these projects was attributable to issues related to inadequate performance. In the majority of cases, the underperforming projects failed to adhere to the prescribed schedule, while in three instances, the need for repair, rework, and realignment of the initial work was identified as a contributing factor to the delays experienced. In addition to the primary causes of project schedule delays under contractor's performance as stated, data also show secondary causes that fall under the purview of contractor performance as mismanagement of resources and poor communication with other parties on the construction site.

These findings suggest that performance-related concerns are a prominent challenge faced by a notable proportion of projects, emphasizing the importance of effective monitoring and evaluation of project activities to ensure timely and successful completion. These results correspond with studies shown in the literature review.

Changes and errors in design represent another factor causing project failing to meeting its time requirement. Based on the data, there are a total of eight (8) projects' duration, which translate to 7% of the projects studied being affected by changes and errors in design. Out of the eight (8), three (3) roadworks and bridge four (4) are building projects and the last one a seashore reinstatement project. Total duration affected range from 7 to 153 days which causes a 5% to 160% of delays to the overall projects' durations.

In the similar context of design changes and errors, the issuance of site instructions is a factor that can significantly impact construction duration. Site instructions are crucial in construction as they provide guidance and directives to the construction team during project execution. When unforeseen problems arise, site instructions are issued to direct immediate action to resolve the problem. However, these instructions can cause delays in construction duration as they often result in changes to the original plan. Implementation of site instructions may also require additional time and resources, which further contribute to the extension of construction duration. Delay in the issuance of site instructions can also lead to significant delays in the construction process as work may need to stop until the instructions are issued. Therefore, site instructions should be managed carefully and issued promptly to minimize their impact on construction duration.

There are nine (9) projects, representing 8% of the 111-project case study experiencing delays caused by Site Instruction. Almost all of the cases involved late issuance of site instructions and one (1) projects received the drawings late. The impact of delays on the total project duration varies significantly, with reported ranges of 5 to 273 days, leading to an increase in project duration ranging from 10% to 180%. In certain instances, such as the latter, the delays may result from a series of sequential instructions that collectively contribute to the prolonged duration of the project.

Following an exploration of factors pertaining to contractors and designers that can impact construction duration, attention must now be directed towards issues associated with clients. Clients are integral to the construction process, and their decisions and omissions have the potential to impede project timelines. One of the most prevalent causes of construction delays attributable to clients is the alteration of design and material preferences, which necessitates a change order. Additionally, delays may arise from late payment, which may lead to a slowdown in the work's progress, and inadequate communication and coordination between clients and contractors. Finally, unclear project requirements can also result in construction delays.

Within the 111-project case study, 4% (4 projects) were found to have encountered delays attributable to clients. These delays were the result of clients modifying the design but failing to furnish timely decisions and confirmations regarding requested changes. The impact of these delays on total project duration was significant, with reported ranges spanning from 16 to 100 days, thereby leading to a project duration increase ranging from 16% to 32%. It is important to note that although the number of cases appears to be low, clients are unlikely to report delays stemming from their own actions. This is because doing so would necessitate providing contractors with Extensions of Time, potentially highlighting inefficiencies within certain project team members.

The following factor considers the issue of work suspension resulting from on-site disputes. Such disputes may arise from conflicts between participants in a construction project, such as contractors, subcontractors, designers, and client representatives. These disputes may center on various matters, including contract breaches, delays, and cost overruns. In certain cases, these disputes may be significant enough to halt work on the project, leading to consequential delays and additional costs. Temporary cessation of construction activities, known as the suspension of work, occurs when the construction project is inactive for a certain period. During this time, no work is conducted, resulting in severe delays, cost overruns, and legal or contractual implications. The reasons for suspending work are numerous and vary. A voluntary suspension of work can occur due to financial constraints or changes in the design, while an involuntary suspension is due to a dispute that may lead to a stop-work order or contract termination.

According to the data collected from the 111 case study projects, six (6) projects, representing 5.5%, were affected by the suspension of work. On-site disputes, particularly over late payments and work quality, were the primary reasons for the suspension. This factor had a considerable impact on the project construction duration, with delays ranging from 26 to 283 days, representing 21% to 106% deviation from the original schedule. These findings are consistent with previous research on the impact of disputes and suspension of work.

This section of the paper explores the external factors that can have a significant impact on the duration of construction projects and must be considered during the project scheduling phase. These factors include the regulatory requirements, approval and coordination with external authorities and agencies, obstruction by third parties including neighboring owners, local residents on social and culture issues, relocation of existing facilities, and land blocked by other structures or properties. External parties can cause delays in construction projects by creating disruptions in the supply chain or the availability of resources. These parties can include local authorities, regulatory bodies, neighboring property owners, public, local residents or even existing structures or facilities. It is important to note that these factors are usually beyond the control of the project team and can significantly affect the project's progress and completion.

In the case study of 111 construction projects, it was found that 14 of these projects, representing 13% of the total, were affected by delays caused by local authorities' regulatory requirements, approval processes, and coordination. The delays were mainly attributed to the slow response and inaction of local authorities in providing necessary approvals, wayleaves, and permits to access certain areas or sections of the projects. In one instance, a delay in the supply of electricity by the energy authority hindered the testing and commissioning of a project. The delays caused by external parties led to a deviation in project duration ranging from 20 days, to almost one year in one of the projects translated as 16% to 160% of the project duration. The severity and prevalence of this factor highlights its impact on construction duration and emphasizes the need for project schedulers to consider external factors beyond their control during project scheduling.

In the context of construction projects, relocation of existing facilities is a significant external factor that can cause delays. The presence of outdated facilities, such as water pipelines, oil and gas pipelines, and electricity and telecommunication lines, in the project site can often go undetected. Contractors may be unsure whether these facilities are active and the dismantling and relocation process requires the presence of relevant authorities. Moreover, these facilities if still active are critical to the functioning of the surrounding infrastructure and require coordination with other relevant authorities before they can be relocated. The process of relocation often involves complex technical procedures, including excavation and dismantling, which can take significant amounts of time and resources. Determining where to relocate these facilities can also pose significant challenges, leading to considerable time wastage.

According to the findings of the case studies, four (4) projects, translated as 4% of the total were delayed due to the relocation of existing utilities. The delay ranged from 20 to 90 days, which represented a significant deviation from the original project timeline, ranging from 16% to 160%. The high percentage of deviation is attributed to the cumulative impact of multiple relocation events, resulting in significant delays to the original construction duration.

Another external factor that can lead to delays in the construction schedule is obstruction by third parties, which commonly refers to individuals or groups outside of the project team, such as local and native community/residents, non-governmental organizations (NGOs), members of the general public, environmental protection group or media. Obstructions by public and third parties during construction projects over issues such as environmental rights, culture and heritage and legal disputes over right to use, can cause significant delays and complications, often resulting in increased costs and legal issues. These obstructions may include protests, roadblocks, or other forms of opposition to the project by members of the public or third-party organizations.

Based on the data collected, the impact of obstruction by third parties was found to be substantial in three (3) projects, resulting in delays ranging from 54 to 137 days, representing a deviation of 21% to 93% from the overall project schedule. The effects of such obstructions are typically significant, requiring pacification through lengthy mediation and negotiation before work can proceed on site.

The study also reveals that delays can arise from land or work way obstructed by other structures or properties. This typically involves illegal squatting or unauthorized land usage. In some cases, the obstruction may be due to the presence of fruit trees, vegetation patches, or other plantations that were planted by local residents who refuse to relocate without proper compensation. In many cases, the presence of unauthorized structures and properties on the land will obstruct the construction team's access to the site. While it is legally rightful to demolish or force the structures/plantations to be removed,

doing so could result in retaliation and further complicate the matters. As a result, delays in starting the project or even stopping work already in progress will ensue. In addition, the presence of unauthorized structures on the project site can cause safety concerns for workers and may require additional time and resources to remove them. There are three (3) case study projects affected by issues of land being blocked by other properties and structures. The effects range from 52 to 177 days, showing 11% and 50% of deviation to original construction duration.

Project durations are also often affected by natural disasters which is usually sudden and unexpected events. Unforeseen natural disaster or force majeure events are caused by natural phenomena, such as floods, storms, earthquakes, tsunami. Based on the collected data, it was observed that unforeseen natural disasters have affected a total of 3 projects, which represents 3% of the total of 111 projects examined. Among these projects, all three were impacted by site flooding, with the highest recorded delay being 28 days. In addition, the effects of such natural disasters often require post-event site clean-up and salvaging works, material and equipment before construction work can resume, thus adding to the overall delay. It is important to note that the number of days of delay includes both the time of the event occurrence and the aftermath.

In contrast to unforeseen natural events, environmental events are characterized by their long-term or chronic nature and are a result of natural or human-induced changes in the environment. These events include air pollution, soil erosion, haze, drought leading to extremely low water levels, and rise in sea level leading to extremely high-water levels or king tides. Out of the total 111 case study projects, 17 (15%) were affected by such environmental factors. The projects involving road with bridges were found to be the most affected as they are often located near waterways, making them susceptible to extreme water levels in the river. Extreme water levels can cause delays in completing specific tasks that need to done within a stipulated window of time, transportation of materials, alternative work methods to suit the sudden water level changes and additional protection works to be carried out should the event occur.

Besides natural and environmental related events, there are also other unforeseen events that are non-environment related. This can include changes in government policies or regulations such as sudden changes in tax laws, trade policies, or labor laws can affect the cost and availability of construction materials and labor, leading to delays or even cancellation of projects. Economic recessions, inflation, and other economic fluctuations can affect the construction industry by reducing demand for construction services, increasing material costs, and making financing difficult to obtain, causing project to delay to the progress of works and in some cases, the start of the project. Unforeseen geopolitical events such as war, terrorism, and civil unrest can disrupt the supply chain of construction materials and equipment, leading to project delays and cost overruns. Others events can include pandemic, thefts and vandalism, unexpected equipment failures, strikes, labor shortages, supply chain disruptions and transportation and logistics that leads to late material delivery.

A total of ten (13) projects in this study were affected by non-environmental related unforeseen event with four (4) projects due to supply chain disruption and transportation issues cause delay in delivery of materials to site. Total of 12% of the projects were affected by unforeseen events with delays ranging from three (3) to 238 days, representing 1% to 93% of deviation from original schedule. The range of impacts is rather broad in these cases.

The study delves deeper into the association between project characteristics, such as project type and scope, complexity, and locality, and their impacts on the formulation of construction duration. The scope and complexity of a project can have a notable impact on its construction duration. Project cost can be an indicator of project scope and complexity, as larger and more complex projects may require greater financial resources to complete. However, this is not always the case, as smaller projects may also have a high degree of complexity that requires a significant amount of resources. However, generally, larger and more complex projects are likely to require more time to be completed than smaller and simpler projects.

Project type can significantly affect project scope, complexity, and construction time. For instance, infrastructure projects such as roadways, bridges, and tunnels are generally more complex and have a larger scope than building projects such as office buildings or residential homes. This is because infrastructure projects involve multiple stakeholders, complex engineering requirements, and may require extensive environmental assessments and approvals.

Based on the data collected as shown in Figure 3 below, there are 61 (55%) projects with a budget range of RM1mil – RM25mil, followed by 24 projects (21.6%) with a budget range of of RM50mil – RM100mil. With the range of RM25mil– RM50mil, there is a total of 11 projects (9.9%). Falling under the two extremes of more than RM100mil and less than RM1 mil, there are 5 projects (4.5%) and 10 projects (9.0%) respectively.

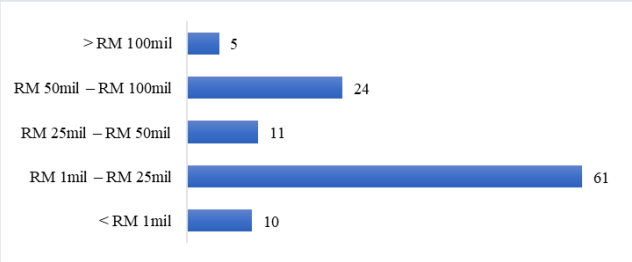

Figure 3 Distribution of projects by cost group

Combining with data on original contract duration, similar pattern is observed in the following Figure 4. When project cost is higher, longer original contract duration is observed.

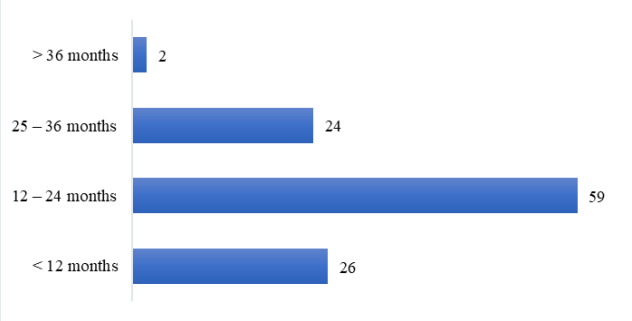

Figure 4 Breakdown of projects according to total contract duration

Based on the data collected, the study found that projects with a budget of less than 1 million to 25 million typically had a construction duration ranging from less than 12 to 24 months. In contrast, projects with a budget exceeding 25 million to over 100 million had a construction duration of 25 to 36 months, with 2 even exceeding 36 months.

In light of the relationship between project cost and the original contract duration, it can be inferred that project scope and complexity are related to project cost. Therefore, it is reasonable to consider project cost as a factor to be considered in determining the project contract duration.

Another factor taken into consideration is the project locality factor. Project locality refers to the geographical location of a construction project and its proximity to necessary resources such as labor, equipment, and materials. Project location and distance in this study is in relation to the nearest urban center. The distance from the nearest available hub is one of the key factors in determining project locality. The closer a project is to a hub, the easier it is to access necessary resources and complete the project within the expected timeframe.

There are total of 41 (37%) projects in this study that are located less than 25km away from its nearest hub, 19 (17%) projects that are located between 25 to 50km, 16 (14%) projects that are located between 50 to 75km, 3 (3%) projects that are located between 75 to 100 km and 5 (5%) that are located more than 100km away from its nearest hub. A total of 27 (24 %) of the projects under study were found to have no access to the site via traditional road and highway networks, making waterways the sole means of access. Based on the data, it can be inferred that the occurrence of high numbers of delay days is widespread in projects that are located over 50 km away from the nearest hub, with the highest number of days of delay occurring in projects with no access. These findings suggest that project locality needs to be carefully considered, as there is a strong correlation between project distance, or the project's location, and an increase in the project duration.

3.1 Formulation Parameters

Based on the findings when exploring the factors that influence construction duration and the ability to meet project time expectations, the factors can be classified into seven parameters, namely project type and scope, project locality, project cost, inclement weather, project internal issues, project external obstructions, and unforeseen natural, environmental, and other events as depicted in Figure 5.

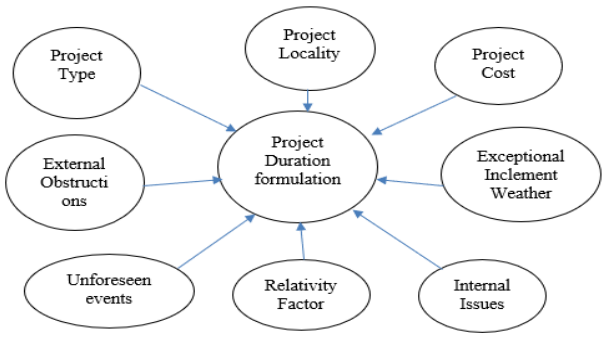

Figure 5 Factors affecting construction project formulation

To holistically determine the construction duration for a project, it is essential to consider the three (3) key factors - Project Type, Locality, and Cost, as they have a significant influence on the construction duration. Project Type serves as a direct indicator of the project's complexity, while Cost and Locality provide a more refined relationship between Project Type and the complexity of the project. It is therefore crucial to take these three (3) factors into account during construction duration.

The research findings of 92 projects affected demonstrate a considerable influence of severe weather conditions, i.e. exceptionally inclement weather on project construction duration. Consequently, it is imperative for project schedulers to take into account the possibility of severe weather events when estimating the construction duration of a project. An awareness of potential weather conditions in the project location is critical to accurately determination construction duration.

The subsequent aspect to be considered is the internal issues of a project, which pertains to factors related to the project team comprising of consultants, contractors, and clients, and issues stemming from their contractual arrangements, such as site possession and work suspension. Effective organization of the team and the members' behavior, its communication, and coordination are significant determinants of the final project delivery, and their role in meeting the designated timelines cannot be side-lined. Prior researches had also identified these factors as contributing to delays but would generally recommended counter measures base on team behavior and efficient communication. Given that 46 projects have been affected by this category of issue, it is crucial to scientifically incorporate this factor during the time formulation process, which can be refine on the effects of these issues during activity scheduling.

Another crucial aspect that determines the success of a project in meeting its stipulated timeline expectations is the external factors, comprising of human agents such as local authorities and third parties not directly involved in the project, and physical elements such as existing facilities, structures, and properties. Typically, these factors are managed reactively, but from the analysis of the 26 affected projects, it is recommended that a proactive approach be adopted by early inclusion of these factors during the construction duration formulation stage, which can provide a more realistic perspective for project scheduling.

Construction projects are susceptible to encountering unforeseen conditions during the construction stage, which can be categorized as natural events, environmental events, and other non-environment related events. As implied by the term "unforeseen," these events are typically unexpected and not apparent during the project planning stage. The findings of this study indicate that a total of 31 projects were affected by this parameter. Therefore, it is imperative to include this parameter in the construction duration formulation process to adopt a proactive approach to the construction schedule. Expecting the unexpected is the suggested approach to construction duration formulation in this regard.

Finally, the study recommends the adoption of a relativity index as the eighth factor in the construction duration formulation process. It is well established that construction projects differ significantly due to varying conditions, including stakeholders, geographical location, complexity, and scope. Therefore, the inclusion of a relativity factor can account for the effects of the project team's experience, management efficiency,

and previous project historical data on similar projects. This adjustment factor is essential for better correlation of all data and to produce a more accurate construction duration.

4.0 CONCLUSION

The conventional approach to the formulation of construction duration involves estimating the duration of activities and integrating these individual durations to determine an overall construction duration. The accuracy of this approach is subjected on the precision of the estimation of activity durations. However, due to the substantial number of activities requiring during estimation, the formation of durations for each activity is often done hastily, without considering the various factors that can impact the project. The traditional estimation process with all existing scheduling tools entails benchmarking, past historical data, the level of experience of the scheduler, and, in some cases, some consideration of project risks. However, this method is neither systematic nor scientific, and the prevalence of delays in construction projects attests to its ineffectiveness.

The present study proposes a comprehensive and holistic approach to construction project duration formulation by estimating an overall construction duration that incorporates certain parameters typically responsible for construction projects exceeding their original timelines. The study was conducted through a multiple case study method, encompassing 111 projects, whereby issues contributing to project timeline deviations were extracted, studied, and recompiled into eight parameters. These parameters include project type and scope, project locality, project cost, inclement weather, project internal issues, project external obstructions, unforeseen natural and environmental events, and other events, all of which are incorporated with a relativity index as previously discussed.

The study findings advocate for the inclusion and consideration of these parameters and related factors as a primary step in formulating an overall construction project duration. This approach seeks to establish a measured and scientific means of estimating construction duration. Once the overall duration is determined, a guided framework for estimating the duration of each activity can be established. Consideration of these factors can serve as a cross-check for between overall construction estimation and the estimating the durations of each activity. It is recommended that a formula with these 8 parameters to be created and risk management system to be developed and integrated into project scheduling to enhance the accuracy of overall construction project duration estimates. It is hoped that through this method of construction duration estimation, project planning can more effectively establish time and schedules, making monitoring easier, and prompting a proactive approach to time management in construction projects.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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