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Investigation on the Factors Influencing Construction Time and Cost Overrun for High-Rise Building Projects In Penang

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Abstract. Time and cost overruns have become one prominent issue for most construction projects around the world. Project costing and timeframe extension had been causing a lot of wastage and loss of opportunity for many parties involved. Therefore, this research was carried out to investigate the factors influencing time and cost overruns for high-rise construction projects in Penang, Malaysia. A set of questionnaires survey was distributed to the project managers who had been or currently involved in the high-rise building projects in Penang to get their input and perceptions for each factor identified as well as its frequency of occurrence. In order to rank all the factors gathered, the mean index of the most distinguishing factors and its frequency of occurrence were multiplied to get the severity index. The results revealed that for time overrun, the most predominant causes were due to design changes, inadequate planning and scheduling and poor labor productivity. Meanwhile, the predominant causes of cost overrun were poor pre-construction budget and material cost planning, inaccurate quantity take-off and materials cost increased by inflation. The significance of establishing the issues related to time and cost overruns for the high-rise building construction project is to provide a greater insight and understanding on the causes of delays, particularly among the main project players: contractors, client, and consultants.

1. Introduction

For a developing country like Malaysia, many construction projects had taken place due to the support from the government. Just like any other construction projects in the world, cost and time overrun had caused delays and losses to the parties involved. To enhance understanding of the construction projects, it is basically comprising three phases [1], which are:

- i) Pre-construction – at this stage, the client will convey the intention and purpose to the architect to be transformed into the design (draft).
- ii) Construction phase – at this stage, the design will be transformed from drawing into physical structures. A contractor would be appointed to start the construction process based on the approved architect's drawings by the state authorities.



- iii) Post-construction phase - this is the final stage of the construction process and the completed building would be handed over to the client.

In the past decade, rapid development in the construction industry had taken place. It was economically benefited and contributed to the improved Gross Domestic Product (GDP) of a country, enhanced quality of life by providing more infrastructures such as highways, roads, clinics, hospitals and many more. Thereupon, to complete the construction project within the agreed time and budget without compromising its quality is vital for all parties involved [2].

Despite the rapidity of the project development, Malaysia's construction industry suffers from the several major drawbacks such as low quality and productivity, cost overrun, time overrun, poor construction waste management and poor safety performance [3-6]. Olawale and Sun had informed that the cost overrun had a major impact on the overall development of the country [7]. On top of that, as what had been reported by Kaming et. al., it was a scarce event for any construction project to finish within the estimated cost [8]. Many other studies from Memon et al [9, 10] and Shehu et al [11] were also agreed with the findings and this indicates the needs to understand various perceptions of the issues existed among construction project stakeholders, such as clients, contractors, consultants, financial and government authority. From the contractor's viewpoints, the delay on the project (time overrun) would be resulting in the increase of overall project cost, directly reducing the profit margin and at the same time, battered their own reputation. Not only that, the client too would need to succumb all the additional charges and professional fees while attaining smaller margins due to late occupancy.

As a developed nation, the construction industry has become one of Malaysia's economic key pillars and due to that, the study on the factors affecting the cost and time overruns is necessary and significant. Many studies had been taken previously but mostly focusing on infrastructure construction projects and building construction projects in general. The study of cost and time overrun conducted for high-rise building construction projects, particularly in Malaysia however, is still lacking. Therefore, the main purpose of this study is to investigate the factors influencing the construction time and cost overruns specifically on high-rise buildings project in Penang and also to determine its significant factors.

2. Overview of time and cost overruns

Time, cost and quantity are the three equilibrium triangle of construction success factors elements used in determining and measuring the success of construction projects. These elements are embedded throughout the overall project lifecycle beginning from the stage of planning, implementation and finally, handover phase. Nevertheless, to be able to meet the requirements set up for each element was not easy as what had usually happened where most contractors were unable to meet up the dateline, resulting in the additional overall budget in completing their project [12-14].

Zaini et al [15], had listed out few risk factors affecting the project's time and cost overruns such as accidents, price fluctuation, inadequate materials, and unfavorable weather condition. Major factors affecting this issue will be discussed in the next section.

a. Causes of construction project's time overruns

Prominent factors in construction project's time overruns are design changes, poor labor productivity, inadequate planning, and resource shortages. Table 1 shows the variables influencing time and cost control on high-rise projects in Indonesia based on the study conducted by Kaming et. al. [8].

Table 1. Variables influencing time, and/or cost control (Source: Kaming et al [8])

Time and cost controls	Time controls	Cost controls
Environment restriction	Buildability	Inflation of material cost
Experience of project location	Labour productivity	Accurate quantity take-off
Accurate prediction of equipment production rate	Level of planning	Experience of project type
Equipment availability	Accuracy of materials estimate	
Weather conditions	Material availability	
Experience of local regulation	Accurate prediction of craftsmen production rate	
	Skilled labour availability	
	Locational restriction of the project	

In accordance with Ahmed et al [16], internal causes and external causes were the two categories of the causes in construction projects' delay. Internally, the causes were contributed by the four parties which were the owner/client, designers, contractors, and consultants. Other than these four parties such as the government, materials suppliers, or the weather, are considered as external factors. Table 2 below has the list of factors influencing the cost and time overruns based on the study done by Alwi & Hampson [17].

As for Malaysia, poor site management, construction error, late delivery of material to the site, and lack of material coordination were the factors listed causing a delay in construction projects. Other than that, owner's financial issue is also another contributing factor for this. Chan et al. [18] in their studies had mentioned that as from consultant's point of view, incompetent or inadequacy of supervision, followed by late in site instruction, and absence of consultant's knowledge and experience were the causes for time and cost overruns on site.

Table 2. Factors influencing cost and time overruns (Source: Alwi & Hampson [17])

Category	Factor
Owner	Finance and payments of completed work.
	Owner interference.
	Slow decision-making by owners.
	Unrealistic imposed contract duration.
Contractor	Subcontractors.
	Site management.
	Construction methods.
	Improper planning.
	Mistakes during construction.
	Inadequate contractor experience
Consultant	Preparation and approval of drawings.
	Contract management.
	Quality assurance/control.
	Waiting time for approval of tests and inspections
Material	Quality of material.
	Shortage in material.
Labor and equipment	Labor supply.
	Labor productivity.
	Equipment availability and failure.
Contract	Change orders.
	Mistakes and discrepancies in contract documents.
Contractual relationships	Major disputes and negotiations.
	Inappropriate overall organizational structure linking
	Lack of communication between the parties.
External factors	Weather condition
	Regulatory changes and building Code
	Problems with neighbors.
	Unforeseen ground conditions

b. Causes of construction project's cost overruns

Adam et al [19], Kaming et al [8] and Chimwaso [20] had found four factors resulting in cost overruns and they were changes in design, incompetent and incomplete planning, uncertain weather circumstances and variations in the pricing of the building materials. There were also list of critical factors such as partially-done design at the tendering stage, new changes at owner's request in terms of design and brief, shortage of cost for the planning / monitoring at the pre-and-post contract stages, impaired soil and site conditions, modification in the construction prime cost and provisional sums, remeasurement of provisional works, logistics due to site location and shortage of cost reports at the construction phase.

There were also critical factors which had been neglected such as postponement in delivering information to the contractors in the events of project's delays, technical failing while at the design stage, contractual claims – expansion of time with additional cost claims, standard architectural drawings development at the construction stage, hesitation in providing final solution by the supervising team while entertaining the contractor's queries in delays, restriction in costing variations and additional works, omissions and errors in the bills of quantities and ignoring items with abnormal rates during tender evaluation especially items with provisional quantities.

The prime variable of cost overruns had been identified as unpredictable weather, inflationary material cost, inaccurate materials estimations, the complexity of the project, contractor's shortfall in

understanding the geographical experience and lack of the project type experience, and finally non-familiarity with the local regulations [8]. As what had been studied by Morris [21] on the overruns factors in public sector projects, it was found that the escalation in cost was partly attributed due to the inefficient original estimates without reflecting the current pricing schedules. The other half was due to the delays in the project which results in inflation, escalation in costs, change in scopes, errors and etc. He also had listed out ten factors affecting the cost overruns of construction projects. The first factor was dealing with the early stage of the project which was a delay in construction due to inadequate project preparation, planning and implementation. Secondly, it has resulted from the suppliers of the raw materials and equipment needed by the contractors. The third factor was due to the change of the project's scope. Resources constraints in getting the funds, foreign exchange, power and matters associated with the auxiliaries which not ready were listed as the fourth factor. The fifth factor was delays in decisions making by the authorities and failure of specific coordinating bodies. Wrongly and inappropriate chosen of the site also listed as the sixth factor. Technical incompetence and a poor organizational structure were placed as the seventh contributed factor and the labor unrest was placed at number eight. The ninth factor cause cost overruns were natural calamities, Indo-Pakistan war and the last one was the lack of experience of technical consultants, an inadequacy of foreign collaboration agreements, a monopoly of technology.

Kaming et al [8] examined the factors influencing construction cost overruns on high-rise projects in Indonesia and found that cost overruns had been occurred more frequently, resulting in a more severe problem than time overruns on high-rise construction in Indonesia. The major factors influencing cost overruns were due to the increased in material costs. This was in the effect of inflation, faulty materials estimations and degree of project complexity.

Frimpong et al [22] had revealed that there were 26 factors of the cost overruns in the construction of groundwater projects in Ghana, from the perceptions of clients, contractors, and consultants. Monthly payments difficulties from agencies was on top of the list for the cost overruns factors from the perceptions of both contractors and consultants, while owners perceived poor contractor management as the most voted factor in affecting the cost overruns. Despite the difference in viewpoints of their choices, there was a high degree of agreement among their ranking of the factors listed in the survey conducted.

3. Methodology

This study involved quantitative method to evaluate the project manager's perceptions on the factors influencing time and cost overruns for high-rise building projects in Penang. The questionnaire design and analysis were adopted from Kaming et al [8]. The questionnaire was designed based on the identified factors to attain the important factors that influence time and cost overruns for high-rise building projects in Penang, and the frequency of occurrence for each factors. Similar to Kaminng et al's [8] method of analysis,

'The questionnaire gave each respondent an opportunity to identify variables that they perceived as likely to contribute to overruns by responding on a scale from 5 (strongly agree) to 1 (strongly disagree). Participants then rated the frequency of occurrence for each variable on their present construction sites on an ordinal scale: high (3), medium (2), or low (1). For each variable, the mean value of the respondents' importance rating was named the importance index, which then used to rank the perceived importance of all variables. Secondly, the mean value from respondents' frequency rating was named the frequency index and used to rank the frequency of occurrence of variables on their sites. Finally, an overall measure, derived from multiplying the importance index

by the frequency response, was named the severity index. These severity indices were used to rank the overall impact of the variables upon time/cost overruns for high-rise construction sites.'

Respondents were also asked on the percentage of projects successfully completed within time and cost by labeling their percentage in three types which are less than 70%, 70% – 90%, and more than 90%. Before conducting actual questionnaire survey data collection, pilot study was carried out to test and prove the questionnaire questions are reliable and clear to be answered in a way that help to achieve the target of the study.

4. Results and discussion

a. Response rate & demographic analysis

Detailed questionnaires were designed and distributed for the assessment of cost overrun and time overruns on high-rise building construction projects in Penang Malaysia. A total of 40 questionnaires were distributed to project managers, construction managers and professional engineer, out of that 30 questionnaires were accurately filled and returned, and then creating a 75% responds rate. The number of questionnaire received is deemed adequate because it is more than the minimum sample measurement for population highlighted by Gay & Diehl [23], which is 10 percent form overall population which is minimum 25 returned questionnaire from 215 G7 construction company registered CIDB in Penang.

From the thirty returned questionnaires the respondents hold different designation in their organizations. Table 3 shows the respondents working designation at their current organizations. Most of the respondents were Project manager (67%), followed by Senior Project Manager (20%) and Professional engineer (P.E) (13%). Majority of the respondents working experience is between 10 to 20 years (63%).

The respondents were also asked about the number and percentage of projects completed on time and within budget. Ten percent (10%) of the respondents indicated that they have completed more than 90% of their projects on time. While, 17% of respondents indicated that less than 70% of their projects were completed on time, and 73% of them stated that 70 - 90% of their projects were completed on time. On the other hand, 60% of the respondents indicated that 70 - 90% of their projects were completed within budget, while seven PMs (23%) said that less than 70% of their projects were to budget, and only five PMs (17%) claimed that 90% of their projects were completed within budget.

Table 3. Summary of responses' rate and demographic analysis

Questions		Total	Percentage	
Responses' rate	Distributed	40	100%	
	Received and processed	30	75%	
	Non-returned	10	25%	
Demographic	Position	Senior Project Manager	6	20%
		Project Manager	20	67%
		Professional Engineer	4	13%
	Working experience	Less than 10 years	4	13%
		10 to 20 years	19	63%
		More than 20 years	6	20%
		More than 30 years	1	3%
	Project completed	On time:		
		Less than 70%	5	17%
		70 - 90%	22	73%
More than 90%		3	10%	
Within budget:				
Less than 70%		7	23%	
70 - 90%	18	60%		
More than 90%	5	17%		

b. Time overruns

Ranking the importance, frequency and severity of delay variables by the 30 respondents enabled identification of: (i) the most important factors that influence time and cost; (ii) the most frequently occurring variables; and (iii) the overall severity of each variable. The summary of the analysis is shown in Table 4.

A total of 11 construction delay variables were identified. “Inadequate planning and scheduling” ranked the most important (0.97) followed by “Design changes” (0.95), “poor labour productivity” (0.88), and “inaccuracy of materials estimating” (0.87). “Design changes” (0.90), and “inadequate planning and scheduling” (0.85) were respectively identified as the most frequently occurring time overruns on sites surveyed. On the severity scale, “design changes” (0.86), “inadequate planning and scheduling” (0.85) and “poor labour productivity” (0.85) were identified as the most severe time overruns. Overall inadequate planning and scheduling, design changes, poor labour productivity were ranked top 3 for important index, frequency index and severity index.

Based on previous study, inadequate planning and scheduling were one of the top factors that cost time overrun [30]. Ineffective planning and scheduling has also a major impact on construction time overruns. Effective planning and programming of a project is a must to secure early completion of the project. The planning process should be developed from start of the project until completion of a project. The planning stages should be devised very carefully, starting from strategic, tactical and operational planning.

The importance index was used to rank the significant causes of time overruns, and it was found that ineffective planning and scheduling of project by project manager, construction manager and professional engineer on difficulties in finishing project on time. Respondents agreed that ineffective planning and scheduling on technical staff by project manager and professional engineer are the most sever causes of time overruns on high-rise construction project where poor labour productivity is also part of the inadequate of planning and scheduling. Whereas, the project manager and professional engineer reported that ineffective planning and scheduling of project, design changes and poor labour productivity are the most sever causes of time overruns.

Table 4. Variables of time overruns and their importance, frequency, and severity in construction in Penang

Variables/causes of cost overruns	Important		Frequency		Severity	
	Index	Rank	Index	Rank	Index	Rank
Unpredictable weather conditions	0.63	10	0.66	8	0.42	8
Inaccuracy of materials estimate	0.87	4	0.69	7	0.6	6
Inaccuracy prediction of craftsmen production rate	0.84	5	0.79	5	0.66	4
Inaccurate prediction of equipment production rate	0.65	9	0.61	9	0.4	10
Material shortage	0.79	6	0.81	4	0.64	5
Equipment shortage	0.5	11	0.58	11	0.29	11
Skilled labour shortage	0.72	7	0.75	6	0.54	7
Locational restriction of the project	0.7	8	0.6	10	0.42	9

Inadequate planning and scheduling	0.97	1	0.88	2	0.85	2
Poor labour productivity	0.88	3	0.85	3	0.75	3
Design changes	0.95	2	0.9	1	0.86	1

The findings in Table 5 shows that the top 3 major causes of construction time overruns in Penang are inadequate planning and scheduling of project, design changes and poor labour productivity. ‘Design changes in building design and construction is a very complex process, and even with careful control it is inevitable that changes will be made and decisions revisited (Kaming et al [8])’. However, these changes should be kept to an absolute minimum as they disrupt the project and have impacts on time, cost and quality. Broadly, the later in the development of the project that changes occur, the greater those impacts are likely to be. Therefore without a proper project management which will link to design changes which will cause a lot of impact on time and cost overruns. These three significant causes of time overruns are strongly contributing to construction time overruns in Penang.

c. Cost overruns

A summary of the causes of cost overruns on projects (regardless of which party is at fault) by the contractors is presented in Table 5. The factors that are considered as the most important were ‘Poor pre-construction budget and material cost planning’ (0.88), ‘Inaccurate quantity take-off’ (0.82) and ‘Materials cost increased by inflation’ (0.79), which were ranked as first, second and third respectively. Similarly, these three causes also ranked as the top three most frequently occurring causes of cost overruns in Penang Malaysia. In terms of overall severity, the highest-ranking variables were found to be ‘Poor pre-construction budget and material cost planning’ (0.84), ‘Inaccurate quantity take-off’ (0.74) and ‘Materials cost increased by inflation’ (0.70).

Poor pre-construction budget and material cost planning, Inaccurate quantity take-off and materials cost increased by inflation were ranked the top three of cost overruns. Poor pre-construction budget and material cost planning was ranked the most major factor on cost overruns in this group. Therefore poor budget planning lead to over budget which lead to cost overruns which related to second major factor inaccurate quantity take-off. Majority of projects suffer cost over runs where, cost overruns on construction projects are the norm across the high-rise construction industry, driven mainly by poor planning and design, which extends to inadequate or flawed scope, budget and schedule management; a lack of risk identification and project control systems and tools; ineffective decision making; and weak contract terms.

Poor project design is another driver of cost overruns, with construction often starting based on incomplete designs. This sees building contractors subsequently requesting more information and later additions to the project, resulting in both cost overruns and delays. This can be avoided through a detailed design review for completeness and conformance to the owner’s scope as well as interdisciplinary coordination prior to construction. Even in the event a design flaw arises once construction has started, fluid communication across the team of designers, project managers can minimize cost and time overruns.

Table 5. Variables of cost overruns and their importance, frequency, and severity in construction in Penang

Variables/causes of cost overruns	Important		Frequency		Severity	
	Index	Rank	Index	Rank	Index	Rank
Unpredictable weather conditions	0.6	6	0.7	4	0.42	5
Materials cost increased by inflation	0.79	3	0.88	3	0.7	3
Inaccurate quantity take-off	0.82	2	0.9	2	0.74	2
Labour cost increased due to environment restriction	0.58	7	0.55	8	0.32	8
Lack of experience of project location	0.55	8	0.66	5	0.36	7
Lack of experience of project type	0.72	4	0.62	6	0.45	4
Lack of experience of local regulation	0.66	5	0.58	7	0.38	6
Poor pre-construction budget and material cost planning	0.88	1	0.95	1	0.84	1

The third major factor ranked by project manager and professional engineer was ‘materials cost increased by inflation’. Inflation in prices has a significant impact on cost increase. Often the contractor estimates prices of the tender according to the present prices at local markets. It's known that the tendering phase and awarding is the early phase of the project, even the awarding process takes long time, so there is a chance of price fluctuation. In case of high prices, the contractor would face the problem of cost overruns at the execution phase. The inflation cost increased cause fluctuation of prices in Penang is associated with Malaysian economy and the surrounded countries. The research result of Chimwaso [13] contravenes with this result, that the cost increased by inflation cause fluctuations in the cost of construction materials is one of major factors to cause cost over runs. The fluctuation in the cost of construction materials is associated with the location of project country, the economic level, and the volume of required materials. The result of this factor differs from country to country.

5. Conclusion

The first phase undertaken in this research covers literature study in the area of construction with time and cost overrun. In total, 19 categories of causes of time and cost overruns for construction projects. were identified from the various related studies reported in the literature. The significant causes of cost and time overrun were identified based on the responses of the respondents. The most frequent causes of cost overrun are also identified by the research based on the ranking of the rate of severity of the variables of cost overrun which is poor pre-construction budget and material cost planning, inaccurate quantity take-off and materials cost increased by inflation. Where for time overruns the most frequent causes are design changes, inadequate planning and scheduling and poor labour productivity. There are significant variations in the total amount of cost overrun for the different types of high-rise building construction projects investigated in this research. From the survey, labour cost have the lowest rate of severity for cost overrun, while equipment shortage have the lowest rate of time overrun.

The significance of establishing the issues related to the high-rise building construction project time and cost overruns was to provide a greater insight and understanding on the causes of delays particularly among the main project players: contractors, client and consultants. These findings might encourage the practitioner to focus on delay problem that might have existed in their present or future projects. Other than that, this study is expected to provide a better ways and methods in delivering construction projects by minimize the major causes of delays.

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