

Construction readiness parameters for highway projects

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Abstract. Highways greatly contribute to a country's economic development and growth. Therefore, it is vital for highway construction projects to complete on time and budget. However, when a project starts construction prematurely, projects frequently experience interruption that eventually resulted in delays, causing a multitude of adverse effects on all project stakeholders. In other words, premature starts are one of the factors of construction delays. However, prior studies have little understanding of information that can help practitioners determine whether a highway project is premature or ready for construction. This study aims to identify the parameters used in practice to differentiate whether a highway construction project is ready or not to begin construction. To achieve this objective, interviews with sixteen industry practitioners working on highway construction projects are being conducted and analyzed. The significant findings include: (1) construction readiness can be assessed even as early as during the project start-up phase; and (2) not fulfilling the construction readiness parameters may cause a work stoppage, inefficient work, rework, and shortages in labor, equipment or materials. This study contributes to the current body of knowledge by identifying the parameters that indicate whether a highway project is construction-ready or construction-not-ready. The lessons from this study could help the industry to avoid premature starts in highway construction projects.

1. Introduction

A highway can be defined as a public road, especially an important road that joins cities or towns together. Highway construction is vital for every nation because of its contribution to social and economic development. As an essential part of modern transportation systems, highways represent an essential infrastructure for the rapid delivery of people and goods to meet the demands of regional economic development. Empirical evidence suggests that there are significant and positive correlations between highway transportation infrastructure and economic activity [1]. While governments are pushing for successful highway projects because of its importance, highway projects are negatively affecting Malaysia's economic growth from delays and cost overruns [2]. Therefore, identifying approaches to improve the chance of having a successful highway construction project is crucial to nations economic and social development.

A construction project is commonly acknowledged as successful when it is completed on time, within budget, and to stakeholders' satisfaction. Since at least one stakeholder on virtually every construction project benefit from an early start to construction, project teams nearly always feel pressure to begin construction, whether or not they are in fact ready. Premature starts to construction happened when a decision, by at least one party, to start construction with at least one risk that exceeds an acceptable tolerance to a party and which can result in an interruption to construction. Cost overruns, schedule

slippage, overtime, and poor productivity are among the most common and significant impacts projects face when they are not ready to start [3]. Therefore, the industry must prevent premature starts in a construction project that will ultimately lead to various unwanted impacts. Construction readiness is defined as the series of activities and procedures that should be completed or substantially completed before construction so that construction can productively start and sustain operations. Numerous projects begin construction before they are ready to do so (premature start), leading to reduced productivity, and unsatisfactory project performance. Construction-ready projects have on average 22% schedule reduction, 29% productivity improvement, 20% cost savings, 7% less rework, and 21% less change, relative to construction-not-ready projects [4]. Moreover, adequate construction readiness can contribute to avoiding many of the factors causing out of sequence work, and ultimately result in improved project performance [4]. Thus, it is crucial for industry practitioners to assess the readiness of the project before starting the construction. This research sets out to investigate the parameters used in practice to differentiate whether a highway project is ready or not to begin construction. To achieve the objective, this paper addresses research question related to: What are the parameters that can be used to differentiate whether a highway construction project is ready or not ready to begin construction? The author answers the question by conducting interviews with sixteen industry practitioners working on highway construction projects in Malaysia. Then, the data acquired from the interviews were analyzed using thematic analysis. Finally, a set of construction readiness parameter for highway construction is determined. The lessons from this study could help the industry to prevent premature starts in highway construction projects by assessing the construction readiness of a project.

2. Background

2.1. Construction Readiness

Readiness in the construction industry is one of the topics that have been studied by researchers. A readiness assessment identifies the potential challenges that might arise when implementing new procedures, structures, and processes within a current organizational context. The purpose of a readiness assessment is to determine if there are potential barriers to success and provide the individuals or organizations the ability to overcome such barriers before beginning the project. Assessing construction readiness of a project helps project team prevent premature starts by quantitatively determining if a project is “construction ready” resulting to increase in construction cost performance, construction schedule performance, and construction productivity [4]. In order to prevent premature starts to construction, prior research has identified parameters to evaluate construction readiness in general. However, different types of construction projects have different characteristics. For example, highway construction is a horizontal construction, involves more land area and geographic scale is larger compared to building construction. Moreover, it consists of working around a broad and challenging range of existing conditions such as traffic, wetlands, underground utilities, or above-ground infrastructure. Therefore, it is worthwhile to identify the construction readiness parameters specific to highway projects.

2.2. Highway Construction in Malaysia

Due to the importance of highway construction for the development of a nation’s economic and social, numerous studies have been conducted by researchers and industry practitioners in Malaysia. Effective communication system, good project governance, responsibility and commitment of public and private sectors, competitive procurement process and ability to delegate authority have been identified as the top five critical success factors for the Butterworth Outer Ring Road BORR expressway in Malaysia [5]. Meanwhile, the top five factors that contribute to the delay in the highway construction projects is the improper planning, weather, poor site management, inadequate site investigation and underground utilities [6]. On the other hand, five aspects of green highway terminologies namely; conservation and ecosystem management, life cycle energy and emission reduction, recycle, reuse, and recycle, watershed driven stormwater management, and overall societal benefits were identified as common understandings among the stakeholders [7]. Various studies have been investigating both the common

issues in highway projects and the different aspects of highway projects in Malaysia because it is an important topic. However, there is still a lack of research on how to determine whether the highway project is ready or not ready to begin construction. Therefore, this study will fill the gap by investigating on the parameters to assess the readiness of highway construction projects.

3. Methods

The data collection involves acquiring data from interviews with industry practitioners working on highway construction projects. Qualitative approaches are used to analyze the collected data. The following subsections discuss the methods of collecting and analyzing the construction readiness parameters. Figure 1 summarizes this study's methodology in investigating the parameters used in practice to differentiate whether a highway project is ready or not to begin construction.

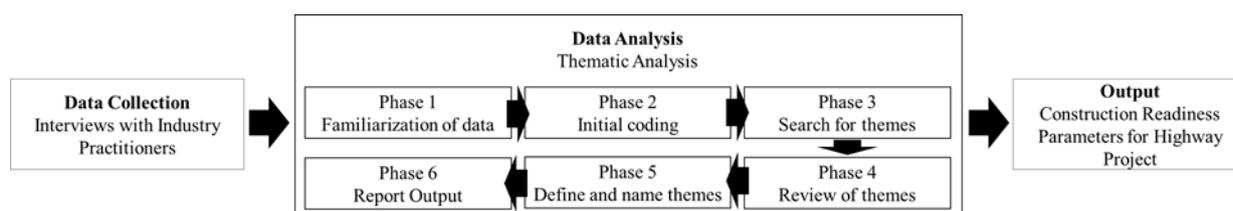


Figure 1. Research methodology

3.1. Data Collection

This study collects information through interviews with industry practitioners. Individual interview has been chosen as the approach for data collection because it helps the interviewer to explain, better understand, and explore research subjects' opinions and experiences. Industry practitioners were consulted to share their unique perspectives, practical knowledge and experiences. The personnel involved in the interviews are all from companies that hold a CIDB's grade G7 license. A contractor with Grade G7 license approved by the Construction Industry Development Board (CIDB) Malaysia is permitted to undertake Civil Engineering Construction and Building Construction projects for an unlimited amount. Therefore, this research purposely selected contractors with grade G7 license because these contractors are well-established organizations in the Malaysian construction industry with strong financial capability. The authors use open-ended questions because these encourage participants to contribute as much detailed information as desired [8]. This study's data collection involves interviewing sixteen valid respondents. The interview started with an introduction that explained why the author wanted to talk with them and what the author wanted to discuss. The question for the interview is: What parameters can be used to differentiate whether a highway construction project is ready or not ready to begin construction? The question was followed by additional questions depending on the participants' response. The follow-up questions aimed to obtain a deeper understanding of the information that they gave and to check whether their statements were understood correctly. If the participant was unable to respond or elaborate on the questions asked, the interviewer tried to rephrase the interview question in another way and gave time for a response. The interviewer encouraged the participants to continue if they had started on an answer without finishing their explanation. After each interview, a summary of the interview was made and sent to the participants for validation purposes.

3.2. Data Analysis

The qualitative analysis involves performing thematic analysis to identify the construction readiness parameters of highway construction because the approach can assist in making sense of qualitative data [9]. This method has been employed by Rahman and Ayer [10] and Radzi et al. [11] to analyze qualitative data associated with construction management topics. The thematic analysis was conducted based on the six phases described in Braun and Clarke [9]. The first phase is becoming familiarized with the data. The authors transcribed the interview data, read, reread and noted the initial ideas. The second phase is to generate the initial codes. The authors coded for as many potential themes and

patterns as possible from the data. The authors then reviewed, discussed, and agreed on any additions and/or changes to the coding. The third phase is to search for themes based on the initial codes. During the process of creating the themes, the authors frequently revisited the codes from the second phase and the original data from the first phase. The fourth phase is to review the themes. To ensure saturation of the data, the authors continually reviewed the subthemes, defined and refined them, checking if themes work in relation to the coded extracts and the entire data set, and reviewing data to search for additional themes. The fifth phase is to define and name the themes. The authors continually went back and forth between the themes, codes, and transcription of the interview to ensure that the themes were true to the independently coded responses. The final phase (sixth phase) is to report the output of the analysis.

4. Results and Discussions

Figure 2 summarizes the themes and subthemes of the construction readiness parameters for highway construction projects that were identified through analyzing this study's interviews with sixteen industry practitioners from Malaysia. A total of 28 parameters have been identified in this study. The parameters can be categorized into five categories: "Approval", "General Requirement", "Drawing Requirement", "On-site" and "Material". These five categories can be grouped into two themes: "Project Start-up" and "Execution." The details of each parameter are discussed in the subsequent subsections.

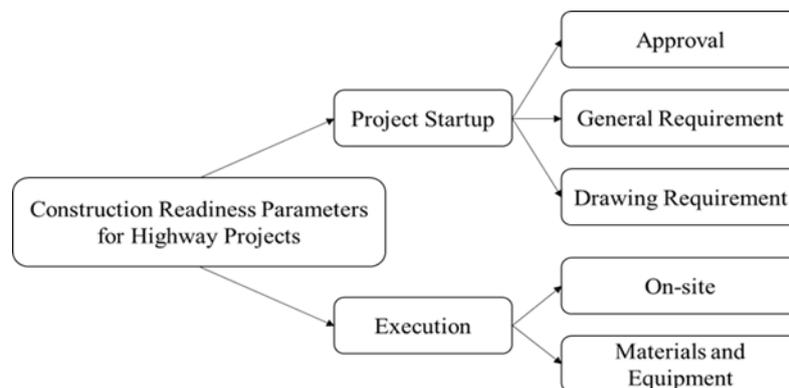


Figure 2. Overview of the construction readiness parameters of highway projects

4.1. Parameters related to Project Start-up

4.1.1. Approval. According to the interview results, one of the parameters used to determine whether the construction is ready or not is making sure that the project received approvals from different legal agencies in Malaysia such as, local authorities, utility companies, Department of Occupational and Safety (DOSH), and Construction Industry Developmental Board (CIDB). Approval in construction project refers to obtaining permissions from the relevant authorities to ensure the development follows the standards laid down in the building regulations and certain stages of the construction are inspected by officers from the local authority. Sometimes during construction, authority officers will perform inspections at the construction site to ensure the works progress as intended, both in terms of quality and compliance. Failed to show notice of approvals to the inspection officers might cause them to stop the construction work until decision have been made leading to loss of productivity and delay.

4.1.2. General Requirement: (a) *Received letter of award from client.* Letter of award is sent by the client to the contractor as written confirmation that the contractor has been successful and will be awarded the project. Without a letter of award, various problems might occur because there is no written and signed contract stated that the owner had awarded the project to the contractor. Without a contract, there's no agreement, no protection for the contractor and no guarantee that the contractor will be paid for the work they do. Furthermore, failure to agree on the contract terms and conditions

before work starting means that when the project manager finally reviews them, they have often incurred costs on the project and are not in the position to persuade the client to alter the terms and conditions to those that are more appropriate or acceptable. When a contractor incurred too much cost, it might affect their cash flow. Consequently, workers might refuse to work due to contractors unable to pay their salary on time resulting from halting in construction work. Without workers, construction work could not be done causing loss of productivity.

(b) Finished land acquisition. Land acquisition is the process of acquiring the required or compulsory land for the project. It is one of the critical elements in the land development process. The process of land acquisition provides a legal procedure for the public sector in acquiring any land for development projects that benefits the country. Highway development may require the acquisition of land from local people for the infrastructure and economic development of the country. In many cases, acquiring land from the public is not easy for many reasons, primarily related to compensation or the price of land consequently prolongs the duration of the project. If project have begun, construction work might need to stop until the land acquisition is completed leading to loss of productivity.

(c) Sufficient funding. Funding is vital for a construction project. Project managers should ensure that the project has enough money throughout the construction. Inadequate funding might cause workers and suppliers refuse to work and supply material to the site affecting construction work resulting to loss of productivity. Also, lack of funds may affect the project's cash flow and lead to delay in site possession, which consequently causes delays in the project as a whole [12].

(d) Obtained project insurance. Construction insurance is a practice of exchanging a contingent claim for a fixed payment to protect the interests of parties involved in a construction project. It is a major method of managing risks in the construction industry. Construction is a dangerous and usually unpredictable industry to work in and presents a considerable risk of personal injury, damage to existing property and financial loss. Lack of insurance may make workers refused to work because if accidents happened, they might not have enough money to pay for medical expenses.

(e) Verified official commencement date and construction duration. The commencement date is the date at which the time begins to run, based upon the project schedule. Conversely, construction duration is defined as the time frame given by the owner for the contractor to complete the project under normal work conditions. It is a necessary step for project managers to verify the commencement date and construction duration to plan construction works accordingly. Poor project planning can result to project delay [13]. Poor planning means that the schedule that the workers are supposed to follow is not set out. The workers will have no clear picture of what is expected of them as they work on the projects. There will be no deadlines to meet hence creating a lazy atmosphere among the workers decreasing productivity. This means that the project will not be completed on time resulting to project delay.

(f) Verified nearest authority. Construction site theft can cause various problems to the project. Therefore, working with local authorities is necessary to prevent crime at the construction site. Project managers should verify nearest local authorities and inform them about the construction site. Besides, project managers can ask the authority to monitor the site on weekends or holidays when the site is unattended to avoid theft. In addition to the direct costs of replacing the stolen goods, there is also rental costs to replace stolen equipment and lost productivity. Interruptions to the project schedule due to a shortage of equipment and materials can also lead to delay.

(g) Meeting with consultant and client. The client is the owner of the project and consultants are professionals such as architect, structural engineers, and others, appointed by the client to perform expert tasks on a project. During this meeting, stakeholders can discuss and answers outstanding questions about the project. Productivity might decrease due to outstanding questions about the

project. Also, some decisions on the project could not be made resulting in interruption to project schedule.

(h) Verified construction work plan. A work plan is a sequence of step that must be taken or activities that must be performed well for a project to succeed. Furthermore, a work plan shows all the tasks involved in a project, who is responsible for each task, and when the tasks will be completed. It can help the contractor to stay organized while working on projects and helps them to complete the project in time and within the budget. Starting construction without a work plan could cause various problems such as reduced productivity and schedule slippage.

(i) Client and consultant approved construction work plan. Client and consultant should know the work plan that has been developed by the contractor so that there is no dispute between stakeholders. Lack of understanding of the project work plan might cause conflict between stakeholders. If disputes are not adequately managed, they may cause project delays, undetermined team spirit, increase project costs and above all, damage continuing business relationships [14]. Also, work stoppage might happen because of a decision could not be made due to a dispute between stakeholders causing loss of productivity and delay. Therefore, client and consultant should approve the work plan before starting a project.

4.1.3. Drawing Requirement. (a) Drawings approved by consultant. It is important that the consultant can review and approve the construction drawing before the project manager can start the project. Consultant's approval can ensure conformity to construction drawings, specifications, and standards. Clients always change the design during the construction period and at the same time, it will affect the whole project duration. The contractor cannot carry out the construction work until the latest drawing issue by the architect. Consequently, the work cannot be done within the contract period resulting from delaying and reduced productivity. Therefore, to prevent work stoppage, drawings must be approved by the consultant before construction.

(b) Drawings approved by authorities. Approval of drawings by authorities is a process undertaken by authorities to ensure new construction safe for human and as per planning regulations. The approval process checks whether the building is safe and structurally sound and whether the building materials proposed are safe for human habitation. Starting construction with a drawing that had yet been approved by an authority can risk project schedule. If authority officers inspect at the site and acknowledge that the drawing has not been approved, they might stop the construction work resulting to delay and lost productivity.

(c) Complete drawings are all supplied. Complete drawings are vital to ensure the project can be completed within a time frame. Errors and omission can cause the drawings to be incomplete leading to project delay. During construction, due to drawing is unclear and important details are not shown in the drawing, workers could not continue the work. As a result, the works have to stop immediately until details of that particular drawing can be obtained leading to loss of productivity and delay.

(d) Verified discrepancies between tender drawings and construction drawings. Discrepancies between tender drawings and construction drawings can cause project delay. Tender drawings are drawing given to the bidders(contractors) at the tender time. Construction drawings are given by the consultant for construction purposes. Sometimes, there are discrepancies between these drawings. These discrepancies result in rework, changes in quantities, and delays and defects in construction. Furthermore, reworks lead to lower productivity [15].

4.2. Parameters related to Project Execution

4.2.1. *On-site. (a) Site office.* Office facilities are necessary at the construction site to provide accommodation for project managers, provide space for meetings, and to provide storage for site documentation. Besides, the site office is vital to make sure that all project's documentation is kept safe. When the construction project starts before site office have been built, documentation such as projects files and drawings can be all over the place. Missing project documentation such as contract files or drawings can cause interruption to project schedule. For example, project managers need to find the missing drawings before the work can resume resulting in lost productivity and delay.

(b) Site condition as per the contract. Project managers should make sure that the site condition is the same as stated in the contract and there is no differing site condition. A differing site condition occurs when the project manager experiences a condition on the site that differs materially from the conditions indicated in the contract with the owner of the project or from what is to be normally expected in the site area. Differing site condition will cause time delay to the project due to work stoppage at the site until relevant decisions are made by stakeholders [16].

(c) Verified utility cables and relocate if necessary. Utility relocation is the adjustment, replacement, or relocation of utility facilities as required by a highway construction project, such as: removing and reinstalling the utility, acquiring necessary right-of-way, moving or rearranging existing facilities, changing the type of utility and applying any necessary safety and protective measures [17]. Damage to underground utilities due to construction work can result in weeks of delays. For example, accidentally hitting a water pipe can lead to a temporary halt of the project. The water would spill out and flood the area, which makes the site unworkable. Also, there will be community complaints and legal issues that will further the delay.

(d) Verified traffic diversion and control system. Traffic diversion system relates to making sure the traffic around the construction site will not be interrupted by the project and if necessary, traffic diversion is made to minimize interruption. On the other hand, the traffic control system relates to a system of managing traffic in and around construction sites. The above parameters can be related in terms of preventing an accident at a construction site. Vehicles move in and around the workplace, reversing, loading and unloading are often the leading cause of death and injuries to workers and members of the public. Inadequate planning and control are the root cause of workers and construction vehicle accidents. Accident involving construction vehicle can lead to equipment shortage due to the accident eventually result to time overrun. Also, an accident involving construction workers can lead to a labor shortage, ultimately resulting in a construction delay.

(e) Placed safety signboard. Safety signboards are crucial in any work environment. The primary importance of displaying safety signboard is to prevent accidents and ensure workers are well aware of the possible dangers and hazards ahead in certain situations and environments. Without signboards, many workers would lack the necessary direction in times of crisis, and employers might find themselves in significant legal difficulties if any accidents were to arise as a result. Accidents involving construction workers due to inadequate site safety can reduce the work rate and efficiency, which will lead to work disruption and ultimately to project schedule delay [18]. Besides, accidents can affect the number of workers leading to interruption to the project schedule. In some cases, finding a replacement for the injured workers takes more time than expected.

(f) Installed closed-circuit television (CCTV) and verified parking space for construction machinery. CCTV is a system that sends television signals to a limited number of screens and is often used in shops and public places to prevent crime. Conversely, verified parking space for construction machinery relates to designing parking space for construction machinery. Installing CCTV and verifying parking space for construction machinery can be linked in terms of preventing crime at the construction site. Nowadays, theft and vandalism on construction sites in the commercial construction

industry is a problem that can affect productivity and drain profits. One of the techniques used to prevent crime at the construction site is by installing security cameras [19]. Besides, construction machinery should be parked in the designated parking area at the site to prevent crime. Machinery with no parking space at the site and left unattended in remote locations can be easily targeted by thieves. Companies need to pay to replace the loss machinery or rent it in the interim to keep projects on schedule. Besides, there are other costs involved as well, not the least of which is the resulting downtime caused by the lack of availability of machinery. Hence, it is essential to make sure there is parking space designated for construction machinery before construction and to ensure that CCTV had been installed before starting the construction to avoid a shortage of equipment.

(g) Verified temporary utilities on site. Before work can begin on a construction site, several services such as electricity, water, lighting, internet connection, and others must be temporarily set up. Construction site without electricity can disrupt office works leading to delay in a construction project. Also, internet connection and telephones are necessary at the construction site for project managers to contact the client about the project. Lack of readily available utilities on site is one of the causes of delays in the Ethiopian construction industry [20].

(h) Adequate workforce. Construction workforce means the workers who are engaged in the construction industry. Shortage of workers causes interruptions to project schedule. For example, inadequate equipment operators at the site will disrupt construction work because there are not enough workers to operate construction equipment. Moreover, although materials are ready there is an inadequate worker to carry the work can affect project duration. Lack of foreign and local workers is listed as one of the most frequent factors that lead to delay in the Malaysian construction industry [21].

4.2.2. Materials and Equipment. (a) Verified nearest material supplier and quarry. Material supplier means any entity that supplies materials, services, or equipment to be used in conjunction with the performance of work on a construction contract. On the other hand, a quarry is a place where rocks, gravel or sand, dimension stone, slate construction aggregate and others are excavated from the ground. The geographical location of material supplier and quarry might affect the delivery lead-time, transport and logistics costs. For example, selecting a supplier or a quarry that is near to the site can ensure the material arrives at the right time. Dealing with distant suppliers or quarry might mean longer delivery times and extra freight costs. Supplier failure to deliver material on time can disrupt operations and delay the completion of a project. Unavailability of materials on site is one of the factors that influences productivity.

(b) Equipment availability. Highway construction requires a variety of specialized equipment. Lack of equipment affects labor productivity since labor relies on equipment to aid the construction process. For example, the excavator is used to excavating and move a large object. Without it, construction material could not be move resulting to project disruption and work stoppage. Also, equipment availability is one the cause of delay in the Malaysian construction industry [22].

5. Conclusion

This study identified the construction readiness parameters for highway projects by analyzing interviews with sixteen industry practitioners in Malaysia. In conclusion, readiness parameters related to either the project start-up or execution phase have been identified. In other words, construction readiness can be assessed as early during the start-up phase of a highway construction project. Also, starting construction without adequately satisfying the parameters can result to a work stoppage, inefficient work, rework, and shortages in labor, equipment, or materials. These findings highlight the need for industry practitioners to assess the readiness of a project before starting construction. While some of the parameters identified in this study can be associated with other types of construction projects, there are several parameters that are specific to highway construction. Specifically, parameters such as finished land acquisition, verified traffic around the construction site, and traffic control system are not part of the readiness factors for general construction [4]. These findings suggest

the land acquisition process is vital in highway construction because highway projects are usually long and involve lots of lands. Meanwhile, because of construction workers face the danger of working in the close vicinity of passing traffic, verification of traffic and traffic control system are essential before construction. In other words, this study contributes to the existing body of knowledge on highway construction by providing additional parameters that are specific to evaluating construction readiness of highway projects. The lesson of this study, when properly used, would help the industry to prevent premature starts in highway construction projects by assessing the project construction readiness.

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