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A Comparative Study on the Readiness Parameters of Highway Construction Projects

A R Radzi[1], R A Rahman[2,3], S I Doh[1] and M Esa[4]

1 Department of Civil Engineering, College of Engineering, Universiti Malaysia Pahang, 26330 Gambang Pahang

2 Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

3 Earth Resources & Sustainability Center, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia

4 School of Housing Building and Planning, Universiti Sains Malaysia, 11800, USM, Penang, Malaysia

E-mail: nurafiqah279@gmail.com

Abstract. Successful highway projects could help contribute to a country's economic development and growth. One of the factors that cause delays in highway projects is starting too early (i.e., premature start), and assessing the readiness of the project before construction could prevent it from happening. However, different types of highway projects can have various causes of delay. Therefore, having inappropriate readiness parameters can impair the process of assessing construction readiness. This study aims to compare the construction readiness parameters (CRPs) between different types of highway projects. To achieve that objective, questionnaire survey data from 105 industry practitioners with highway construction working experiences is analyzed using the analysis of variance (ANOVA), descriptive statistics, and mean score ranking technique. The results reveal 32 CRPs that are critical for both highway and expressway projects. Also, there are 6 CRPs that are only critical for highway projects. This study contributes to the current body of knowledge by illustrating any discrepancies of the readiness parameters between types of highway projects. The lessons from this study could help the industry to justify the usage of the parameters for assessing their highway projects in preventing premature starts.

1. Introduction

Highways are major public roads that are used to connect places for travel or transportation of people and goods. Highway construction plays an important and vital role in growing the economy of the country [1]. It also contributes positively to the development of Gross Domestic Product (GDP) as well as in the employment of labor forces [2]. Besides, empirical evidence suggests that there are significant and positive correlations between highway transportation infrastructure and economic activity [1]. Thus, identifying approaches to improve the chance of having a successful highway construction project is crucial to nations' economic and social development.

Highway construction is a public project, significantly large enough to affect the ecosystem and society around it. As a developing country, Malaysia has a wide range of highway network systems that link facilities and people within and across the country. However, delays are a common issue in

infrastructure projects, especially in highway construction projects [3]. One of the reasons for project delay to happen is premature starts - 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 [4]. Premature starts can be avoided by adequate construction readiness assessment and performing appropriate preconstruction activities [5]. Hence, construction readiness parameters (CRPs) are used to assess the readiness of a construction project so that premature starts could be avoided. Readiness parameters are the parameters that are used to differentiate whether the highway project is ready or not ready to start construction.

In Malaysia, roads are divided into two groups by area, rural and urban [6]. Roads in rural areas are further classified into five categories by function, namely expressway, highway, primary road, secondary road, and minor road. While roads in urban areas are also categorized by function, namely, expressway, arterial, collector, and local street, this study focuses on different types of highway projects, which are expressway and highway. An expressway is a divided highway for through traffic with full control of access and always with grade separations at all intersections [6]. In rural areas, they apply to the interstate highways for through traffic and make the basic framework of National road transportation for fast traveling. They serve long trips and provide a higher speed of traveling and comfort. To maintain this, they are fully access-controlled and are designed to the highest standards. Expressway in urban areas forms the basic framework of the road transportation system in urbanized area for through traffic. Expressways also serve relatively long trips and smooth traffic flow and with full access control and complements the rural expressway. Highways constitute the national interstate network and complement the expressway network [6]. They usually linkup directly or indirectly the Federal Capitals, State capitals, and points of entry/exit to the country. They serve long to intermediate trip lengths. Speed service is not so important as in an expressway, but relatively high to medium speed is necessary. Smooth traffic is provided with partial access control. If the CRPs are incorrect, industry practitioners might make the wrong decision, and consequently, it may affect the project schedule. For instance, preparing a good selection of material suppliers might be more important in highway projects because highway projects are often in rural areas compared to expressway projects. Therefore, it is necessary to determine the suitable parameters to use for assessing construction readiness of a project because highways and expressways have different characteristics.

This research sets out to compare the CRPs between different types of highway construction projects. To achieve the objective, survey data from 105 industry practitioners are analyzed using the analysis of variance (ANOVA), descriptive statistics, and mean score ranking technique. This study contributes to the current body of knowledge by illustrating any discrepancies of the readiness parameters between different types of highway projects. In addition to providing additional insights into the existing highway construction body of knowledge, the lessons from this study could help the industry to justify the usage of the parameters for assessing their highway projects in preventing premature starts.

2. Background

2.1. Highway Construction Delay in Malaysia
Highway construction projects in Malaysia have been experiencing various problems, including delays. Numerous delays have been reported during the construction of the East Coast Expressway Phase 2 (LPT2). For instance, the delay in the completion of the LPT2 was due to changes in the entire design and structure, from a Federal highway to a Toll highway [7]. Besides that, Pan Borneo Highway, in Sabah, which is currently under construction, also has been delayed due to land compensation [8]. In 2018, Bank Negara Malaysia Quarterly Bulletin reported that the slower growth in the civil engineering subsector is affected by near completion of large petrochemical projects and delays in highway construction [9]. The top five factors that contribute to the delays in highway construction projects, which are improper planning, weather, poor site management, poor site investigation, and underground

utilities [10]. Site location, top management and client involvement, public acceptance, and efficiency of authorities are also influencing the success of highway construction projects [11]. In summary, as delays in highway projects is a common problem in Malaysia, researchers and industry practitioners must find suitable ways to prevent it from happening.

2.2. Readiness Parameters for Highway Construction
One study had identified 31 CRPs for highway projects in Malaysia [12]. The study collects data through interviews with industry experts. The parameters are categorized into five categories: approval, general requirement, drawing requirement, on-site, and material. These five categories can be grouped into two themes, which are project start-up and execution. The study concluded that construction readiness could be assessed as early during the start-up phase of a highway construction project. Also, starting construction without adequately satisfying the parameters can result in a work stoppage, inefficient work, rework, and shortages in labor, equipment, or materials. Therefore, it is necessary to ensure that the readiness parameters that are being used are suitable for the project to prevent project delay.

2.3. Positioning this study
Notably, existing studies identify the readiness factors for construction projects in general [5] and parameters for assessing the readiness of highway projects [12]. While the parameters identified are generally for all type highway projects, there might be some discrepancies in the usable parameters because expressway and highway have different characteristics. This study aims to compare the readiness parameters between highway projects and expressway projects through an online questionnaire survey with industry practitioners. The data from the survey are analyzed to find any differences in the usage of CRPs between highway projects and expressway projects. To the best of our knowledge, this is the first work to explore this theme in the literature globally.

3. Methodology
The method employed in this study is a questionnaire survey. Figure 1 presents the methodology for the research. Several quantitative approaches are used to analyzed the collected data as different methods can triangulate and complement each other, thus yielding stronger and more reliable findings [13]. The following subsections discuss the methods of collecting and analyzing the construction readiness parameters.
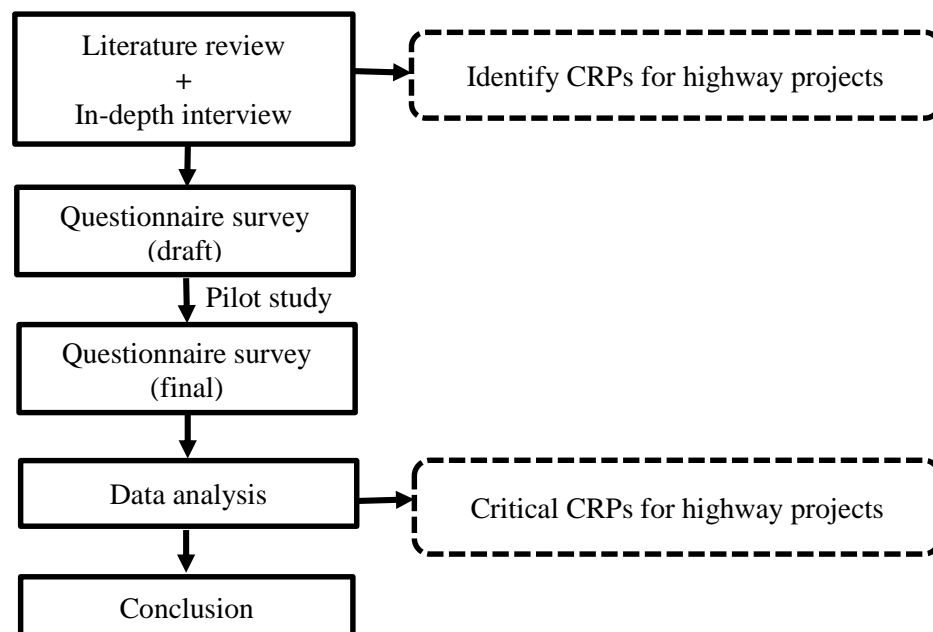

Figure 1. Research methodology.

3.1. Data Collection
This study collects information through questionnaire surveys distributed to industry practitioners. A questionnaire survey is a systematic method for gathering data from a sample. Furthermore, it enables respondents to respond at their convenience and allows for the collection of a comparatively large number of responses, relatively quickly and cheaply [14]. Other construction management research efforts are also using questionnaire surveys, such as in investigating the relationship between site supervisors and modular-based construction [15] and barriers and drivers for adopting model-based construction [16].

In order to develop the questionnaire survey, a comprehensive literature review and in-depth interviews with the industry practitioners are conducted to identify the CRPs. While the results of the literature review showed the construction readiness parameters investigated by prior research, in-depth interviews with industry practitioners are used to explore the readiness parameters that are currently used in practice in the Malaysian context.

The in-depth interview is a technique used to collect qualitative data and enables the interviewees to express their opinions on a particular subject or matter. Based on the interviews with industry practitioners, 31 CRPs are identified. More specific details of the in-depth interviews could be found in Radzi et al., 2019 [12].

Then, an initial list of 228 CRPs reported in an earlier study by Ibrahim, 2018 [5] is used in this study. The CRPs are sorted by their weight. Therefore, the normalized value of each CRPs is calculated using the weight, and CRPs with normalized values equal to or higher than 0.60 are added to the questionnaire survey because a normalized value of 0.60 is equivalent to a three on the five-point Likert scale, which is usually the threshold for important or very important. As a result, a list of 11 CRPs is identified based on prior literature.

After that, an initial version of the questionnaire is developed using the information from the literature review and in-depth interviews. CRPs with the same meaning are merged. Consequently, a total of 40 construction readiness parameters for highway projects is established. Table 1 shows the identified CRPs for highway projects based on the in-depth interview and literature review.

The questionnaire for this study consisted of two sections. Section one is an introductory section that includes questions related to the profile of the respondents and their companies. This is necessary to determine the reliability of the responses before conducting further analysis of subsequent data. The second section contained the list of the identified CRPs on a five-point Likert scale with one being not important and five being very important. A response scale of 1 - 5 is used in order to achieve optimum reliability and validity [17]. Thoughtfully, spaces are provided at the end of the 40th CRPs for respondents to list and rate the importance of it. This is necessary to make sure all the CRPs is included in the study

A pilot study is conducted to test the significance and comprehensiveness of the CRPs. Six participants are involved in the pilot study: three project managers with at least five years of experience in highway projects and three university lecturers, who are all knowledgeable in the research topic. The participants are requested to review and evaluate the questionnaire survey for construct validity, response time, question design, and ease of understanding. The comments from the participants on the quality of questionnaire content, grammar, and wording, is used to modify the questionnaire survey.

A snowball sampling method is used in this study to attain a valid and effective overall sample size. The method is selected as it is a method where existing study subjects recruit future subjects from among their acquaintances, and it is often used when the desired sample characteristic is rare [18]. This method

is also used in previous construction engineering and management studies [19], and it allows the gathering and sharing of information and respondents through referral or social networks. This study has a minimum of 100 responses because it aims only to illustrate the different levels of the importance among the CRPs rather than presenting the whole population's perception of the variables.

The questionnaire survey was conducted from November 2019 to January 2020. To obtain a balanced perspective, the target participants for the questionnaire survey included the main stakeholders in construction projects, such as the government, clients, contractors, and consultants with knowledge and experience in highway projects from all over Malaysia. The questionnaire is disseminated through an online survey platform to target a wide range of professionals in the construction industry. To attain an increased success rate of the survey, two follow up emails and messages are sent to the target populations two weeks after the first email and messages.

Table 1. Identified CRPs for highway projects.

Code	Construction Readiness Parameters (CRPs)
CRP 1	Local authorities have approved the project
CRP 2	Letter of award from the client has been received
CRP 3	Land acquisition is done
CRP 4	Funding for the project has been acquired
CRP 5	The necessary insurance has been obtained for the project
CRP 6	The official commencement date has been verified
CRP 7	Construction duration has been verified
CRP 8	Nearest authority to the construction site has been verified
CRP 9	Kickoff meeting between stakeholders
CRP 10	Project workplan has been verified
CRP 11	Project workplan has been approved by the client
CRP 12	Project workplan has been approved by the consultant
CRP 13	Drawings have been approved by the consultant
CRP 14	Drawings have been approved by the authority
CRP 15	Discrepancies between construction drawings and tender drawings have been verified
CRP 16	Complete IFC (issued-for-construction) drawings have been issued
CRP 17	Nearest material supplier to the construction site has been verified
CRP 18	Nearest quarry to the construction site has been verified
CRP 19	Equipment for the project have been acquired
CRP 20	The site office is ready
CRP 21	The site condition has been verified as same to the contract
CRP 22	Location of utility cables at the construction site have been verified
CRP 23	Relocation of utility cables that will be interrupted by the project has been completed
CRP 24	Traffic around the construction site has been verified
CRP 25	Roads that will be interrupted by the project have been diverted
CRP 26	Safety signboards have been placed at the construction site
CRP 27	CCTV has been installed at the construction site
CRP 28	The traffic control system is ready
CRP 29	Parking space for machinery at the construction site have been verified
CRP 30	Utilities on construction site are ready (e.g., electricity, water, Wi-fi, etc.)
CRP 31	Adequate workforce has been acquired
CRP 32	Labor productivity rates have been verified
CRP 33	Schedule for design deliverables compatible with the sequence of construction have been verified
CRP 34	Project team include representatives from the procurement team
CRP 35	Process for reporting RFI (Request For Information) has been verified
CRP 36	Hold points/handoffs have been identified
CRP 37	Process for responding to delay has been verified
CRP 38	System to align construction with commissioning and operations have been verified

| CRP 39 | Discipline design interfaces have been well-coordinated |
| CRP 40 | Clear procurement process and supporting systems in place for storage have been verified |

3.2. Data Analysis

Before analyzing the data collected, Cronbach's alpha coefficient is used to evaluate the reliability of the five-point rating scale used in capturing the survey responses. Cronbach's alpha determines the average correlation or internal consistency among factors in a survey questionnaire to assess the questionnaire's reliability. Its coefficient value should be higher than the threshold of 0.70 [20]. The Cronbach's alpha for this study is 0.946 for highway project items and 0.958 for expressway project items, which reflects an extremely high level of reliability.

This study first used analysis of variance (ANOVA) to check whether there are any significant differences in mean values of CRPs between highway projects and expressway projects. ANOVA is a commonly applied parametric test for checking differences between mean scores from three or more groups; it has an assumption that the population from which the sample is drawn is normally distributed [21].

Then, the most commonly used descriptive statistics of mean and standard deviation (SD) are used to rank the CRPs for highway projects. Following Mao et al., 2015 [16] approach, where two or more CRPs had the same mean score, the CRPs with the smallest SD is given the highest rank. A smaller SD suggests that the differences in responses are not statistically large, and thus the average is more likely to be valid for the majority [22].

In addition, as a typical quantitative analysis method for ranking the relative importance/criticality of factors, the mean score ranking technique has been widely used in previous studies in the construction management field. In this study, the mean score ranking techniques are used to determine the criticalities of the identified CRPs. The statistical mean, standard deviation, and normalization values for each CRP are computed. Based on the computed normalized values, the criticality of a factor is determined. Only factors with a normalized value of $\geqslant 0.50$ are considered critical [23]. The results of the analysis and the discussion are presented in subsequent sections.

4. Results and Discussions

Overall, a total of 105 completed questionnaires are analyzed in this study. Table 2 summarizes the respondents' profile. It shows that more than half of the respondents (55%) had more than five years of experience in highway and expressway projects. Considering the many years of experience of the respondents, the data collected from these respondents could be dependable and representative of the Malaysian construction industry.

Table 2. Respondents background information.

Profiles	Categories	Number of respondents	Percentage
Types of organization	Owners (e.g., government, developers)	44	41.9%
	Contractors	31	29.5%
	Consultants	25	23.8%
	Others	5	4.8%
Types of projects	Highway Construction	43	41.0%
	Expressway Construction	9	8.6%
	Both	53	50.5%
	Less than 2 years	8	7.6%
	2 - 5 years	39	37.1%

Years of experience in	6 - 9 years	21	20.0%
highway and	More than 9 years	37	35.2%
expressway projects			
Numbers of highway	Less than 2 projects	25	23.8%
and expressway	2 - 5 projects	53	50.5%
projects involved	6 - 9 projects	7	6.7%
	More than 9 projects	20	19.0%

4.1. Critical CRPs for both highway and expressway projects

As shown in Table 3, based on the one-way ANOVA analysis, all CRPs have a p-value higher than 0.05, indicating that there are no significant differences between highway projects and expressway projects. Therefore, industry practitioners could use the identified CRPs both in highway projects and expressway projects.

Also, Table 3 shows a summary of the survey results of CRPs for highway and expressway projects. For highway projects, based on the calculated normalization values, 38 CRPs are identified as critical (normalization values $\geqslant 0.50$). Only two CRPs, Parking space for machinery at the construction site have been verified' (CRP 29) and 'CCTV has been installed at the construction site' (CRP 27) with normalization values below 0.50 are considered not critical. These two CRP's are considered not critical because highway projects are often in rural areas. Thus, there are a lot of spaces for machinery and not a lot of crime happened in this area compared to the city. While for expressway projects, 32 CRPs are identified as critical with normalization values equal to or greater than 0.50. Eight CRP's with normalization values below 0.50 are considered not critical.

Table 3. Summary of the survey results on the CRP's.

Codes	Highway				Expressway				p-Value
	Mean	SD	NV	Rank	Mean	SD	NV	Rank	(highway vs. expressway)
CRP 2	4.80	0.52	1.00[c]	1	4.77	0.56	1.00[c]	1	0.748
CRP 4	4.70	0.56	0.95[c]	2	4.60	0.64	0.91[c]	3	0.298
CRP 1	4.65	0.78	0.93[c]	3	4.73	0.63	0.97[c]	2	0.500
CRP 3	4.61	0.64	0.92[c]	4	4.60	0.66	0.91[c]	4	0.866
CRP 13	4.56	0.63	0.89[c]	5	4.52	0.65	0.87[c]	5	0.655
CRP 22	4.47	0.66	0.85[c]	6	4.47	0.69	0.84[c]	6	0.993
CRP 14	4.47	0.78	0.85[c]	7	4.39	0.78	0.80[c]	7	0.521
CRP 10	4.44	0.63	0.84[c]	8	4.29	0.69	0.75[c]	11	0.168
CRP 7	4.42	0.66	0.83[c]	9	4.34	0.68	0.77[c]	8	0.474
CRP 9	4.40	0.67	0.82[c]	10	4.31	0.67	0.76[c]	9	0.415
CRP 6	4.33	0.78	0.79[c]	11	4.21	0.87	0.71[c]	16	0.353
CRP 26	4.32	0.73	0.79[c]	12	4.31	0.80	0.76[c]	10	0.894
CRP 5	4.32	0.79	0.79[c]	13	4.26	0.81	0.73[c]	13	0.618
CRP 23	4.30	0.81	0.78[c]	14	4.27	0.79	0.74[c]	12	0.831
CRP 11	4.29	0.85	0.77[c]	15	4.24	0.78	0.72[c]	14	0.711
CRP 15	4.27	0.81	0.76[c]	16	4.18	0.90	0.69[c]	18	0.500
CRP 16	4.24	0.87	0.75[c]	17	4.10	0.94	0.65[c]	22	0.329
CRP 25	4.21	0.75	0.73[c]	18	4.21	0.85	0.71[c]	15	0.992
CRP 24	4.18	0.78	0.72[c]	19	4.10	0.82	0.65[c]	21	0.538
CRP 8	4.14	0.82	0.70[c]	20	4.02	0.86	0.61[c]	26	0.381
CRP 12	4.10	0.93	0.69[c]	21	4.16	0.75	0.68[c]	19	0.687
CRP 39	4.07	0.77	0.67[c]	22	4.18	0.74	0.69[c]	17	0.399
CRP 31	4.04	0.79	0.66[c]	23	3.98	0.74	0.59[c]	28	0.646

CRP 35	4.03	0.69	0.65^c	24	4.06	0.65	0.63^c	23	0.762
CRP 21	4.03	0.76	0.65^c	25	4.02	0.84	0.61^c	25	0.907
CRP 37	4.02	0.77	0.65^c	26	4.02	0.74	0.61^c	24	0.970
CRP 33	4.00	0.78	0.64^c	27	3.95	0.76	0.57^c	29	0.701
CRP 28	3.99	0.90	0.64^c	28	4.13	0.88	0.66^c	20	0.338
CRP 34	3.94	0.77	0.61^c	29	3.90	0.88	0.55^c	31	0.796
CRP 40	3.93	0.80	0.61^c	30	3.94	0.83	0.56^c	30	0.949
CRP 19	3.92	0.75	0.60^c	31	3.84	0.77	0.51^c	32	0.529
CRP 38	3.90	0.79	0.59^c	32	4.00	0.77	0.60^c	27	0.414
CRP 32	3.83	0.85	0.57^c	33	3.76	0.82	0.47	35	0.584
CRP 18	3.80	0.80	0.55^c	34	3.53	0.92	0.35	38	0.053
CRP 36	3.76	0.76	0.53^c	35	3.79	0.77	0.49	33	0.811
CRP 17	3.76	0.82	0.53^c	36	3.60	0.95	0.39	36	0.251
CRP 30	3.76	0.93	0.53^c	37	3.77	0.93	0.48	34	0.928
CRP 20	3.69	0.92	0.50^c	38	3.53	1.10	0.35	39	0.339
CRP 29	3.56	0.98	0.44	39	3.60	1.00	0.39	37	0.832
CRP 27	2.57	1.14	0.00	40	2.85	1.10	0.00	40	0.126

Note: SD = Standard deviation

NV (Normalized value) = (mean – minimum mean) /(maximum mean – minimum mean)

^{c} The normalized value indicates that the CRP is critical (normalized ≥ 0.50)

Figure 2 shows that the respondents agreed that 32 CRPs are critical for both highway projects and expressway projects. However, six CRPs are considered critical only for highway projects. These six CRPs are discussed in the next subsection.

4.2. CRPs that are only critical for highway projects

4.2.1. Nearest material supplier to the construction site have been verified (CRP 17)

Generally, for any construction project, selecting a supplier that is near to the site can ensure the material arrives on time. Dealing with distant suppliers might mean longer delivery times and extra unwanted costs. Expressway projects are mainly located in the city or town. Therefore, having material on time for construction is not a problem because suppliers are usually located in the same area. On the other hand, highway projects sometimes can be in a rural area, hence delivering materials to the site on time is difficult. Thus, CRP 17 is critical only for highway projects.
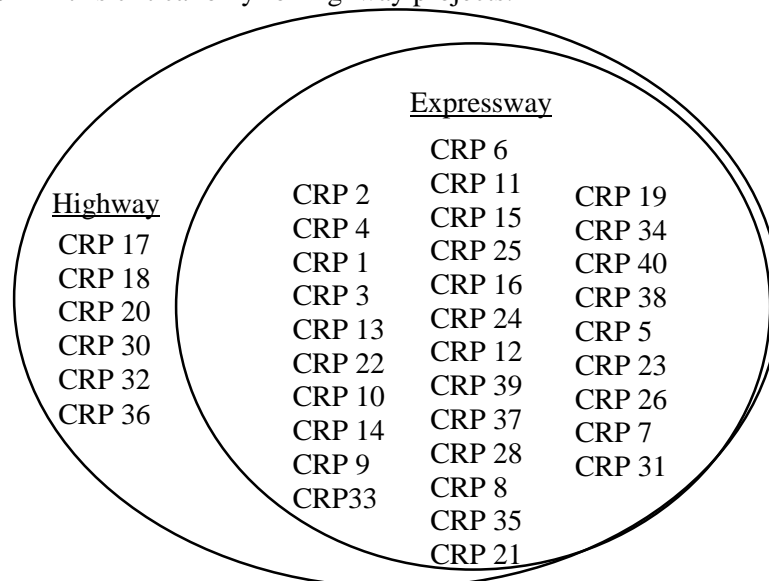

Figure 2. Comparison of critical CRPs between highway and expressway projects.

4.2.2. Nearest quarry to the construction site had been verified (CRP 18)
Quarry usually is located in the rural area, thus getting the material to the site at the right time is sometimes difficult. For instance, delivering stone materials from the quarry to the highway project that is also located in other rural areas might take days. Therefore, it can be concluded that verifying the nearest quarry to the site is critical only for highway projects.

4.2.3. The site office is ready (CRP 20)
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. For expressway projects, the site office might not be as important as for highway projects because the construction site is near to the office due to it is located in the city. Project documentation could be kept in the main office while waiting for the site office to be built. Hence, site offices are not a critical CRP for expressway projects.

4.2.4. Utilities at the construction site are ready (CRP 30)
Usually, 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 sites without electricity can disrupt office works leading to delay in a construction project [24]. Because expressway projects are mainly located in the city, utilities such as internet connection and water do not need to be temporarily set up because all the resources are readily available. Therefore, CRP 30 is not critical for expressway projects.

4.2.5. Labor productivity rates had been verified (CRP 32)
Many factors could affect labor productivity, such as overtime, worker morale, and turnover [25]. For expressway projects, labor productivity might not be affected because it is located in the city. Construction workers usually live in the city and hiring them is not a problem. However, sometimes highway projects are located in rural areas, where it is hard to find workers to do the work. Hence, there will be workers shortage and current workers need to work overtime. Scheduling of more extended workdays than a standard eight-hour workday or weeks greater than a 40-hour workweek lowers work output and efficiency through physical fatigue and poor mental attitude and eventually leads to loss of productivity. Numerous research reports show that labor productivity declines with the extended use of overtime [26]. Therefore, it could be concluded that verification of labor productivity rates is critical only for highway projects.

4.2.6. Hold points/handoffs had been identified (CRP 36)
Hold Point is a mandatory verification point beyond which work cannot proceed without approval by the engineer or consultant or municipality inspector. The work cannot proceed until the engineer or consultant can verify the quality of the completed work. In order to connect two different cities, highway projects can sometimes be located in rural areas. On the other hand, expressway projects are usually located in the city. Thus, the length of it is shorter compared to highway projects. Hold points for highway projects might be a lot more compare to expressway projects because of its length. Therefore, CRP 36 is critical for highway projects.

5. Conclusion
This study compared the CRPs between different types of highway projects by analyzing questionnaires distributed among industry practitioners. In conclusion, thirty-two CRPs are critical for both highway projects and expressway projects. Besides, six CRPs are critical only for highway projects due to the project location and length of the project. Highway projects are usually located in the rural area, thus verifying the material supplier location, quarry location, site office, utilities at the construction site, and labor productivity rates are necessary in order to avoid premature start. Also, identifying holdpoints/handoffs before starting highway construction is crucial. This study contributes to the current body of knowledge by illustrating any discrepancies of the readiness parameters between types

of highway projects. The lessons from this study could help the industry to justify the usage of the parameters for assessing their highway projects in preventing premature starts.

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