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Challenges of Front-End Engineering (FEE) in Construction Industry in Malaysia

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Abstract: Front-End Engineering (FEE) is an early stage of a construction process that helps to identify risks in capital project planning phases. It is also known as Front-End Planning (FEP), Front-End Engineering Design (FEED), Front-End Loading (FEL) and pre-project planning. Lack of expertise to implement good FEE cause problems such as underestimation on quantity, material and equipment for construction and cause changes on project rhythm. Besides, confusion about FEE definition and deliverables cause project stakeholders to have low expectation on FEE. This paper is conducted to identify the challenges of FEE in construction industry in Malaysia and propose solutions to overcome challenges. The preliminary data of the challenges of FEE were gathered from literature review. Questionnaire was made to collect data for analysis. Questionnaire consists of 3 sections which are demographic profile, general perspective of respondents and challenges of FEE. There are 11 challenges of FEE were proposed in questionnaire. Questionnaire was reviewed by the experts before distributing to the respondents. Questionnaire was distributed to construction parties such as developers, contractors, consultants and suppliers in Kuala Lumpur, Malaysia. Collected data were analysed by using Statistical Package for the Social Sciences (SPSS) software version 28. Principal Component Analysis (PCA) was used to analyse the critical challenges of FEE. From the PCA results, critical challenges of FEE obtained are (1) leadership quality, (2) skilled labour shortage, (3) communication barrier, (4) lack of supports from top management and (5) lack of expertise or professionals. Therefore, it can be concluded that the most critical challenges of FEE were on the human factors.

Keywords: Front-End Engineering (FEE), Challenges, Principal Component Analysis (PCA)

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1. Introduction

Front-End Engineering (FEE) is an early stage of construction process to exploit adequate information for developers and investors to identify risk in the capital project planning phases. [1]. FEE is a process involving all tasks between project initiation and commencing of detailed design. FEE is also known as Front-End Planning (FEP), Front-End Engineering Design (FEED), Front-End Loading (FEL) and pre-project planning. FEE can provide better control over the project schedule and cost [2]. Construction Industry Institute (CII) was the first to implement the FEE by promulgating Pre-project planning Handbook (1995). It shows that FEE can achieve lower deviation in the cost, schedule and operating characteristic Construction Industry Institute (CII) has developed a scope definition tool which is a Project Definition Rating Index (PDRI) to appraise the execution of project scope definition. PDRI is an extensive, weighted checklist of significant scope definition elements developed by CII to undertake in the FEE process. The recent status and inadequate planning areas of the project during the FEE process can be easily evaluated by the project team through a simple and easy use PDRI tool [3].

According to Project Management Institute, project management is defined as application of knowledge and techniques to fulfil requirements for project activities. The project management process includes varieties of processes such as initiating, planning, executing, monitoring and controlling. Thus, FEE is a vital process of initiating and planning to deliver a successful project. FEE can ease the project team to understand execution in a systematic manner and facilitate to achieve project objectives [2].

In Malaysia, oil and gas (O&G) industry acts as one of the most significant sectors that contributes to Malaysia economics. O&G industry being the most challenging engineering and technology in Malaysia. Therefore, project management skill developed in O&G projects is important to avoid cost and time overrun, poor arrangement of workmanship and delay of projects. FEE design is developed for the oil production facilities to accelerate the design and construction of chemical plants[4].

FEE in project management practice barely understood can causes inconsistency throughout the construction of projects. Failure of implementing FEE are due to lack of effective, clear and suitable guidance along the process. These frequently cause confusion among stakeholders to make decisions during work [2]. Challenges occur during FEE may lead to project overtime and increase of project cost. Therefore, engineers need to have sufficient FEE studies to completely understand the FEE process to ensure a good FEE can be adequately implemented [5].

In this study, the scope is focused on the challenges of FEE in construction industry in Malaysia. A survey is conducted to collect data from construction parties in Kuala Lumpur, Malaysia. Questionnaire is designed and distributed to the construction parties such as developer, contractor, consultant and supplier in Kuala Lumpur, Malaysia. Google form is used as the platform to collection data. Therefore, data collected can be used for analysis to determine the critical challenges. Solutions and suggestions are proposed in this study to overcome the challenges of FEE in construction industry in Malaysia.

The findings of this study can benefit project teams to implement Front-End Engineering (FEE) in construction projects. A good FEE can make sure all the procedures are clear and changes may be managed and controlled. Besides, proper material and labour supply can be guaranteed by implementing a proper FEE. Lastly, this study can provide better operational performance and reduce chances of project failures to achieve a better construction project.

2. Literature Review

Construction industry is one of the significant sectors that contributed to development of economy in Malaysia. Construction industry create investment opportunities for foreigners or local people to drive economic growth in Malaysia [6]. It plays an important role to the Gross Domestic Product (GDP) of Malaysia. Construction industry consists of variety of parties, processes, different stages of work and from private or public sector. However, there are some challenges faced in construction process [7].

Table 1: Challenges of FEE in construction industry

No.	Challenges of FEE in construction industry	Author
1.	Poor management of material supply chain.	[8]
2.	Design changes.	[9],[10]
3.	Late payment.	[7]
4.	Leadership quality.	[11]
5.	Skilled labour shortage.	[12]
6.	Communication barrier.	[13],[14]
7.	Uncertainties and inadequate guideline from government.	[15],[16]
8.	Lack of supports from top management.	[15]
9.	Lack of expertise or professionals.	[15],[17]
10.	High capital needed for the advanced technologies.	[17],[18]

Poor management of material supply chain during pre-project planning phase cause low productivity in construction work. One of the challenges faced is the poverty of necessary construction material in the local market. Besides, delay of procurement of materials such as late confirmation of submission by the engineer has affected the material supply chain [8]. Besides, design changes lead to time and cost overrun problem. Rework, schedule delay and cost overrun from extra resources and wastages are direct effects from the design changes [10]. For example, Kuala Lumpur International Airport 2 (KLIA2) is one of the well-known case studies of cost overspend due to design changes [9].

The project delay caused by late payment had influenced the stakeholders such as supplier, main contractor and subcontractor in the construction industry in Malaysia. Late payment stops an organisation from putting financial ability into development. Therefore, potency and integrity of entire construction project may influence by this factor [7]. Furthermore, poor construction leader may lead to project failure and cause some issues such as time and cost overrun, quality issues and safety issues [11]. According to the Department of Occupational Safety and Health, the occupational accident statistic of 2019 showed that 84 worked die during construction work, 15 workers suffering permanent disability and 227 workers suffering from non-permanent disability. Construction leaders have the responsibility to ensure workers work under safe conditions. Hence, a competent leader is needed in project management and eliminate risks occur during construction process.

Shortage of skilled workers become issues in construction industry in Malaysia due to poor participation from local workers. Construction industry are highly depend on foreign workers to fulfill the high demand of workers.[12] Factors of poor participation of local workers are poor career path, low salary and bad working environment [12]. Lastly, communication barriers among the workers are the issues in construction sites. For example, foreign workers from Bangladesh, Indonesia or Nepal not able to understand local language delivered by their supervisors [14]. Communication barriers contributed to the occurrences of the accidents on site and affect the delivery of instruction to the workers and hence delay of project or disturbance of project planning may occur [13].

3. Methodology

This section explained step by step methodology processes to carry out the research. Quantitative method is used in this research to analyse the challenges of FEE in construction industry in Malaysia. The preliminary data of the challenges of FEE are gathered from literature review. Then, a survey is conducted by distributing questionnaires to a construction party in Malaysia.

3.1 Methodology Framework

First, data was collected through literature review. Relevant information regarding the challenges of FEE is obtained from the literature review. Next, questionnaire is designed based on the

data gathered in literature review and reviewed by experts before distributing to respondents. Then, data collected from the questionnaires are analysed. Besides, discussions will be made based on the results. Lastly, conclusions and recommendations are generated in the last part of this research.

3.2 Literature Review

Literature reviews related to the topic have been analysed through the thesis, journal, articles and other relevant resources. From the literature review, information on challenges of FEE were gathered and put in summary table. This information can use to design questionnaire.

3.3 Design Questionnaire

The questionnaire is divided into 3 sections which are demographic profile, general perspective of respondents and challenges of FEE in construction industry. Then, questionnaire is reviewed by experts in building and construction field before distributed to construction parties in Kuala Lumpur, Malaysia.

3.4. Pilot Study

Pilot studies are small-scale preliminary studies which propose to investigate feasibility of critical components of main study [19]. A minimum of 8 experts are needed to conduct a pilot study. Therefore, questionnaire is distributed to building and construction field's lecturers in Universiti Tun Hussein Onn Malaysia (UTHM). Comments provided by the experts is used for amendment of questionnaire to satisfy the objection of the study.

3.5 Data Collection

In this research, questionnaire method is used as a tool to collect data. Due to the COVID-19 pandemic, Google Form is used as the platform for data collection to avoid direct contact with people. Thus, Google form is made based on the information in the questionnaire. Google Form are distributed to the construction parties such as developer, contractor, consultant and supplier in Kuala Lumpur, Malaysia.

3.5.1 Population Study

A population study is data collection from a group of people that possess common characteristics such as education background, employment and working experience to meet criteria interest of researchers [20]. Population study for this research is focus on construction parties such as developer, contractor, consultant and supplier in Kuala Lumpur, Malaysia. Based on the CIDB annual report 2019, the population size of the construction parties in Kuala Lumpur for year 2019 are 11060 [21].

3.5.2 Sample Study

Sampling is a method to conclude information about a population based on outcome from a subset of population without inquiring into every individual. In order to obtain the sample size, Taro Yamane method is used which developed by Tara Yamane in 1967 [22]. The formula that used to determine the sample size is shown below:

$$n = \frac{N}{1 + Ne^2}$$

Where,

n = Required sample size,

N = The population size.

e = Margin error which is usually 0.10, 0.05, 0.01

According to CIDB annual report 2019, the population size (N) of the construction parties such as consultant, contractor and developer for year of 2019 are 11060 [21]. The margin of error (e) of sample size are taken as 0.10. The sample sizes were obtained by calculation below:

Value obtained,

N = 11060, e = 0.10

The number of sample size obtained are shown below:

$$n = \frac{N}{1 + Ne^2} = \frac{11060}{1 + (11060)(0.10)^2} = 99$$

By using the Taro Yamane method above, sample size needed for this study is 99 respondents.

3.6 Analysis of Data

In this research, Statistical Package for the Social Sciences (SPSS) version 28 is used to analyse the data obtained. Reliability analysis and principal component analysis (PCA) are used in this research to determine the critical challenges of FEE in construction industry in Malaysia.

3.6.1 Reliability Analysis

Reliability Analysis is a measurement technique that allows researchers to assess the consistency of measures. Cronbach's alpha is used to determine the reliability of multi-question Likert scale in a questionnaire. Cronbach's alpha can tell whether the designed test is accurately measuring the variable of interest. Cronbach's alpha can be carried out by using Reliability Analysis in SPSS software version 28. The Cronbach's alpha value that exceed 0.7 is considered as reliable [23].

Table 2: Cronbach's Alpha value

No.	Challenges of FEE	Mean	Standard Deviation	Cronbach's Alpha
1	Poor management of material supply chain.	3.787	0.695	0.812
2	Design changes.	4.156	0.617	
3	Late payment.	3.812	0.731	
4	Leadership quality.	3.598	0.712	
5	Skilled labour shortage.	4.074	0.682	
6	Communication barrier.	3.598	0.735	
7	Uncertainties and inadequate guideline form government	3.353	0.812	
8	Lack of supports from top management.	3.590	0.713	
9	Lack of expertise or professionals.	4.049	0.714	
10	High capital needed for the advanced technologies.	3.934	0.689	
11	Lack of knowledge about Front-End Engineering.	4.303	0.667	

Table 2 above shows the Cronbach's Alpha value obtained from SPSS software. The Cronbach's Alpha value for the 11 challenges of FEE is 0.812. The Cronbach's Alpha value exceeding 0.7 indicates that the challenges of FEE are acceptable and reliable.

3.6.2 Principal Component Analysis

Principal Component Analysis (PCA) is a dimensionality-reduction technique that is frequently used to reduce the dimensionality of large data sets. This is due to smaller data sets are easier to explore

and analyse data [24]. PCA can be carried out by using SPSS statistics and some different assumptions need to be met in order to give a valid result for PCA.

4. Results and Discussion

This section discussed results to meet the objectives of research. Questionnaire was made based on literature review and reviewed by experts. After that, corrections were done based on the comments. Then, questionnaires were distributed to construction parties in Kuala Lumpur. In order to start the data analysis process, sample sizes were determined to represent the population of construction parties in Kuala Lumpur. Then, Reliability Analysis was carried out to measure the reliability of the collected data. Moreover, PCA was used to analyse the data by using the (SPSS) software. Thus, by referring to the critical challenges of FEE, solutions were proposed to overcome the challenges.

The number of respondents based on the challenges of FEE is shown in Table 3 below. There are total of 122 respondents. The results show that most of the respondents chose scale 3 to 5 for all the challenges. All these results can be used for analysis.

Table 3: Summary of results based on number of respondents

No	Challenges	Scale					Total no of respondents
		1	2	3	4	5	
1.	Poor management of material supply chain.	0	3	36	67	16	122
2.	Design changes.	0	0	15	73	34	122
3.	Late payment.	0	3	37	62	20	122
4.	Leadership quality.	0	4	53	53	12	122
5.	Skilled labour shortage.	0	3	15	74	30	122
6.	Communication barrier.	0	7	46	58	11	122
7.	Uncertainties and inadequate guideline from government.	0	12	69	27	14	122
8.	Lack of supports from top management.	0	6	48	58	10	122
9.	Lack of expertise or professionals.	0	4	16	72	30	122
10.	High capital needed for the advanced.	0	1	30	67	24	122
11.	Lack of knowledge about Front-End Engineering.	0	1	11	60	50	122

4.1 Data analysis using Principal Component Analysis (PCA) method

Principal Component Analysis (PCA) is analysed by using SPSS statistics with assumptions to obtain results. Therefore, PCA derives all the 11 challenges to obtain the critical challenges of FEE.

Table 4: Total variance of initial eigenvalues

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative percentage
1	3.871	35.195	35.195
2	1.145	10.407	45.603
3	0.980	8.906	54.508
4	0.918	8.349	62.858
5	0.852	7.742	70.600
6	0.679	6.174	76.774
7	0.669	6.084	82.858
8	0.559	5.079	87.937
9	0.490	4.450	92.387
10	0.450	4.089	96.477
11	0.388	3.523	100.000

Based on table 4 above, the principal component of correlation matrix shows two eigenvalues more than one. Eigenvalues more than 1 indicate the principal component can be used for further analysis. The highest number of eigenvalues for principal component one was 3.871 with the variance of 35.195%. However, the second highest number of eigenvalues for principal component two was 1.145 with the variance of 10.407%. The total cumulative percentage of variance for eigenvalues more than one is 45.603%. Besides, principal component three to eleven shows the total number of eigenvalues was 5.985 with percentage of variance of 54.397%.

4.1.1 Scree Plot

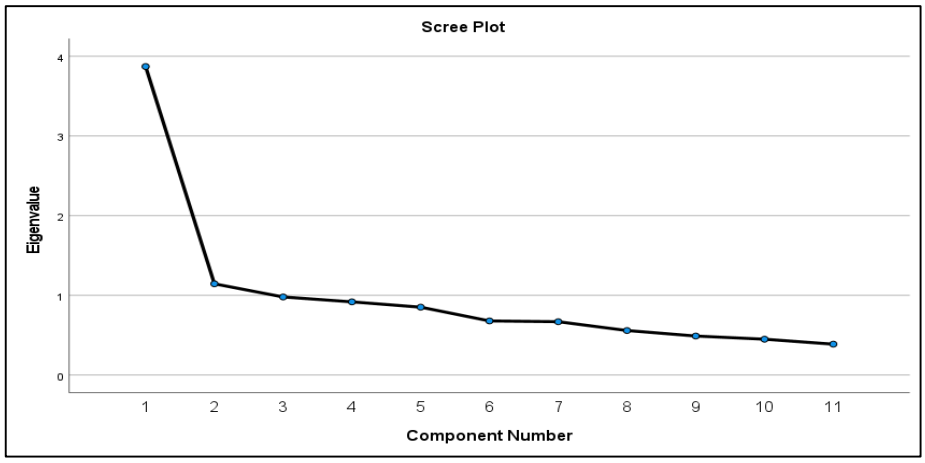

Figure 1: Scree plot for challenges of FEE.

Based on Figure 1 above, principal components 1 and 2 have the eigenvalue of more than 1. However, eigenvalues for principal component 3 to 11 were close to 0. These components were eliminated from data analysis process. Thus, only principal components 1 and 2 are used for coefficient matrix analysis.

4.1.2 Component score of coefficient matrix

Table 5: Component score of coefficient matrix

No	Challenges	Component	
		1	2
1	Poor management of material supply chain.	0.560	-
2	Design changes.	0.537	-0.330
3	Late payment.	0.471	0.327
4	Leadership quality.	0.522	0.422
5	Skilled labour shortage.	0.748	-0.201
6	Communication barrier.	0.637	0.182
7	Uncertainties and inadequate guideline form government	0.591	0.346
8	Lack of supports from top management.	0.583	0.442
9	Lack of expertise or professionals.	0.644	-0.281
10	High capital needed for the advanced technologies.	0.580	-0.169
11	Lack of knowledge about Front-End Engineering (FEE).	0.607	-0.500

Table 5 shows two component scores of coefficient matrix obtained from SPSS software. Each challenge has a particular component score for component 1 and 2. The most critical challenge for every component would be maximum value of coefficient matrix that closer to 1. Whereas, other challenges with value of coefficient matrix that not close to 1 are less influences when comparing with the critical challenges. For principal component 1, the most critical challenges are skilled labour shortage, lack of expertise or professional and communication barrier. Besides, for principal component two, the most

critical challenges were lack support from top management, leadership quality and uncertainties and inadequate guideline from government. Therefore, results were tabulated to have a better understanding.

Table 6: Summaries of Principal Component Analysis findings

No	Challenges	Component	
		1	2
1	Poor management of material supply chain.	-	-
2	Design changes.	-	-
3	Late payment.	-	-
4	Leadership quality.	-	0.422
5	Skilled labour shortage.	0.748	-
6	Communication barrier.	0.637	-
7	Uncertainties and inadequate guideline form government	-	0.346
8	Lack of supports from top management.	-	0.442
9	Lack of expertise or professionals.	0.644	-
10	High capital needed for the advanced technologies.	-	-
11	Lack of knowledge about Front-End Engineering (FEE).	-	-

Table 6 show summaries of Principal Component Analysis (PCA) findings. By using PCA method, the critical challenges of FEE in construction industry obtained are (1) leadership quality, (2) skilled labour shortage, (3) communication barrier, (4) lack of supports from top management and (5) lack of expertise or professionals. Therefore, these 5 challenges that generated from PCA method can be used for the further analysis. Solutions could be proposed to overcome the challenges of FEE.

4.2 Propose solutions to overcome the challenges of Front-End Engineering (FEE)

Solutions were proposed based on the 5 critical challenges that obtained from PCA analysis. First, Leadership quality. Leadership training program can be attended by the leaders to develop new skills and enhance skills to improve leadership skills. Besides, a good leader should possess the ability to coach and mentor their subordinates. Leadership quality can maintain by training their capable subordinates to become next leader. Second, skilled labour shortage. Malaysia brought in a lot of foreign workers in construction industry. Most of them are come with low skills and low education background. Therefore, technical and vocational skills training should be provided for them to have basic knowledge of skills needed in the construction industry such as welding, painting and operate crane.

Next, communication barrier. Foreign workers from Bangladesh and Nepal unable to speak any local language such as Bahasa Malaysia and English. This may affect their working ability if they not able to understand instruction delivered by their supervisor. Therefore, company itself or government can provide language learning program for them to learn the basic communication skills. This can avoid the misunderstanding among the workers and supervisor to cause delay of works. Besides, lack of support from top management would be challenges for implementation FEE in construction industry. Top management have the responsibility to programme strategic and direction when implement new technology or strategy. Therefore, workers need supports from top management during execution process to make sure the construction project can run smoothly. Team building activities can be carried out to improve the relationship between top management and lower position workers. Thus, the ability of the competence workers can be seen and supports will be given for those workers during works.

Lastly, lack of expertise and professionals. Engineers that possess knowledge of FEE is needed for company that wish to implement FEE in construction project. Therefore, CIDB can provide seminar or training program for engineer to gain information about benefit of implementing FEE in construction project. Engineers need to expert skills so that FEE can be executed more effectively and smoothly.

5. Conclusion

This research was conducted to determine the critical challenges of FEE in construction industry in Malaysia and suggestions should be proposed to overcome the challenges. From PCA analysis, there are 5 challenges which having component score of coefficient matrix which closer to 1. These are the critical challenges of FEE which are (1) leadership quality, (2) skilled labour shortage, (3) communication barrier, (4) lack of supports from top management and (5) lack of expertise or professionals. Besides, recommendations are proposed to provide suggestions on the improvement of study for future studies. First, after COVID-19 pandemic, interviews sessions can be considered such as face to face interview with respondents to gain more information on the challenges of implementing FEE. Additional views or perspective from the construction parties can be obtained from the interview. Lastly, government should provide a standard or system that can be utilised by all the construction parties. Hence, construction parties can follow the standard to apply FEE in their construction project. Misunderstanding and confusion of implementation of FEE can be eliminated or reduced.

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