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PERFORMANCE OF SUSTAINABLE CONSTRUCTION PROJECTS: A CONTRACTOR'S VIEWPOINT

Nur Afiqah Zahirah Abdul Aziz[1], Afizah Ayob[1,2*], Siti Aisyah Ishak[1], Umi Farishah Mohd Shoeb[1], Mustaqqim Abdul Rahim[1], Nur Rahmahwati Syamsyiah[3], and Aizat Abd Halim[4]

[1]Faculty of Civil Engineering & Technology, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia

[2]Research Cluster of Construction Management Technology, Faculty of Civil Engineering & Technology, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia

[3]Architecture Department, Engineering Faculty, Universiti Muhammadiyah, 57102 Surakata, Indonesia

[4]Construction Industry Development Board (Perlis Branch), 10, Jalan Tunku Syed Putra, 01000 Kangar, Perlis, Malaysia

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*Corresponding author's email: afizah@unimap.edu.my

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Abstract — Achieving stakeholder satisfaction and attaining the objectives are considered indicators of success in construction projects. Performance criteria may consist of one or more indicators influenced by project's stakeholders and characteristics. This study uses an exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to determine the key indicators affecting project performance from the contractors' viewpoint. A set of 120 structured quantitative questionnaires survey were distributed to actively registered G7 contractor companies in Pulau Pinang. Ten hypothesized factors consisting of 42 indicators were measured using a five-point Likert scale and subsequently analyzed using SPSS software. Results of EFA showed eight re-evaluating affected factors of construction project performance in Pulau Pinang; most notably, factors such as *Labor, equipment, consultant, and contract (*LCC) which consists of fifteen indicators, giving factors loading of 0.495 to 0.804, Eigenvalues (20.5), and variance (48.9%). Based on stakeholders' perspective, CFA identified four statistically significant project performance factors: LCC*, People, Time*, and *Project characteristic* with factor loading and covariance values > 0.7 and < 0.8, respectively. By pinpointing these factors and validating them via a dual-phase statistical approach, this study provides actionable insights for enhancing performance in sustainable construction projects, offering practical value to stakeholders and contractors in similar contexts, particularly during difficult situation in project delivery.

***Keywords*:** contractor, exploratory factor analysis, confirmatory factor analysis, project performance indicator, construction sustainability

1.0 INTRODUCTION

The global construction business size was valued at 7.28 trillion USD in 2021 and expected to increase to 14.1 trillion USD by 2030, with a Compound Annual Growth Rate of 7.3% from 2022 – 2030 [1]. The Asia-Pacific region holds of a significant share of the global construction business: the region is anticipated to pursue market domination for forecast years due to factors such as growing population, advancement in technology, adequate regulatory policies, favorable government standards, and continuing construction activities. Although construction businesses worldwide have analogous profiles, some of these businesses remain largely country-specific and socio-economic [2]. Unlike global business profiles, the production processes of construction projects in developing nations are dubious, which makes it exhausting to attest quality.

Delivering project success is the goal of every project stakeholder. Stakeholders are comprised of various professions and organizations that are part of a competitive project-based domain of complex specialized services. The goal of all stakeholders is to construct built environments for the user and client. Unfortunately, unforeseen circumstances alter pre-agreed terms, which trigger delays and lead to loss of time and money [3]. Thus, the non-success of a project to deliver what is stated in its targets typically have a negative effect on the practitioners involved. For example, the client encounters low productivity, profit loss, and increasing reliance on facilities [4]. The successful completion and quality of service delivered by the construction teams many times become a topic of in-depth studies. In Malaysia, Yap et al. [2] rules out how poor project schedule management continues to plague construction projects, and many studies shed light on the pivotal topic of adversely lessening the timely completion delivery of projects. Some clients understate the effects of substandard consultant work on the success of a project. Janatora et al. [5] stated that perception on the public projects in third-world countries is entirely underachieving. Low profitability from lack of training, limited trust, poor communication, and adversarial relationship are among the key issues explored by researchers in Malaysia. Salleh et al. [6] mentioned that delays in providing instruction and approval have been a major concern to contractors in Johor despite financial problems. Numerous delays, cost overruns, reworks, variations, claims and conflicts would be discovered back to fallacious design, delay in reviewing design documents, faulty contract administration, and lack of technical observation from the client's on-site representative [7]. Thus, for projects to be efficient and successful, this study explored the correlation of performance factors, such as cost, time, quality, and profitability, as indicators of project completion.

Tracking and deliberately analyzing Key Performance Indicators (KPI) assist a construction company create long-term resilience while achieving short-term predefined goals. Performance is about effectiveness and achieving desired results. KPI focuses on vital signs that depict the business of one company. It functions according to plan, referring to ways in which the company operates. Most studies have been on financial and multi-dimensional performance indicators [8]. Since 1980, multiple aspects of non-financial indicators have been analyzed to improve the overall performance of projects [9]. These aspects of non-financial indicators are what managers must follow to create reliable predictions for their project's progress. Prognostications could assist contractors in monitoring and controlling projects during the execution phase, wherein teams can provide warnings of potential issues. Nevertheless, performance prediction is complex and is vigorously linked to many indicators [10]. Any modification of one indicator could affect all other indicators and consequently affect projects' entire construction performance due to their intricate and interconnected systems. According to Cleary and Lamana [11] and Rivera et al. [12] , construction managers, as project delivery companies, should direct the project to achieve their definition of project success. The team must emphasize the perception of project factors, statistics, or indicators associated with project management accomplishments such as profit. The Project Management Institute recognizes that achieving construction project specifications has eleven essential knowledge domains: integration; scope; schedule; cost; quality; communication; risk; procurement; stakeholder; health, safety, security, and environment; and financial management [13]. Self-assessing performance and foreseeing potential problems are important for a contractor to control the planned level of expenditure and for independent performance enhancement [14, 15]. This influenced the current authors to analyze the framework of the multi-dimensional performance for an efficient measurement of projects performance.

In Malaysia, studies on evaluation of performance at the project level generally explores within its three main indicators: time, cost, and quality. Yusof et al. [16] studied a framework for mitigation measures of low performance for public projects. Kamaruddeen et al. [17] investigated factors causing overrun in projects in Sarawak. Muhamad and Mohammad [18] studied the effects of design changes in the project, while Chan [19] previously proposed critical success indicators for construction projects. Cheung et al. [20] suggested that at the project level, conventional indicators become an inefficient consideration of project success. All of the mentioned studies merely focus on the causes using a single parameter of either agreement or frequency, which could limit the reliability of their findings. Moreover, investigations on the project performance evaluation at the company level remain at the minimum. In real situations, different factors, apart from the conventional key indicators affect project performance both directly and indirectly. Therefore, this study analyzed the key indicators affecting project performance from deeper insights of contractors' viewpoint in Pulau Pinang using exploratory and confirmatory factor analyses. Exploratory factor analysis (EFA) is normally applied in the early stages of research to detect the underlying structure of a relatively unknown dataset, without setting preconceived structures on the outcome. Unlike EFA, Confirmatory Factor Analysis (CFA) is used when there is an obvious hypothesis about the structure of the data. This offers a more rigorous method compared to other forms of analysis, such as principal component analysis (PCA) as it accounts for evaluation error and allows for further testing of model fit [21, 22]. By combining these two analyses, this study explored potential factor structures of construction performance using EFA. It then confirmed these structures with CFA, thus enhancing the robustness and validity of the findings. This two-step approach is often more sophisticated and reliable than methods used in older studies that either did not test factor structures or relied on single methods. This study's findings may help researchers and stakeholders in developing a framework for alleviating the issues that trigger non-performance business from planning until reaching its completion phase of projects in Malaysia. Figure 1 shows the conceptual flow of the study and its relationship with project performance.

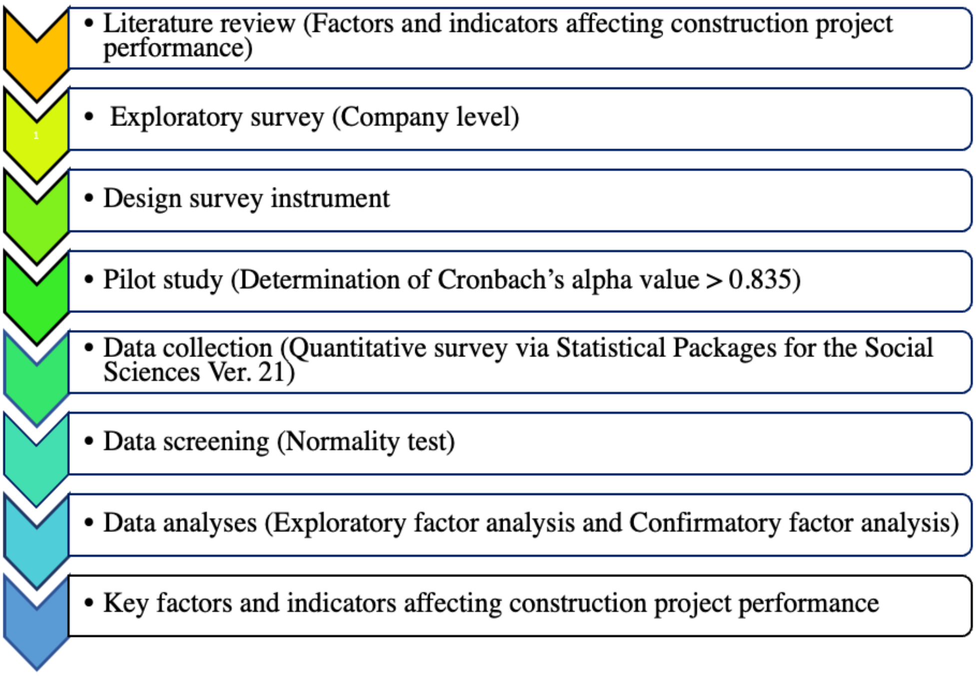


Figure 1 Conceptual flow of current study

2.0 LITERATURE REVIEW

The construction business is a high-value industry all over the world. The technology's scope and complexity are increasing in most cases. The business represents civil engineering works of construction such as hospitals, schools, homes, hotels, factories, roads, highways, dams and others [23]. It is a huge, labor intensive, and project specific industry that has a significant effect on the efficiency and production of other industries [18, 22, 24]. Although these businesses demonstrate a constant rise in developed continents such as Europe due to increasing renovation activities of residential infrastructures, Langston [25] suggested a gradual possible rise in project complexity. The author highlighted that the USA is annually outperforming Australia in constructing modern buildings by 1.10%. Meanwhile, in several developing countries, this business is outpacing population and contributes approximately 10% to gross domestic product, increases employment, capital, and interchange between different economies [23, 26–29].

In Malaysia, the 2020 Budget grants of MYR 48.8 billion for states and signifies an increase in agreement following the 12th Malaysia Plan. The 10th Malaysia Plan allocated MYR 250 billion for national development and facilitation funds undertaken by the construction business [30]. Despite the significant capital investment and the acknowledged role of construction in contributing to national economics, the industry often faces issues such as time slippage and cost overruns, leaving clients dissatisfied with their construction project experience. Jatarona et al. [5] reported that there were 426 delayed projects between 2011 to 2013, along with a decrease of 20% in the number of non-performance projects which is consistent with higher allocation to the public construction budget of MYR 550 billion in 2013. Previously, projects confirmed to be executed within the specified budget were 46.8% and 37.2% of public and private projects, respectively [31]. Meanwhile, 20.5% of public projects and 33.35% of the private projects were delivered within the period.

The construction business is intrinsically complex due to the large number of stakeholders involved, including clients, contractors, consultants, shareholders, and regulators [32–35]. For stakeholders, team relationships form and disband on a regular basis. Several interconnected issues and components between teams might affect project performance. Hence, construction business performance remodeling has influenced research activity within the business for more than 50 years [26]. Globally, studies on project success aimed highly on time delivery [35–37], project delivery within budget [37, 38], client satisfaction, and safe project execution [39–41]. Similarly, Siew [42] measured the finance performance of construction companies in Malaysia, and Ali and Rahmat [7] investigated the performance measurement of projects managed by ISO-certified contractors. Safety practice in construction was explored by Razak et al. [43], and the effects of innovation and research and development in project performance were studied by Raman [44]. Additionally, Sulaiman [45] explored client satisfaction, while Salleh et al. [6] studied stakeholders management for excellent project performance. Good construction project performance is when the project is free from any defects and conflicts among the stakeholders. Stakeholders are often powerless due to the project being controlled by various factors, which can either be intrinsic or extrinsic [3]. Unsatisfactory project performance is not entirely due to the contractor and can be from the client and consultant. Findings by Muhammad and Mohammad [18] mentioned that design reviews originating mainly from the client's side are important factors that cause time and cost overrun. Meanwhile, Yusof et al. [16] highlighted that the project quality deteriorates due to contractors ignoring the terms and conditions prescribed in the contract. Ramli et al. [4] mentioned that contractors ruled out significant characteristics of slow reviewing instruction and approving cause of non-performance of project.

Clients of public projects are initiating a pre-qualification model for selecting the most suitable contractor or completion method based on the interrelation between project performance and project distinctives. Adeleke et al. [23] suggested that the factors of schedule and quality have positive effects, while cost has a considerable negative control to Malaysian contractors. The prolonging of extended time given for completing project will reduce profit margin of the contractor, and if the issue continues, it will disrupt the contractor's cash flow. Even worse, if the company relies on bank loans, the accumulating interest can lead to financial collapse and insolvency [6]. This outlines the importance of the contribution of the affected indicators faced by the contractors.

Performance management is vital in construction because it allows managers to identify how personnel can contribute to the project's methodology and success [46, 47]. Managers may use comprehensive performance monitoring to swiftly identify and resolve problems, motivate and engage employees, keep them on track, and increase productivity and profitability [48–51]. Ten performance factors were identified to affect construction projects in India, such as client relation, safety, schedule, cost, quality, productivity, finance, communication and collaboration, environment, and stakeholder satisfaction [51, 52]. Soewin and Chinda [53] indicated that errors in determining project scope and lack of understanding of quality goals and policy are the most significant factors affecting construction performance in Thailand. For Bitamba and An [54], the main factor contributing to poor construction in Congo is the lack of modern construction equipment. However, Simukonda and Kamwela [55] and Abbasbhai and Patel [56] reported that site preparation time can potentially be used as a predictor of project success. Similarly, Ademola et al. [57] stated that time is a main factor determining the success of construction in Nigeria. Another important factor to ensure successful construction is the cost. Cost overruns are common and are inevitable without proper management. Slow delivery of materials and subcontractors were seen as contributing to problems in construction [58]. Material loss during construction and the use of low-quality materials result in higher-than-expected construction costs [32], largely due to poor material management systems. Meanwhile, because of the inability to prevent cost overruns, many Thais construction enterprises have collapsed [53]. These abovementioned research findings are used to analyze construction performance herein (Table 1).

In this case, despite the considerable growth in the global construction industry, particularly in regions like Asia-Pacific, where construction projects are the key role in economic development, the assessment of construction project performance remains limited on conventional parameters for instance delivery of project, resources availability, and fit-to-purpose quality. Existing studies on these criteria in Malaysia have mainly aimed on public projects or singular aspects of performance such as delays, cost overruns, and design changes. While these factors are integral to understanding project success, this procedure may limit the depth and reliability of outcomes by overlooking other dimensions of project performance. The evaluation of construction project performance at the company level specifically from the contractors' perspective, remains underexplored in Malaysian context. Additionally, while the importance of sustainability in construction is increasingly acknowledged globally, there is minimal focus on how sustainable practices are incorporated and assessed within the Malaysian construction industry. Particularly, in regions experiencing rapid economic and industrial growth such as Pulau Pinang, there is a need to explore how sustainability can be linked with construction performance goals. Therefore, this study sought to fill these gaps by conducting in-depth analysis of multi-dimensional construction project performance in this state via the lens of contractors' viewpoints, thus providing a more holistic view of the factors influencing project success in Malaysia.

Table 1 The Hypothesized Factor and Indicators Affecting Construction Performance

Factor	Indicators/Code	References
Project Characteristic (PC)	Types of projects (TOP)	[4, 48]
	Size (SOP)	[14]
	Construction techniques (NCT)	[14]
	Accessibility to the site (ATS)	[7, 16]
	Conflict at site (CPS)	[3, 14, 41]
Time (TM)	Time for document approval (TDA)	[2, 6]
	Contract duration (CTD)	[12]
	Delays of subcontractors' works (DLS)	[12, 25]
	Time for imported material (PCD)	[12, 32]
	Demolition and rework (DAR)	[8, 27, 48]
	Delays payment to subsontractors (DPS)	[12, 48]
	Shorter completion duration (SCP)	[3, 7]
Cost (CT)	Error in determining the project scope (EDP)	[4, 12]
	Payment terms (PAT)	[3, 53]
	Inaccurate estimation (IAE)	[12]
	Increase in overhead expenses (IOE)	[16]
	Additional revenue by contractor (ARC)	[2, 16]
	Design change (DSC)	[3, 5, 12, 18]
People (PE)	Lack of team leader's commitment (TLC)	[4, 12]
	Lack of technIcal skill of team leader (TSP)	[12]
	Late decision about design change (LAE)	[48]
	Lack of technical and experinced manpower (TEM)	[4, 48]
	Lack of subcontractor skills (LSC)	[25, 41]
	Decrease in productiovity of workers (DPW)	[4, 12]
	Desputes between parties on contract (DPC)	[5, 48]
Labor, Equipment and Material (LM)	Unvailabilty of skill workers (USW)	[2, 48]
	Technology change (TCC)	[48]
	Improper quality control of materials (IQC)	[48]
	Insufficient suplly of materials (ISM)	[16]
	Excalation of material prices (EMP)	[2, 3, 48]
	Lack of moderm equipment (MCE)	[16, 48]
	Inappropriate use of material (IUM)	[4, 16, 32]
	Material theft and damage (MTD)	[55]
Quality (QT)	Lack of understanding of goal and policy (UQP)	[16, 53]
	Poor workmanship (PWP)	[4, 16]
	Lack of supplier quality management (SQM)	[43]
Safety and Health (SH)	Delay of implementation on health and safety awareness (HSO)	[8, 39, 40]
	Level of safety awareness (LSA)	[39, 41]
	Site condition (SCD)	[4, 41, 56]
Project Management (PM)	Degregation of health and safety amongst workers (DHS)	[4, 12]
	Unavailability of fund, machinery, and materials (FMP)	[12]
	Poor site management (PSM)	[48]
	Waiting time for approval of tests and inspections (WAI)	[4, 48]
	Mistakes duirng construction (MDC)	[25, 43]
	Changing in economic condition (CEC)	[4, 12]
Consultant (CN)	Absence of consultant's site staff (ACS)	[7]
	Contract management problem (CMP)	[4, 37, 43]
	Slowness in giving instruction and poor coordination (SIC)	[4, 50]
	Delay in reviewing the design documents (DRD)	[12, 16, 47, 48]
	Poor inspection by the consultants (PIP)	[16, 27]
	Safety consideration in design (SCP)	[8]
	Inadequate design and specifications (IDS)	[3, 5, 49]
Scheduling and Contract (SC)	Lack of cost planning at pre/post contract stage (CPP)	[4, 5, 12]
	Inadequate review for drawings and contracts (IDC)	[12, 37]
	Uncertainty of supervising teams (CQR)	[4, 41]
	New government regulation (NGR)	[12, 15]
	Discrepencies between contract documents (DCD)	[5, 7, 12, 28]

3.0 RESEARCH METHOD

3.1. Exploratory Survey

An exploratory survey questionnaire was initiated based on 57 indicators with 10 hypothesized factors to gain data on performance measurement at the company level. The targeted respondent group consisted of managers at the head of department level (or higher) with at least five years of experience in construction. The 12 respondents were based in the Northern Region States of Malaysia including Perlis, Kedah, and Pulau Pinang who have been involved in different decision making associated with construction improvement process of the company. Three of the respondents from Pulau Pinang were counted for the next stages of the pilot and main questionnaire surveys. These three states were chosen due to their growth associated with the notable increase of construction project development [59]. There were three sections in each set of questionnaires. Section A includes six questions related to the demographic information of the respondents. Section B covers the elements affecting construction performance. To minimize the respondents' bias, a fixed choice of closed-ended responses was designed for this section. The Statistical Package for the Social Science (SPSS) software was used to analyze data the of respondent's frequency, and its percentage. The value of the Average Index (AI) was assessed to obtain three highest ranked hypothesized factors according to Equation 1 [60]. Table 2 shows the range scale of point to calculate whether the respondents are Strongly agree or Strongly disagree with each of the statement. Section C is for suggestions and comments.

$$Average\ Index = \frac{\sum(a_i . x_i)}{\sum x_i} \tag{1}$$

Where, x_i is number of respondents agreeing with an indicator choice, a_i is score at index of Likert scale, and i is 1,2,3,4, and 5.

Table 2 The range of Likert scale points

No	Rating answer	Range value
1	Strongly disagree	1.0 < AI > 1.5
2	Disagree	1.5 < AI > 2.5
3	Neither agree nor disagree	2.5 < AI > 3.5
4	Agree	3.5 < AI > 4.5
5	Strongly agree	4.5 < AI > 5.0

3.2. Design of Survey Instrument

The research design and questionnaire formulation were established through an extensive literature review, which included determining the title of research project, the problem statement, objectives of the study, research scope, and study limitations (Figure 1). This study used a systematic empirical research design of quantitative properties and phenomena, which allows for the use of structured questionnaire surveys and allows researchers to generalize their findings from a sample population [61].

3.3. Pilot Study

A pilot study was conducted on 10 experienced construction personnel based in Pulau Pinang with a minimum of five years of experience. To ensure the originality and avoidance of any hidden accurate information, all survey respondents remained anonymous. This study provided advanced guidance on the main questionnaire construct on terminology and question flow, and the appropriate range of answers. Table 1 shows 42 indicators for the final questionnaire survey retrieved via pilot study. Variables such as Additional revenue for contractor (ARC), Demolition and rework period (DAR), Degradation of health and safety amongst workers (DHS), Changing in economic condition (CEC), New government regulation (NGR) and Safety consideration in design (SCP) were marked as unimportant indicators by panels of the pilot study based on the corresponding state's current social, political, economic, and technological circumstances. Mistakes during construction (MDC) and Poor workmanship (PWP) indicators were indirectly explained through Poor site management (PSM) and Lack of technical and experienced manpower (TEM), respectively.

Meanwhile, Disputes between parties to the contract (DPC) indicator was indirectly explained by Uncertainty of supervising teams in dealing with the Contractor's queries (CQR) and Discrepancies between contract documents (DCD). The indicator Decrease in productivity of workers (DPW) was removed which was explained by Lack of technical skill of team leader (TSP) and TEM. The indicator Conflict in the project site (CPS) was explained by Site condition (SCD) and Accessibility to the site (ATS). The indicators of Increase in overhead expenses (IOE), Delays payment to subcontractor (DPS), Inadequate design and specifications (IDS), and Technology change (TCC) were explained by Inaccurate estimation (IAE), Payment term (PAT), Design change (DSC), and New technology technique (NCT), respectively.

3.4. Sampling Method and Size

The class of G7 contractors was chosen because they are primarily responsible for a substantial amount of the industry's output. This class exhibit higher tendering and constructing capacity than other contractor categories [62]. The selection of this group ensures that the study focusses on companies with the highest capacity for handling complex projects. A total of 120 questionnaire surveys were distributed following the information of pilot study and exploratory interviews, and after accessing respondents' email profile. The selection of these respondents was constructed by several considerations based on both methodological and practical factors. First, the size aligns with prior studies in the construction industry that have successfully used similar numbers of respondents to statistically meaningful results while maintaining feasibility [63, 64]. According to the Central Limit Theorem, a sample size of 30 or more is generally considered adequate to provide reliable data for factor analysis [65]. Given that, this present study carried out both EFA and CFA, this sample size ensured that the results are robust and can be generalized within the context of G7 contractors in Pulau Pinang. In addition, this target population was carefully determined from Construction Industry Development Board database, which lists 578 companies in the state. The 120 respondents represented a stratified sample that spans various sector such as building, infrastructure engineering, mechanical and electrical, and facility management, capturing the diversity within the size-to-variable ration of 3.1 or greater was suggested, and the authors adhered to this guideline by surveying 120 respondents to analyze 42 indicators [66, 67].

EFA was conducted to extract the 42 indicators into key factors linked to construction performance. This method was performed to assess the validity and reliability of measured variables. This technique analyzes the unidimensional key factors of each defined construction performance of its original variables, which will then be minimized to a common score factor by examining relationships among these quantitative factors. Next, the final framework of the EFA model of the eight constructs was used for Analysis of Moment Structure of Confirmatory Factor Analysis [68]. Then, the PCA was used for confirmatory of factors to standardize the range of steady initial variables with each of them equally contributing to the analysis, thus avoiding biased results. Obtained survey data was run through these methods during the identification of the factor and factor loading value of measured variables, thereby validating the basis of pre-established theory [46]. The Varimax Rotation Method and factor loading were set at 0.30. The Eigenvalues were extracted to explain whether the factors tested have a noticeable effect on responses linked to variables of the original analyzed construct.

3.5. Data Analysis

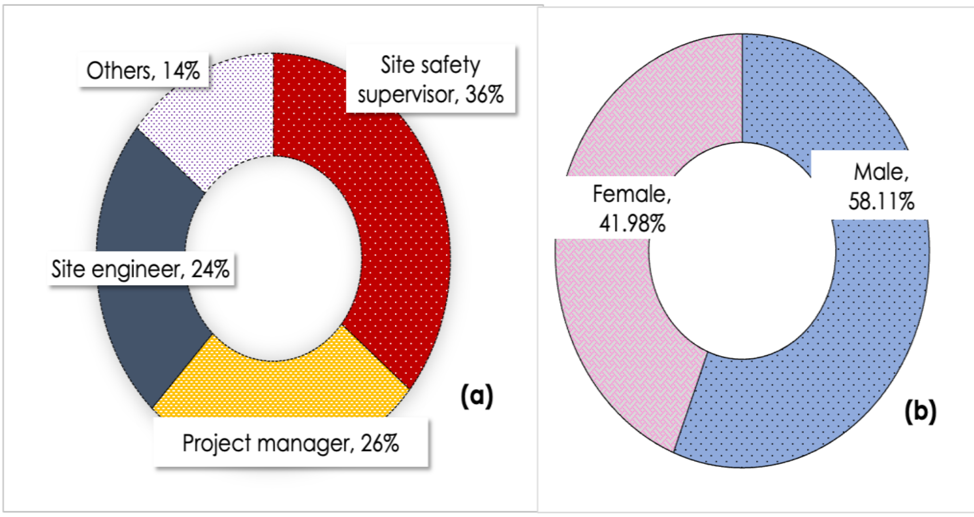
The SPSS software was adopted to determine the factor analyzability of construction performance using inferential statistics. This method is widely used and was chosen herein for both breadth and depth. In Section B, to rank the 10 factors consisting of 42 indicators affecting construction performance, the measurement of contractors' viewpoint was rated on a close-ended five-point Likert scale. Data screening was used in the section to increase the confidence of collected data. The normality test was used in data screening, which shows all elements were in normal distribution. The significant p-value is 0.071 (> 0.05) for Kolmogorov-Smirnov. Next, for the internal consistency reliability of factors in pilot study and confirmatory analysis, the Cronbach's alpha value was tested at a cut-off value of 0.835. The optimal inter-item correlation of mean was set at factor loading value of 0.3. To confirm analyzability of data for factor analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests were adopted. The KMO sampling adequacy measures a high statistical value between 0.5 and 1 which indicate that the data was suitable for factor analysis, whereas a low statistic value (< 0.5) shows erroneous measurement. The Bartlett's Test of Sphericity (BTS) provides statistical probability of correlation matrix contains significant correlations among some of its components ($p < 0.05$ following Adeyemi & Aigbavboa [68]. For factor extraction, PCA was used to summarize the information into a minimum number of factors. This analysis concentrates on the explanatory power of the first factor (or the principal components of data). When the number of variables (or measures) is between 20 and 50, it is more reliable to use Eigenvalues method in extracting factors as it provides easier interpretation. The highest Eigenvalues show the principal components in data, which were retained to form a set of a few new variables.

CFA is a statistical method for confirming the factor structure of a set of observed data [21]. This method was used to identify the hypothesis of observed variables and their underlying latent construct, which depends on the convergent validity metric values. Analyzing the initial measurement model conducted to all constructs to find the goodness-of-fit, which required item modification via CFA, eliminated items based on theoretical reasons and statistical analysis. To ensure that the data consistently conformed to theory, items were removed one at a time. The validity value of average and composite reliability was obtained at > 0.5, and > 0.7, respectively.

4.0 RESULTS AND DISCUSSION

4.1. Demographic Profile

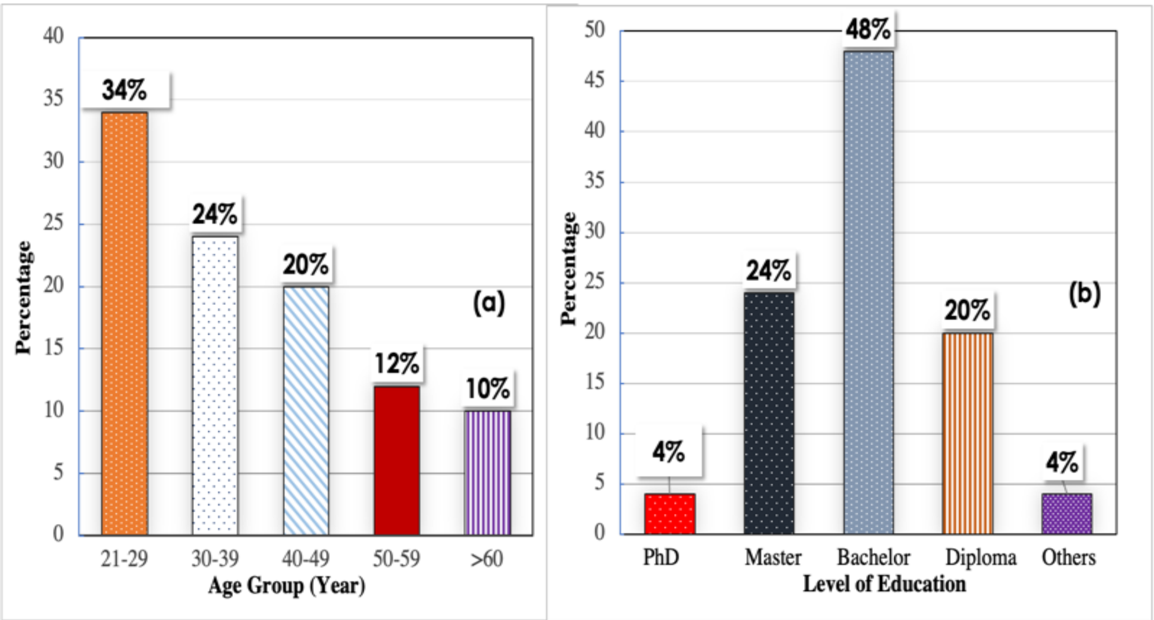
Figure 2 shows the 50 total returned survey forms comprised of staff from G7 companies which includes the project managers (26%), site engineers (24%), and site safety supervisors (36%). While others (14%) consisted of senior engineers, mechanical and electrical engineers, and quantity surveyors. The gender distribution shows 41.98% of the respondents were female and 58.11% were male (Figure 2). While lower than the typical response rate in construction studies usually between 55%– 65% as per Fosnacht et al. [69] and Neal et al. [70], the response rate of 42% was reasonable given the specific context of this study.



Figures 2 (a) Position; (b) Gender of respondents

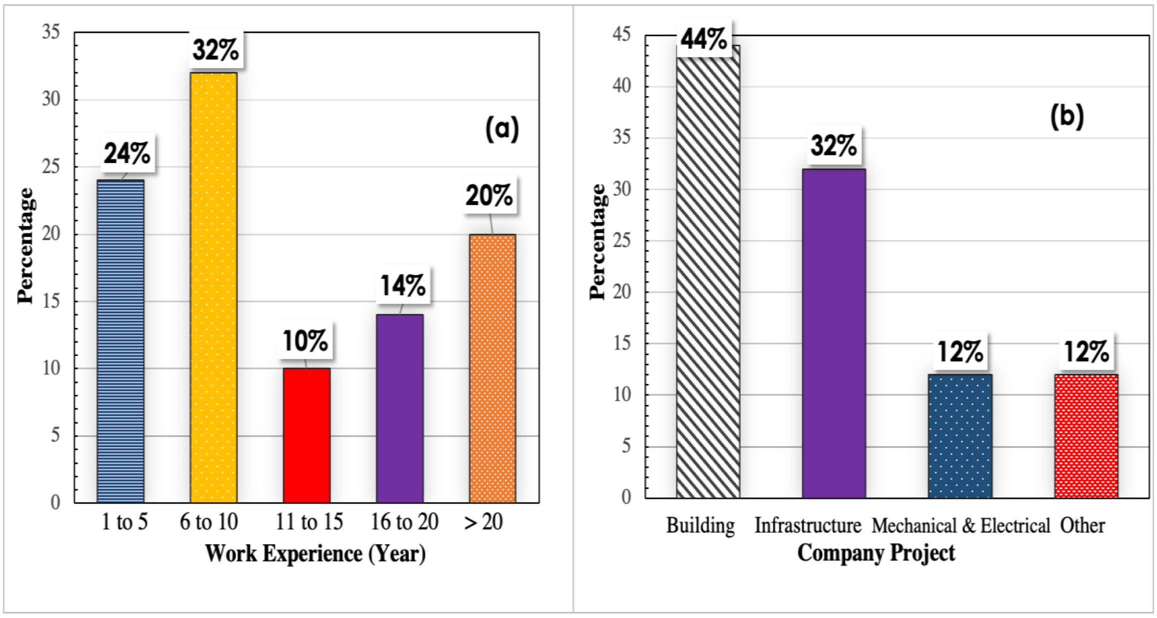
There were several factors contributed to this rate, such at timing of survey, invalid contract information, and survey fatigues and lack of interest, and industry-specific challenges. Firstly, the survey was conducted online during the tail end of the COVID-19 pandemic in 2021. This period gave unique challenges for businesses, particularly in this industry. Many G7 contractors, the target respondents, were still dealing with disruptions caused by the pandemic. Several companies dealt temporary cessations, project terminations, or staff reductions. These conditions likely diminished their availability and interest in participating in surveys. Secondly, the email addresses of some respondents were no longer valid. Many companies listed were either no longer operational or had reduced activities due to the pandemic and the economic downturn. At the same time, the response rates to online surveys are almost always lower than those retrieved when using on-paper surveys [71]. Additionally, contractors during this period were likely experiencing high levels of stress, job uncertainty, and survey fatigue which reduced their willingness to participate in non-essential activities, such as surveys. Survey fatigue is a documented phenomenon, specifically in the wake of the increased number of surveys carried-out during the pandemic [72]. Lastly, in construction sector, in general, tends to have lower return rates compared to other industries due to the demanding nature of the work and time limitations on professionals like project managers and site engineers. A 40%– 75% range is considered acceptable across many fields [73], thus our 42% response rate aligned with the acceptable thresholds for surveys conducted in similar sensitive and disrupted contexts [74].

The distribution of respondents aged between 21 – 29 and 30 – 39 years old comprised 34% and 24% of the total sample, respectively. Most respondents (48%) had bachelor's degrees, and master's degree (24%), and diploma (20%) as shown in Figures 3 (a) and (b).



Figures 3 (a) Working experience; (b) Type of company project

A third (32%) of the respondents had 6 – 10 years of experience, while more than a fifth (24%) had 1 – 5 years of involvement in building and infrastructure construction of 44% and 32%, respectively as seen in Figures 4 (a) and (b).



Figures 4 (a) Working experience; (b) Type of company project

Based on this demographic information, the sampled respondents can be accordingly adjudged following project performance in the business and can participate in this study. In addition, they were carefully selected to represent a broad spectrum of professionals within the construction industry. The respondents incorporate a diverse group of workers employed by G7 contractors, consisting of site engineers, project managers, site safety supervisors, senior engineers, mechanical and electrical engineers, and quantity surveyors. These roles are integral to the execution and management of construction projects, especially within the building and infrastructure sector, which is the focus of this study. The distribution of their qualifications and experience further supports the validity of including them in the analysis. A significant fraction (44%) of the respondents have more than 11 years of work experience in building and infrastructure projects, providing a solid foundation of practical knowledge pertinent to assessing construction project performance. Additionally, 48% of the respondents hold bachelor's degrees, and others possess PhDs, diploma or professional certificates, underscoring their technical competence and expertise in the field. The inclusion of individuals with various levels of experience and educational backgrounds ensures that the study represents a broad range of insights, from strategic management perspectives to hands-on technical expertise. This approach is in line with other studies in the construction industry that rely on respondents with diverse professional backgrounds and experience levels to gain a comprehensive understanding of industry practices and performance metrics [75, 76]. In related studies, diversity in participants' experience and qualifications has been shown to improve the credibility and generalizability of findings. For instance, Zhang et al. [76], noted that including engineers, project managers, and supervisors with various educational qualifications contributed to more reliable findings in construction performance analysis. Lew et al. [75] highlighted the importance of work experience in assessing accurate performance data in construction projects. Thus, the demographic background of these particular respondents not only represents the composition of primary roles in the construction industry but also ensures that the study results are grounded in a range of perspectives required for understanding sustainable construction project performance.

4.2. EFA of Construction Performance

EFA was used with PCA with Varimax Rotation on the 42 indicators affecting construction performance in Pulau Pinang. The result of KMO value was at 0.620 which was above the minimum adequacy value of 0.600 [77]. The BTS value was significant ($p < 0.05$), with an approximate Chi-Square value of 2537.4. These values indicate consistency and sufficient correlation that exist within the data, which demonstrate that factor analysis could be further carried-out. Table 3 indicates the eight factors affecting construction performance in Pulau Pinang.

Table 3 Factors Affecting Construction Performance and its Convergent Validity Values

Item	Construct Factor	Eigenvalues	Variance (%)
1	Labor, Equipment, Consultant, and Contract (LCC)	20.5	48.9
2	Project management (PM)	3.3	7.9
3	People (PE)	2.5	5.9
4	Scheduling (SD)	2.0	4.8
5	Material (ML)	1.6	3.7
6	Time (TM)	1.2	2.9
7	Project characteristic (PC)	1.2	2.8
8	Cost (CT)	1.0	2.4

The extracted factors were consistent with the previously hypothesized 10 factors except Labor, equipment, and material (LM), and Safety and health (SH). These factors were reanalyzed with Schedule and contract (SC), and Consultants (CN), Project management (PM), and People (PE) thus becoming new construct of Labor, equipment, consultant, and contract (LCC), Scheduling (SD), and Material (ML). Total variance was equal to 79.33% for cumulative percent in initial Eigenvalues. Table 4 shows the EFA results for construction performance in Pulau Pinang.

Table 4 EFA for Factors and Indicators Affecting Performance

Indicator	Factor							
	LCC	PM	PE	SD	ML	TM	PC	CT
SIC	0.804							
IDC	0.773							
PIP	0.767							
ACS	0.718							
DCD	0.695							
CPP	0.675							
LSC	0.672							
USW	0.651							
FMP	0.638							
CMP	0.602							
DRD	0.598							
LSA	0.581							
LAE	0.555							
DSC	0.517							
CQR	0.495							
ATS		0.804						
DLS		0.714						
IQC		0.706						
SCD		0.704						
IUM		0.660						
MTD		0.618						
SQM		0.606						
SCP		0.562						
HSO		0.562						
PSM		0.474						
WAI		0.439						
TSP			0.815					
TEM			0.735					
TLC			0.712					
MCE				0.756				
EDP				0.534				
UQP				0.440				
EMP					0.783			
ISM					0.766			
PCD					0.609			
CTD						0.833		
TDA						0.729		
SOP							0.812	
TOP							0.711	
NCT							0.582	
IAE								0.656
PAT								0.528

EFA broke down 42 qualities into 8 factors, with all constructs having a factor loading of > 0.3. The Eigenvalues for remeasures of explained variance of LLC was at 20.5% with a variance of 48.9%. Other constructs recorded the Eigenvalues ranging between 1 – 3.3% (Table 3). The average Cronbach's alpha value was obtained at 0.781, which meant there is sufficient evidence of convergent validity obtained for this remeasurement. The LCC construct consisted of 15 indicators, with recorded factor loadings ranging from 0.804 – 0.495. Indicators such as SIC, IDC, PIP, ACS, DCD, CPP, LSC, USW, FMP, CMP, DRD, LSA, LAE, DSC, and QCR were found to have negatively influenced construction project success in the state. The results show that, the indicator Slowness in giving instruction and poor coordination (SIC) between stakeholders of the projects might lead to several adverse effects on project performance. Slow in making decisions stipulates that delays in the whole project create a chain of events. This indicator thus correlates with increase in time and cost.

Contractors would minimize the quality which expediting the work and fulfill the expenditure. This coincides with Yusof et al. [51], which studied excusable delays for projects in Kuala Lumpur. Project performance factors associated with delay and duration issues are often answerable for turning productive progress into failures [12].

Project delays can be minimized through appropriate pre-project coordination and effective project management, including proper response to instructions from the end of the client team representative. Most public clients (particularly, the government) have a lot of bureaucratic bottlenecks that take longer time when it is involving decisions from the top management. This may stem from issues of variation order, awarding of mechanical and electrical nominated subcontractors' contracts, and honoring valuation certificates. Variation order is related to slow performance and most probably arises at private projects of high-rise building projects. Clients would argue that the changing of plans was due to economic shifting, marketing schemes, and satisfying customers' needs. Meanwhile, non-performance of delay issue related to approval of materials could be due to poor instruction by the client. It could also be from the architect's side, which may lack the time in issuing instructions requested by the contractor due to the obligation to other projects. This result in line with other past studies such as by Adekunle et al. [3] and Mohamad and Mohamad [18].

Next, Inadequate review for drawings and contract documents (IDC) was considered to be a significant indicator causing poor project performance by the respondents. Inadequate review of drawings could be triggered by incompetence wherein the designer may witness that many issues occur due to consultants' inappropriate selection during the contract stage of the project life cycle. It also indicates that construction design was insufficient [16] when the client and their representative overlooked appropriate planning, which directly links both causes. Without sufficient drawings, construction work is unlikely to be accomplished. Additionally, midway through the project, the consultant reviews and redesigns the work, which then returns to the re-approval phase. This process affects the entire system of the project, and numerous issues such as time, cost overrun, quality and despite transpire between the teams. In some scenarios, respondents mentioned many contractors work with half-completed drawings at time a project was awarded to them. As a product of a special nature, the construction business defines a contract as having various characteristics unlike the general contract [37]. For example, a construction contract involves a large amount of money, different stakeholders and authorities, long contract duration, new technology and design buildability, and involves complex legal terms. Thus, insufficient contract management will significantly lead to large errors in commissioning, delays in project settlement, and negative effects on the cash flow of the contractors. Meanwhile, it is important for all stakeholders to keep adequate documentation and reporting systems. This coincides with Ansari et al. [8], who suggested training the team staff on the necessity of contract clauses and their value to minimize ambiguities, disputes, and resolve claims in enhancing project performance.

4.3. Confirmatory Factor Analysis

The key factors of construction performance were determined via EFA (Table 4). These values were subsequently validated with CFA, which enabled the authors to establish measurement indicators affecting construction performance. Table 5 confirms the discriminant validity component factors with its Composite Reliability (CR) values. The Average Variance Extracted (AVE) value (> 0.5) for all constructs were higher than normal levels, thus supporting the CR and convergent validity of the constructs. For all four constructs, the Maximum Share Variance (MSV) value was less than AVE, the Maximum Reliability (H) value was higher than AVE, and the square root of AVE value was higher than the inter-construct correlations (0.26 – 0.67, Figure 5) which support the discriminant validity of the construct [78].

Table 5 Validity and Reliability

Construct Factors	CR	AVE	MSV	Maximum Reliability (H)	Square root of AVE
LCC	0.968	0.672	0.452	0.856	0.820
PE	0.855	0.662	0.452	0.755	0.814
TM	0.752	0.603	0.311	0.674	0.777
PC	0.700	0.508	0.311	0.674	0.713

Figure 5 shows the modification of four constructs of LCC, PE, TM, and PC run for CFA with its factors loading (> 0.7) and covariance values (< 0.8). Following contractors' viewpoint, it is possible to prioritize and order project performance using the CFA method, which is as follows: LCC →PE, LCC →TM, LCC → PC, PE → L CC, PE →TM, PE → PC, TM → LCC, TM → PE, TM → PC, PC → LCC, PC → PE, PC → TM were statistically significant

(Figure 5). The first construct has a significant influence on the second construct, and so on. These four constructs cover the entire range of activities of a project performance and the backbone of its success.

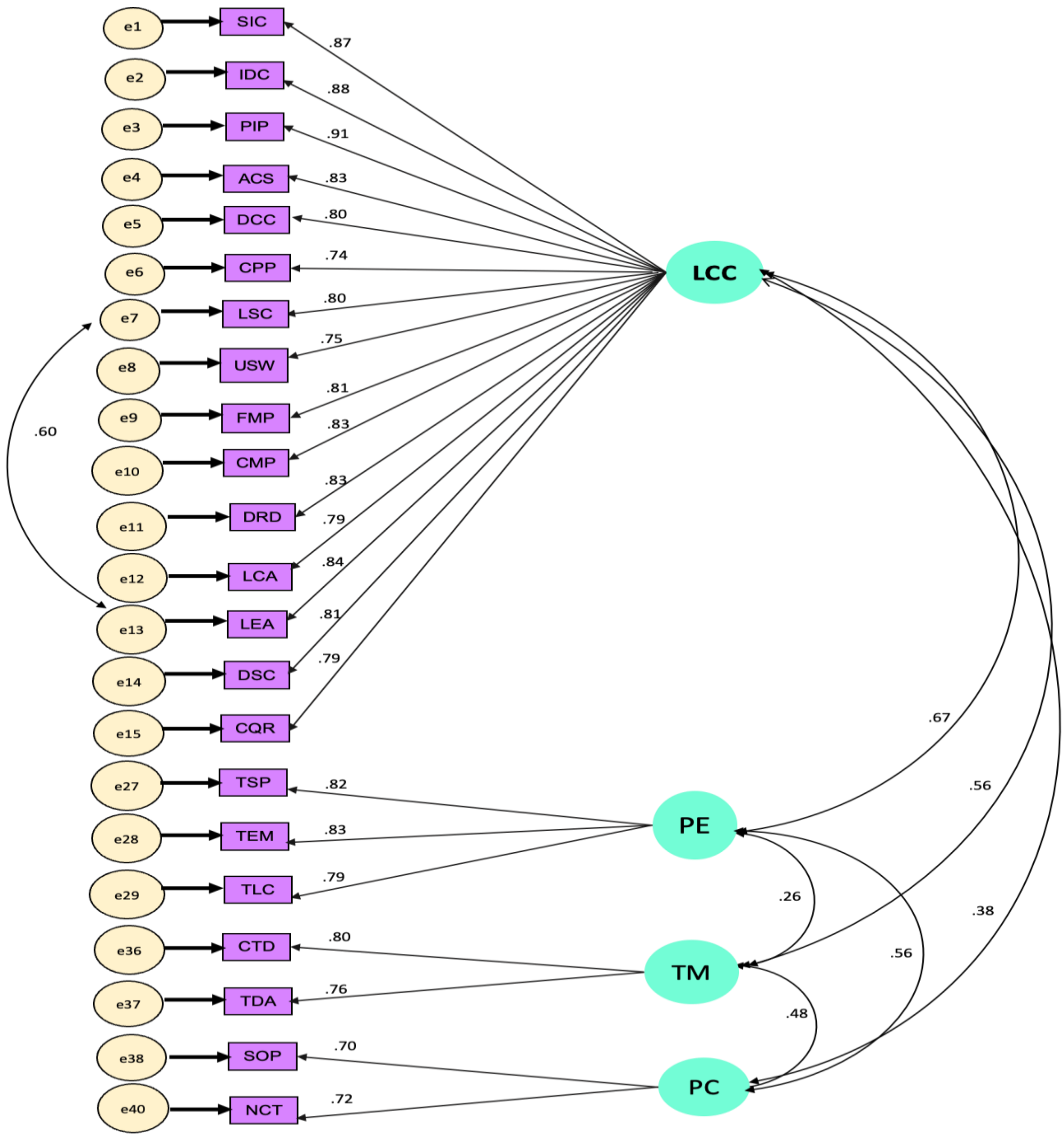


Figure 5 Factors loading values for CFA ad its cross-loading correlation matrix

The LCC construct captured the unique multidimensional indicators of a project performance associated with the nature of labor, material, and equipment arriving in the right time and place; the necessity of competent consultants; the complexity of the contract; and the scheduling and planning and awareness of safety and health which were not specified by other factors. These characteristic indicators collectively defined the construction performance and eventually identify the performance of a project. Contractor related factors subjugated the experience and skill requirements of site managers, subcontractors, and laborers who execute construction work following the prescribed managerial and technical identifications. Consultant related factors captured proper coordination of giving instruction as representative of the client, availability of reviewed drawings, documentations for use by contractors, and even to the extent of inspection of the project on-site.

Performance management paid attention to the construction organization's team and client, and provided a competitive edge in the industry. The construction business may achieve its objectives by maximizing success and avoiding failure. In the construction preparation phase, causes of delays include ineffective project planning and scheduling, rising inflation/material prices, unavailability of onsite utilities, improper project feasibility studies, design and drafting delays, design errors-failure, and poor instruction dissemination. During the post-construction phase, delays occur during the approval of the documents, approval of work across the project, poor construction management and performance, material inflation and rising prices, delayed budget releases, and the approval for high-quality materials [46, 48]. Moreover, the novelty of this study lies upon its remarkable contribution to understanding construction project performance from the viewpoint of G7 contractors in this state. Pulau Pinang is experiencing remarkable growth in construction activities, specifically in infrastructure and building development. This makes it a suitable region for assessing sustainable construction practices. The proliferation of new industrial parks for example Batu Kawan Park 2, and Bertam Technology Parks are set to provide vast job opportunities in technology, property, as well as construction sectors. The intensified infrastructure rollout is mark to benefits contractors at approximately MYR10 to 13 billion worth of contracts predicted in the coming year, induced by the Pulau Pinang Transport Master Plan and development of new industrial technology park [79].

Through an integration of EFA and CFA analyses, the study identified crucial factors such as LCC that considerably affect the success of sustainable construction projects. This intricate approach not only emphasized these KPIs but also weighted the interdependence between contractors and consultants in delivering quality outcomes within the given timeframe. For academic researchers and industry practitioners, the findings of this study contribute to: (i) a customized understanding of the Malaysian context, particularly for construction firms in the northern regions, to optimize resources and project management strategies; (ii) an evidence-based framework of statistical methods that identifies factors influencing project performance (LCC, PE, TM, and PC), providing a robust framework that industry stakeholders can adopt to ensure better project delivery and stakeholder satisfaction; and (iii) enhanced decision-making, particularly for public authorities, such as for extensions of time and quality approval. This party can use the identified KPIs to assess contractor performance, enhancing oversight on project timelines, quality of output, and cost-effectiveness.

5.0 CONCLUSION

In conclusion, this study offers a comprehensive analysis of the key performance indicators that impact sustainable construction projects in Pulau Pinang from the contractors' perspective. The Labor, Equipment, Consultant, and Contract (LCC) factor was identified as a pivotal enabler of project success, emphasizing the importance of synchronized coordination and resource allocation. These findings contribute to the broader discourse on construction project performance by incorporating sustainability considerations, offering both academic and practical value. Contractors and policymakers can leverage these insights to redefine project management strategies and enhance performance evaluation frameworks. Future research could expand on these findings by investing the impact of technological innovations on project performance in evolving construction landscapes.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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References

[1] Report, B. W. (2022). *Global construction market report 2022 huge economic growth in developing countries and low interest rates in number of developed countries driving sector*.

[2] Yap, J. B. H., Goay, P. L., Woon, Y. B., & Skitmore, M. (2021). Revisiting critical delay factors for construction: Analysing projects in Malaysia. Alexandria Engineering Journal, 60(1), 1717–1729. https://doi.org/10.1016/j.aej.2020.11.021

[3] Adekunle, S. A., Aigbavboa, C., & Ejohwomu, O. A. (2020). Improving construction project performance in developing countries: Contractor viewpoint. In Y. Vacanas, C. Danezis, & A. andYazdani Singh (Eds.), Proceedings of International Structural Engineering and. Construction CON-14. https://doi.org/10.14455/ISEC.res.2020.7(1).CON-14

[4] Ramli, M. Z., Malek, M. A., Hamid, B., Roslin, N. T., Roslan, M. E. M., Norhisham, S., & Mohd, M. F. (2018). Influence of project type, location and area towards construction delay: a review on significance level of delay factors. International Journal of Engineering & Technology, 7(4.35), 392. https://doi.org/10.14419/ijet.v7i4.35.22769

[5] Jatarona, N. A., Yusof, A. M., Ismail, S., & Saar, C. C. (2016). Public construction projects performance in Malaysia. Journal of Southeast Asian Research, 940838, 1–7. https://doi.org/10.5171/2016.940838

[6] Mohamed Salleh, R., Mustapa, N. A., Dzain, D. W., & Che Ahmad, A. (2022). Project performance impact factors among developers in Malaysian private projects. International Journal of Academic Research in Economics and Management Sciences, 11(3), 243–250. https://doi.org/10.6007/IJAREMS/v11-i3/14482
[7] Ali, A. S., & Rahmat, I. (2010). The performance measurement of construction projects managed by ISO-certified contractors in Malaysia. Journal of Retail and Leisure Property, 9(1), 25–35. https://doi.org/10.1057/rlp.2009.20
[8] Ansari, R., Khalilzadeh, M., Taherkhani, R., Antucheviciene, J., Migilinskas, D., & Moradi, S. (2022). Performance prediction of construction projects based on the causes of claims: A system dynamics approach. Sustainability (Switzerland), 14(7), 4138. https://doi.org/10.3390/su14074138
[9] Leong, T. K., Zakuan, N., Mat Saman, M. Z., Ariff, M. S. M., & Tan, C. S. (2014). Using project performance to measure effectiveness of quality management system maintenance and practices in construction industry. The Scientific World Journal, 2014, 1–9. https://doi.org/10.1155/2014/591361
[10] Leon, H., Osman, H., Georgy, M., & Elsaid, M. (2018). System dynamics approach for forecasting performance of construction projects. Journal of Management in Engineering, 34(1). https://doi.org/10.1061/(asce)me.1943-5479.0000575
[11] Cleary, J. P., & Lamanna, A. J. (2022). Correlation of construction performance indicators and project success in a portfolio of building projects. Buildings, 12(7), 957. https://doi.org/10.3390/buildings12070957
[12] Rivera, L., Baguec, H., & Yeom, C. (2020). A study on causes of delay in road construction projects across 25 developing countries. Infrastructures, 5(10), 1–16. https://doi.org/10.3390/infrastructures5100084
[13] Institute, P. M. (2023). Construction extension to the project management body of knowledge (PMBOK Guide). Project Management Institute Newtown Square PA USA, 201.
[14] Santoso, D. S., & Gallage, P. G. M. P. (2020). Critical factors affecting the performance of large construction projects in developing countries: A case study of Sri Lanka. Journal of Engineering, Design and Technology, 18(3), 531–556. https://doi.org/10.1108/JEDT-05-2019-0130
[15] Ramanathan, C., Narayanan, S. P., & Idrus, A. B. (2012). Construction delays causing risks on time and cost - A critical review. Australasian Journal of Construction Economics and Building, 12(1), 37–57. https://doi.org/10.5130/ajceb.v12i1.2330
[16] Yusof, A. M., Khoso, A. R., Sohu, S., Khahro, S. H., & Chai, C. S. (2021). Improving performance in construction projects: A case study of malaysian public projects. Pertanika Journal of Science and Technology, 29(4), 2579–2604. https://doi.org/10.47836/PJST.29.4.19
[17] Kamaruddeen, A. M., Sung, C. F., & Wahi, W. (2020). A Study on factors causing cost overrun of construction projects in Sarawak, Malaysia. Civil Engineering and Architecture, 8(3), 191–199. https://doi.org/10.13189/cea.2020.080301
[18] Muhamad, N. H., & Mohammad, M. F. (2018). Impact of design changes in construction project. Malaysian Journal of Sustainable Environment, 4(1), 1. https://doi.org/10.24191/myse.v4i1.5603
[19] Chan, T. K. (2009). Measuring performance of the Malaysian construction industry. Construction Management and Economics, 27(12), 1231–1244. https://doi.org/10.1080/01446190903233137
[20] Cheung, S. O., Suen, H. C. H., & Cheung, K. K. W. (2004). PPMS: A web-based construction project performance monitoring system. Automation in Construction, 13(3), 361–376. https://doi.org/10.1016/j.autcon.2003.12.001
[21] Sarmento, R. P., & Costa, V. (2019). *Confirmatory Factor Analysis -- A Case study*. https://doi.org/10.48550/arXiv.1905.05598
[22] Brown, T. A. (2015). *Confirmatory factory analysis for applied research (2nd year)*. New York: The Guilford Press.
[23] Adeleke, A. Q., Bamgbade, J. A., Gbadebo Salimon, M., & Kuang Lee, C. (2019). Project management performance and its influence on Malaysian building projects. KnE Social Sciences, 3(22), 313–329. https://doi.org/10.18502/kss.v3i22.5058
[24] Amzafi, N. H., Ishak, S. A., Rahim, M. A., Amlus, M. H., Rani, H. A., Syammaun, T., Mokhtar, H., & Ayob, A. (2024). A systematic review of the causes and effects of variation orders in sustainable construction in developing countries. International Journal of Integrated Engineering, 16(4), 188–203. https://doi.org/10.30880/ijie.2024.16.04.023
[25] Hussain, S., Xuetong, W., & Hussain, T. (2020). Impact of skilled and unskilled labor on project performance using structural equation modeling approach. Sage Open, 10(1). https://doi.org/10.1177/2158244020914590
[26] Langston, C. (2014). Construction efficiency: a tale of two developed countries. Engineering, Construction and Architectural Management, 21(3), 320–335. https://doi.org/10.1108/ECAM-02-2013-0014
[27] Olanrewaju, A., & Lee, H. J. A. (2022). Analysis of the poor-quality in building elements: providers' perspectives. Frontiers in Engineering and Built Environment, 2(2), 81–94. https://doi.org/10.1108/febe-10-2021-0048
[28] Alaloul, W. S., Liew, M. S., Zawawi, N. A. W., Mohammed, B. S., Adamu, M., & Musharat, M. A. (2020). Structural equation modelling of construction project performance based on coordination factors. Cogent Engineering, 7(1), 1726069. https://doi.org/10.1080/23311916.2020.1726069
[29] Data, F. M. (2016). Benchmarking construction industry in developed and developing world. Retrieved from https://www.televisory.com/blogs/-/blogs/benchmarking-construction-industry-in-developed-and-developing-world
[30] Shehu, Z., Endut, I. R., Akintoye, A., & Holt, G. D. (2014). Cost overrun in the Malaysian construction industry projects: A deeper insight. International Journal of Project Management, 32(8), 1471–1480. https://doi.org/10.1016/j.ijproman.2014.04.004
[31] Endut, I. R., Akintoye, A., & Kelly, J. (2005). Cost and time overruns of projects in Malaysia. ICONDA Prooceedings of the 2nd Scottish Conference for Postgraduate Researchers of the Built and Natural Environment (PRoBE). Retrieved

from https://www.irbnet.de/daten/iconda/CIB10633.pdf
[32] Albert, I., Shakantu, W., & Ibrahim, S. (2021). The effect of poor materials management in the construction industry: A case study of Abuja, Nigeria. Acta Structilia, 28(1), 1. https://doi.org/10.18820/24150487/as28i1.6
[33] Lin, X., Ho, C. M. F., & Shen, G. Q. P. (2017). Who should take the responsibility? Stakeholders' power over social responsibility issues in construction projects. Journal of Cleaner Production, 154, 318–329. https://doi.org/10.1016/j.jclepro.2017.04.007
[34] Ghenbasha, M., Sabki, W. M., Omar, W., Ayob, A., & Ghenbasha, M. R. R. (2016). Causes of construction delay in developing countries : a theoretical review. The 1st International Conference on Invention and Design, (July 2017). Retrieved from https://www.researchgate.net/publication/318646339
[35] Arantes, A., & Ferreira, L. M. D. F. (2020). Underlying causes and mitigation measures of delays in construction projects. Journal of Financial Management of Property and Construction, 25(2), 165–181. https://doi.org/10.1108/JFMPC-03-2019-0029
[36] Zarei, B., Sharifi, H., & Chaghouee, Y. (2018). Delay causes analysis in complex construction projects: a Semantic Network Analysis approach. Production Planning & Control, 29(1), 29–40. https://doi.org/10.1080/09537287.2017.1376257
[37] Xie, W., Deng, B., Yin, Y., Lv, X., & Deng, Z. (2022). Critical factors influencing cost overrun in construction projects: A Fuzzy synthetic evaluation. Buildings, 12(11), 2028. https://doi.org/10.3390/buildings12112028
[38] Deng, B. (2022). Analysis on influencing factors of construction project management cost control of international real estate companies. International Journal of Engineering Advanced Research, 4(4), 50–61.
[39] Meng, X., & Chan, A. H. S. (2022). Improving the safety performance of construction workers through individual perception and organizational collectivity: A contrastive research between Mainland China and Hong Kong. International Journal of Environmental Research and Public Health, 19(21), 14599. https://doi.org/10.3390/ijerph192114599
[40] Buniya, M. K., Othman, I., Sunindijo, R. Y., Kineber, A. F., Mussi, E., & Ahmad, H. (2021). Barriers to safety program implementation in the construction industry. Ain Shams Engineering Journal, 12(1), 65–72. https://doi.org/10.1016/j.asej.2020.08.002
[41] Rivera, F. M. La, Mora-Serrano, J., & Oñate, E. (2021). Factors influencing safety on construction projects (Fscps): types and categories. International Journal of Environmental Research and Public Health, 18(20), 10884. https://doi.org/10.3390/ijerph182010884
[42] Siew, L. W., Fai, L. K., & Hoe, L. W. (2021). Performance evaluation of construction companies in malaysia with entropy-vikor model. Engineering Journal, 25(1), 297–305. https://doi.org/10.4186/ej.2021.25.1.297
[43] Razak, A. R. A., Halim, H. A., & Hamid, A. R. A. (2017). Construction industry prosecution cases under Malaysian occupational safety and health legislation. The Colloquium, 10, 21–27.
[44] Raman, S. A. (2015). *Innovation and R&D in the construction industry*. Universiti Teknologi Malaysia.
[45] Bin Sulaiman, S. (2016). *A study of customers satisfaction and perceived value relationship in CONQUAS and QLASSIC certified housing projects*. Universiti Teknologi Malaysia.
[46] Das, D., & Ngacho, C. (2017). Critical success factors influencing the performance of development projects: An empirical study of constituency development fund projects in Kenya. IIMB Management Review, 29(4), 276–293. https://doi.org/10.1016/j.iimb.2017.11.005
[47] Mahamid, I. (2022). Relationship between delay and productivity in construction projects. International Journal of Advanced and Applied Sciences, 9(2), 160–166. https://doi.org/10.21833/IJAAS.2022.02.018
[48] Ajayi, B. O., & Chinda, T. (2022). Impact of construction delay-controlling parameters on project schedule: DEMATEL-System Dynamics Modeling Approach. Frontiers in Built Environment, 8, 799314. https://doi.org/10.3389/fbuil.2022.799314
[49] Fashina, A. A., Omar, M. A., Sheikh, A. A., & Fakunle, F. F. (2021). Exploring the significant factors that influence delays in construction projects in Hargeisa. Heliyon, 7(4), e06826. https://doi.org/10.1016/j.heliyon.2021.e06826
[50] Shahsavand, P., Marefat, A., & Parchamijalal, M. (2018). Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol. Engineering, Construction and Architectural Management, 25(4), 497–533. https://doi.org/10.1108/ECAM-10-2016-0220
[51] Persekutuan, W., & Lumpur, K. (2007). Excusable and compensable delays in the construction of building project – a study in the states of Selangor and Wilayah Persekutuan Kuala Lumpur, Malaysia (pp. 21–26). Retrieved from https://api.semanticscholar.org/CorpusID:53123722
[52] Ingle, P. V., & Mahesh, G. (2022). Construction project performance areas for Indian construction projects. International Journal of Construction Management, 22(8), 1443–1454. https://doi.org/10.1080/15623599.2020.1721177
[53] Soewin, E., & Chinda, T. (2018). Factors affecting construction performance: Exploratory factor analysis. IOP Conference Series: Earth and Environmental Science, 140(1), 012102. https://doi.org/10.1088/1755-1315/140/1/012102
[54] Bitamba, B. F., & An, S. H. (2020). Study on factors affecting the performance of construction projects in the democratic republic of the Congo. South African Journal of Industrial Engineering, 31(1), 12–25. https://doi.org/10.7166/31-1-2193
[55] SIMUKONDA, W., & Kamwela, N. (2021). The management of theft and vandalism on construction jobsites in the Southern Region of Malawi. Journal of Construction Business and Management, 5(1), 47–59.

https://doi.org/10.15641/jcbm.5.1.1072
[56] Abbasbhai, M. J., & Patel, A. S. (2020). Factors affecting performance of construction projects. International Research Journal of Engineering and Technology, 7, 344–2351.
[57] Ademola, S. A., Akomolafe, M. A., & Buari, T. A. (2019). Factors influencing time performance of contractors on construction projects in Osun State, Nigeria. In 1st International Conference on Engineering and Environmental Sciences, 870.
[58] Gebrehiwet, T., & Luo, H. (2017). Analysis of delay impact on construction project based on RII and correlation coefficient: Empirical study. Procedia Engineering, 196, 366–374. https://doi.org/10.1016/j.proeng.2017.07.212
[59] Athukorala, P. chandra, & Narayanan, S. (2018). Economic corridors and regional development: The Malaysian experience. World Development, 106, 1–14. https://doi.org/10.1016/j.worlddev.2018.01.009
[60] Abas, N. H., Yusuf, N., Rahmat, M. H., & Ghing, T. Y. (2021). Safety personnel's perceptions on the significant factors that affect construction projects safety performance. International Journal of Integrated Engineering, 13(3), 1–8. https://doi.org/10.30880/ijie.2021.13.03.001
[61] J.W, C. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. London SAGE Publication, Incoporated.*
[62] Ayob, A., Kitt, L. C., Munaaim, M. A. C., Zaki, M. F. M., & Ahmad, A. G. (2018). Contractors' perspectives of risk management implementation in Malaysian construction industry. Malaysian Construction Research Journal, 26(3), 17–28.
[63] Nasir, M. Z., & Syed, B. H. (2022). Material management method and its implication on construction project performance: Case study in Pulau Pinang. Recent Trends in Civil Engineering and Built Environment, 3(1), 436–446. Retrieved from http://publisher.uthm.edu.my/periodicals/index.php/rtcebe
[64] Haslinda, A. N., Xian, T. W., Norfarahayu, K., Hanafi, R. M., & Fikri, H. M. (2018). Investigation on the factors influencing construction time and cost overrun for high-rise building projects in Penang. Journal of Physics: Conference Series, 995(1), 012043. https://doi.org/10.1088/1742-6596/995/1/012043
[65] Memon, M. A., Ting, H., Cheah, J. H., Thurasamy, R., Chuah, F., & Cham, T. H. (2020). Sample size for survey research: Review and recommendations. Journal of Applied Structural Equation Modeling, 4(2), i–xx. https://doi.org/10.47263/jasem.4(2)01
[66] Gorcush, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale N. J. Erlbaum.
[67] Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). New York, Pearson.
[68] Adeyemi, B. S., & Aigbavboa, C. O. (2022). An Exploratory Factor Analysis for conflict resolution methods among construction professionals. Buildings, 12(6), 854. https://doi.org/10.3390/buildings12060854
[69] Fosnacht, K., Sarraf, S., Howe, E., & Peck, L. K. (2017). How important are high response rates for college surveys? The Review of Higher Education, 40(2), 245–265. https://doi.org/10.1353/rhe.2017.0003
[70] Neal, Z., Neal, J. W., & Piteo, A. (2020). Call me maybe: Using incentives and follow-ups to increase principals' survey response rates. Journal of Research on Educational Effectiveness, 13(4), 784–793. https://doi.org/10.1080/19345747.2020.1772423
[71] Nulty, D. D. (2008). The adequacy of response rates to online and paper surveys: What can be done? Assessment and evaluation in higher education, 33(3), 301–314. https://doi.org/10.1080/02602930701293231
[72] Turcan, N., Cuciureanu, G., Cujba, R., Lupu, V., Cheradi, N., & Cojocaru, I. (2022). Perception of open science in the scientific community of the Republic of Moldova. Postmodern Openings, 13(4), 294–334. https://doi.org/10.18662/po/13.4/519
[73] Sataloff, R. T., & Vontela, S. (2021). Response rates in survey research. Journal of Voice, 35(5), 683–684. https://doi.org/10.1016/j.jvoice.2020.12.043
[74] Huang, T. Y., Chen, R. Y., Li, Y. C., Yin, C. H., Hsu, C. H., & Chen, C. (2024). The role of hospice tours in promoting hospice enrollment: A study of Taiwanese family members. Sage Open, 14(2). https://doi.org/10.1177/21582440241256257
[75] Lew, Y. L., Lim, W. H., Tan, O. K., Toh, T. C., Felicia, Y. Y. Y., & Yow, L. P. (2020). Safety performance of subcontractors in Malaysian construction industry. Malaysian Construction Research Journal, 9(1 Special issue), 114–125.
[76] Zhang, N., Deng, X., Zhao, X., & Chang, T. (2019). Exploring the sources of contractors' competitive advantage on international HSR construction projects. International Journal of Civil Engineering, 17(7), 1115–1129. https://doi.org/10.1007/s40999-018-0373-1
[77] Hoque, A. S. M. M., Siddiqui, B. A., Awang, Z., & Syed Muhammad Awaluddin, T. B. (2018). Exploratory factor analysis of entrepreneurial orientation in the context of Bangladeshi small and medium enterprises (SMES). European Journal of Management and Marketing Studies, 3(2), 81–94. https://doi.org/10.46827/ejmms.v0i0.384.
[78] Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in Covariance Structure Analysis: Conventional criteria versus new alternatives. Structural Equation Modeling, 6(1), 1–55. https://doi.org/10.1080/10705519909540118
[79] Wei, L. C. (2023). *Construction sector update, Affin Hwang Investment Bank Berhad*. A partcipating organization of Bursa Malaysia Securities Berhad.