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Critical Success Factors Influencing Construction Project Performance for Different Objectives: Procurement Phase

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***Abstract*—**Critical success factors (CSFs) and the criteria to measure project success have received much attention over the decades and are among the most widely researched topics in the context of project management. However, although there have been extensive studies on the subject by different researchers, to date, there has been little agreement on the CSFs. The aim of this study is to identify the CSFs that influence the performance of construction projects, and determine their relative importance for different objectives across five stages in the project life cycle. A considerable literature review was conducted that resulted in the identification of 179 individual factors. These factors were then grouped into nine major categories. A questionnaire survey was used to collect data from three groups of respondents: client representatives, consultants, and contractors. Out of 164 questionnaires distributed, 93 were returned, yielding a response rate of 56.7%. Using the mean score, relative importance index, and weighted average method, the top 10 critical factors for each category were identified. The agreement of survey respondents on those categorised factors were analysed using Spearman's rank correlation. A one-way analysis of variance was then performed to determine whether the mean scores among the various groups of respondents were statistically significant. The findings indicate the most CSFs in each category in procurement phase are: *proper procurement programming of materials* (time), *stability in the price of materials* (cost), *and determining quality in the construction* (quality). They are then followed by *safety equipment acquisition and maintenance* (health and safety), *budgeting allowed in a contractual arrangement for implementing environmental management activities* (environment), *completeness of drawing documents* (productivity), *accurate measurement and pricing of bill of quantities* (risk management), *adequate communication among the project team* (human resource), and *adequate cost control measures* (client satisfaction). An understanding of CSFs would help all interested parties in the construction industry to improve project performance. Furthermore, the results of this study would help construction professionals and practitioners take proactive measures for effective project management.

***Keywords*—**Critical success factors, procurement phase, project life cycle, project performance.

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I. Introduction

CRITICAL success factors (CSFs) are those fundamental issues vital to the current operating activities and future success of an organisation. It is generally accepted that CSFs are defined as those factors predicting the success of a project [1] and are considered to be a means to improve the effectiveness of a project [2]. Nevertheless, although many researchers have tried to determine the CSFs affecting the success of activities and projects, efforts to reach an agreement on the CSFs have been rather limited and researchers continue to conduct further experiments [3]. In addition, criteria to measure project success play a key role and have been widely adopted in the construction industry. Success criteria can be defined as the set of principles by which favourable outcomes can be completed within a set specification. Time, cost, and quality, known as the "iron triangle", are the basic criteria for project success [4]. It is common knowledge that project success is considered to be tied to performance measures. Performance measurement is used as a business tool to evaluate management performance and monitor a strategic plan [5]. With the increasing complexity of the construction industry, having a limited view of performance and considering the "iron triangle" as the only criteria of performance measurement are inadequate. In addition, over the past decades, the focus on criteria to measure project success has changed and been extended to multidimensional measurement [6], [7].

As can be seen from the above discussion, there remains a need to ascertain critical factors influencing project performance for various dimensions and across the entire stages of the life of a project. Thus, to bridge the gap of this knowledge, the objectives of this research are as follows:

1. to identify the critical factors influencing project performance for different objectives in Thai construction projects; and
2. to determine factors that account for improving project performance through the entire project life cycle.

In this study, the criteria to evaluate the success of a project are measured in terms of time, cost, quality, health and safety, environment, productivity, risk, human resource, and client satisfaction. In addition, the project life cycle is divided into five phases: conceptualisation; planning and design; procurement; construction; and operation and maintenance. However, the discussion in this paper is only focused on the procurement phase.

This paper is organised as follows. The first section

provides a brief review of the relevant literature. In the second section, the research methodology and theoretical hypotheses are described. Then, the data analysis and discussion of results are presented. In the final section, limitations and suggestions for future research are provided.

II. Literature Review

A. Critical Success Factors

Many studies have been conducted to explore the influence of CSFs on project performance. The term "critical success factors" in the context of project management was first used in [8] in 1982 and has received much attention by different researchers and construction practitioners in decades.

Reference [1] conducted a survey to define the critical factors for building projects. The study concluded that there are significant CSFs leading to project success, for example, a well-organised, cohesive facility team to manage, plan, design, construct, and operate the facility; and experience in the management, planning, design, construction, and operations of similar services. A survey to evaluate the relative importance of the significant factors causing delays in building projects was presented by [9]. The results of an investigation indicated that the major causes of delays are poor site management and supervision, unforeseen ground conditions, and low speed of decision-making involving all project teams.

Reference [10] identified many success factors grouped under four main project aspects. The results of the study revealed that there are various sets of CSFs for different project objectives. In empirical research to identify CSFs leading to a successful project, [11] defined the key factors that are critical to project management success. These include the adequacy of company-wide education on the concepts of risk management, allowing changes to scope only through a mature scope change control process, and maintaining the integrity of the performance measurement baseline.

There have been increasing interest and attempts to explore CSFs in the context of project management. A study conducted by [12] found that there are six CSFs affecting schedule performance in Indian construction projects. These include the project manager's competence; supportive owners and top management; monitoring, feedback, and coordination; favourable working conditions; commitment of all project participants; and owner's competence.

Reference [13] conducted a survey to examine factors affecting project performance. The study indicated that the availability of resources as planned through project duration, escalation of material prices, availability of highly experienced and qualified personnel, and quality of available equipment and raw materials are the most significant factors affecting project performance. A survey to investigate factors influencing project performance across the project life cycle was conducted by [14]. The study results showed that clarity of contract, fixed construction period, precise project budget estimate, material quality, mutual/trusting relationships, leadership/team management, and management of work safety on site are the most critical factors.

In recent studies, [15] attempted to distinguish the CSFs for different components consisting of the budget, schedule, and quality performance of construction projects. However, it should be noted that despite many studies on CSFs proposed by various researchers and practitioners, there seems to be little agreement on CSFs and researchers continue to stress on more work in the area [3].

B. Project Performance Criteria

The performance of an organisation is multidimensional and a function of the performance of the members of the group [7]. The term "performance" has received much attention in the context of project management in decades, although its interpretation varies among researchers and construction practitioners [16]. Criteria to measure project performance can evaluate using several indicators [13]. Measuring project performance in terms of time, cost, and quality has traditionally been acknowledged, and is of interest to researchers and construction practitioners. In a survey conducted by [10], three project objectives, namely budget, schedule, and quality, were addressed to identify CSFs for construction projects. The results of the study found that there are different sets of CSFs for different project performance criteria. According to [12], the success of a project is measured in terms of its performance on schedule, cost, quality, and no disputes.

Reference [17] provided some thoughts about a new way to consider other success criteria beyond cost, time, and quality, called the "square route". This consideration is consistent with [4], who shared a similar opinion and claimed that the traditional definition of project performance, which revolves around time, cost, and quality, has proved to be inadequate. In the re-examination of criteria to determine project success by [18], there were two possible viewpoints: micro and macro. Developers or clients and contractors look at project success from the micro viewpoint; the users and stakeholders usually look at project success from the macro viewpoint. Because of the increasing complexity and dynamics of construction projects, numerous factors need to be considered across the whole life of a constructed asset [14].

Clearly, the above examples demonstrate that the focus on the criteria to measure project performance has changed. More recent evidence has proposed a large number of performance indicators to measure project success. These performance indicators could be related to many dimensions, such as health, safety, environment, human resource development, client satisfaction, productivity, risk, contract and administration, profitability, and business efficiency [13], [14], [19].

III. Research Methodology

A. Questionnaire Design

A questionnaire survey was used to examine the degree of importance of each factor of the nine critical project performance criteria. The questionnaire is divided into three parts. Part I provides an introduction that states the nature and purpose of the study and survey. Part II provides general

information for the respondent. Part III includes a set of nine project criteria and 179 individual factors. The study gathered data from stakeholders in the Thai construction industry. Three groups of project practitioners were approached to participate in this research:

- Group 1: client representatives (CR);
- Group 2: construction supervision consultants/design consultants (CD); and
- Group 3: contractors (CS)

A pilot project was conducted using a preliminary questionnaire. The objective of the pilot study was to prove the accuracy and completeness of the questionnaire before distributing it to respondents. Based on the input of these subjects, the questionnaire was reorganised, omitting some of the redundant variables, rearranging questions to provide a more consistent meaning, and adding experts' comments and suggestions to ensure the practicality of a questionnaire.

Before the questionnaire was finalised and distributed to respondents, a measure of its reliability was used to assess its internal consistency. Internal consistency reliability estimates how consistently participants respond to the measurement scale within the questionnaire. For a questionnaire survey, Cronbach's alpha method is most frequently used for calculating internal consistency as the index of instrument reliability [20]. In this study, the Cronbach's alpha test was employed to measure the consistency of the questionnaire. Using Statistical Package for Social Science version 19.0 (SPSS), the calculated Cronbach's alpha (α) of the questionnaire was 0.995; this value indicates that instrument was internally consistent and was considered reliable.

B. Data Collection

In this study, the snowball sampling method, which is a non-probability sampling technique, was used for the referral network. This method of sampling is commonly used where it is difficult to obtain a response from a sample population selected at random [21]. A total of 164 questionnaires were sent to three groups of participants (CR, CD, and CS). Table I shows a breakdown of survey responses. According to Table I, out of 164 questionnaires distributed, 93 were returned, yielding a response rate of 56.7%.

TABLE I
QUESTIONNAIRE RESPONSES BY THREE GROUPS OF RESPONDENTS

Participants	No. of questionnaires		Response rate (%)	Proportion (%)
	distributed	returned		
Clients representatives	51	26	51.0	28.0
Consultants	45	22	48.9	23.6
Contractors	68	45	66.2	48.4
Total	164	93	56.7	100.0

C. Calculating the Mean Score and Relative Importance Index

Reference [9] used the mean score (*MS*) method with the Likert scale rating to evaluate construction project performance. This method was adopted in this study to analyse the data collected from the questionnaire survey. The respondents were asked to rate success factors believed to influence the success of a construction project by responding on a scale from 1 to 5. The five-point Likert rating scale was 1 = least important, 2 = slightly important, 3 = moderately important, 4 = very important, and 5 = extremely important. The mean score for each factor is calculated using:

$$MS = \frac{\sum(f \times s)}{N} \quad , \qquad (1 \leq \mathrm{MS} \geq 5), \tag{1}$$

where f is the frequency of responses to a rating, s is the score given to each factor by the respondents and ranges from 1 to 5, and N is the total number of respondents concerning that factor.

In addition to the mean score, the relative importance index (RII) was used to determine the respondents' perception of the relative ranking of the factors. The RII is evaluated as described by [13], [14] using:

$$RII = \frac{\sum W}{A \times N} \quad , \qquad (0 \leq \mathrm{RII} \geq 1), \tag{2}$$

where W is the weight given to each factor by the respondents and ranges from 1 to 5, A is the highest weight = 5, and N is the total number of respondents.

To explore the most CSFs, the "weighted average" (WA) of the MS and rankings over the nine broad categories and for the top 10 CSFs in each performance group were evaluated. The combination of three MS or RII used to calculate the WA was obtained from the sum of the results of the proportion of the questionnaires received from each group associated with the total number of respondents (n/N) as described by [9], [14]. The WA is computed using:

$$WA = \sum \left[\left(\frac{n}{N}\right) x \; MS \; (or \; RII) \right], \tag{3}$$

where n = 26 for the client representative group, n = 22 for the consultant group, n = 45 for the contractor, and N = 93.

D. Hypothesis Testing

Spearman's rank correlation is a nonparametric test used to measure any agreement in ranking of the performance group between different parties. In this study, the Spearman's rank correlation was used as in works by [9], [14], [15]. The Spearman's rank correlation coefficient for any two sets of rankings is calculated by:

$$rs = 1 - \frac{6 \sum_{i=1}^{n} d_i^2}{n(n^2-1)}, \tag{4}$$

where r_s is the Spearman rank correlation coefficient between two parties, d_i is the difference between ranks assigned to variables for each cause, and n is the number of pairs of rank. The correlation coefficient ranges from -1.0 to +1.0. The value of r_s close to 1 represents a strong positive correlation between the two variables, while the value of r_s close to -1 is a high negative linear relationship between the two variables [22].

To test the rank of the correlation coefficient, a *t-test* at a 95% confidence interval of the null hypothesis, H_0, was used. Significant testing can be summarized using the assumptions:

- H_0: There is an insignificant degree of agreement among the participants (client representatives, consultants, and contractors).
- H_1: There is a significant statistical degree of agreement among the participants.

The *t-test* is defined by:

$$t = rs\sqrt{\frac{n-2}{1-rs^2}}\ , \qquad (5)$$

To further investigate the data, we used analysis of variance (ANOVA) to determine whether there is a significant difference between the means of three groups of respondents on the most critical factors in each performance dimensions. A summary of the ANOVA test is as:

- H_0: There is no difference between the three groups of respondents on the perceived critical success factor.
- H_1: There is a difference between the three groups of respondents on the perceived critical success factor.

IV. Results and Discussion

A. Background of Respondents and Characteristics of Projects

Tables II and III provide a demographic profile of the survey respondents and characteristics of projects. As shown in Table II, 32.3% of the respondents were between 36 and 40 years old, and 29.0% were over 45 years old. In addition, half of the questionnaire participants (50.3%) held a critical role in a senior managerial position. These include managing director, executive vice president, project director, and project manager. Other participants were middle or line managers, such as production manager, design manager, and quantity surveying manager. Furthermore, the respondents had been in the construction business from a minimum of 5 years to more than 25 years. Thus, it can be inferred that the competency of the respondents was adequate for them to participate in the survey.

According to Table III, the majority of respondents (94.6%) had worked mostly in the private sector. Regarding the field of specialisation, residential and building projects accounted for 91.4 %. It is important to note that the vast majority of those facilities were concerned with high-rise building projects. Lump sum contracts (69.9%) were the most type of contract preferred by professionals. Design – bid – build was a favourable form of project delivery systems used by contracting agencies. In addition, the survey participants were involved in various sizes of construction projects.

TABLE II
Respondent Profiles

General Information	Frequency	Percentage
Age		
<30 years old	2	2.2
31–35 years old	17	18.3
36–40 years old	30	32.3
41–45 years old	17	18.3
46–50 years old	15	16.1
>50 years old	12	12.9
Job Title		
MD/DMD/Vice President	8	8.6
Project Director	10	10.8
Project Manager	38	30.9
Production Manager	10	10.8
QC/QS	5	5.4
Design Manager/Technical Manager	8	8.6
M&E	3	3.2
Others	11	11.8
Number of years working experience		
<5 years	-	-
5–10 years	9	9.7
10–15 years	32	34.4
15–20 years	25	26.9
20–25 years	14	15.1
>25 years	13	14.0

Note: MD=Managing Director, DMD=Deputy Managing Director, QC= Quality Control Manager, QS=Quantity Surveying Manager, M&E= Mechanical and Electrical Manager.

TABLE III
Characteristics of Projects

General Information	Frequency	Percentage
Type of business		
Public sector	5	5.4
Private sector	88	94.6
Field of specialisation		
Building construction	15	16.1
Residential construction	70	75.3
Heavy engineering construction	1	1.1
Industrial construction	7	7.5
Type of project delivery systems		
Design – bid – build	36	38.7
Design – build	30	32.3
Construction management	26	28.0
Public private partnership	1	1.1
Type of contract		
Lump sum contract	65	69.9
Unit price contract	18	19.4
CM – agent	3	3.2
Turnkey	6	6.5
Joint venture	1	1.1
Contract size		
Less than 3 million USD	7	7.5
3 – less than 15 million USD	14	15.1
15 – less than 30 million USD	11	11.8
30 – less than 45 million USD	15	16.1
45 – less than 60 million USD	13	14.0
60 – less than 75 million USD	11	11.8
75 – less than 90 million USD	1	1.1
More than 90 million USD	21	22.6

B. Procurement Related Critical Success Factors Influencing Construction Project Performance

1. Major Group

Table IV summarises the ranks, mean scores, and importance indices of nine major factor categories during the procurement phase, according to all groups of respondents.

Equations (1)–(3) are used for this purpose. According to Table IV, it can be concluded that the agreement on the importance of project performance varies among all target groups, and some performance groups are more significant than others. Cost, time, and quality performance were of interest to survey respondents. These significant criteria were ranked as the top three most important performance groups, with a weighted average RII equal to 0.811, 0.704, and 0.688, respectively. This finding is consistent with that of [14], who found cost performance is the most significant performance criteria during the procurement phase.

Cost performance is the most important group, particularly during the procurement phase because completing a project within the budget is fundamental for any successful project. Moreover, project cost overrun is of high concern because it occurs more frequently and it is a more severe problem than time overruns [23].

Time performance was ranked second by client representatives' respondents, with an RII equal to 0.754. This performance is a critical issue for the customer because time overruns means a loss of revenue through a lack of production facilities and rentable space or a dependence on present facilities [24].

Quality performance was ranked second by contractors' respondents, with an RII equal to 0.676. This performance is significant for contractors because the consequences of poor quality can be a loss in productivity, additional expenditure from rework and repair, and eventually, loss of reputation [25].

Client satisfaction was ranked fourth by all survey respondents. The satisfaction criterion is important for all interested parties because it is one of the measures that evaluate how products or services provided by a company meet or exceed a customer's expectations. Over the past decade, a number of companies have assessed their performance periodically through client satisfaction [26]. In addition, environment performance and health and safety performance were ranked eighth and ninth, respectively. This result implies that these groups are less likely to influence project performance than other criteria, particularly during the procurement phase.

2. Time Performance

Table V shows the ranks, mean scores, and relative importance indices of the top 10 CSFs for time performance. As shown in Table V, *proper procurement programming of materials* was ranked first by all groups of respondents, with a weighted average RII equal to 0.874. This key factor is observed as an essential element because poor procurement programming of materials occurs frequently and is one of the most significant contributing factors to causes of delays in construction projects [27]. This result is in line with many studies such as [13], [23].

Timely delivery of materials/equipment as planned was ranked second by all survey respondents, with a weighted average RII equal to 0.835. This factor is paramount because of the lack of storage space at construction sites. When materials are delivered too early, it results in double handling. Conversely, when materials or equipment is late in the supply, this sets back the project progress rate [28].

TABLE IV
SUMMARY OF MEAN SCORE, RANK, AND RELATIVE IMPORTANCE INDEX OF MAJOR GROUPS

Performance group	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Time	3.77	0.754	2	3.55	0.710	4	3.36	0.672	3	3.52	0.704	2
Cost	**4.00**	**0.800**	**1**	**4.05**	**0.810**	**1**	**4.09**	**0.818**	**1**	**4.06**	**0.811**	**1**
Quality	3.62	0.724	3	3.36	0.672	6	3.38	0.676	2	3.44	0.688	3
Health and safety	2.85	0.570	8	2.41	0.482	9	2.51	0.502	9	2.58	0.516	9
Environment	2.73	0.546	9	2.73	0.546	8	2.51	0.502	8	2.62	0.525	8
Productivity	3.27	0.654	5	3.09	0.618	7	3.04	0.608	6	3.12	0.623	6
Risk management	3.27	0.654	6	3.68	0.736	3	3.13	0.626	5	3.30	0.660	5
Human resource	2.85	0.570	7	3.45	0.690	5	2.96	0.592	7	3.05	0.609	7
Client satisfaction	3.35	0.670	4	3.77	0.754	2	3.33	0.666	4	3.44	0.688	4

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

TABLE V
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR TIME PERFORMANCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Proper procurement programming of materials	4.31	0.862	2	**4.23**	**0.846**	**1**	**4.47**	**0.894**	**1**	**4.37**	**0.874**	**1**
Timely delivery of materials/equipment as planned	**4.31**	**0.862**	**1**	3.59	0.718	16	4.38	0.876	2	4.17	0.835	2
Top management's enthusiastic support	4.04	0.808	3	3.82	0.764	7	4.02	0.804	3	3.98	0.796	3
Mode of financing and payment for completed work	4.04	0.808	4	3.77	0.754	9	3.96	0.792	4	3.94	0.787	4
Project participants competence	3.85	0.770	5	3.86	0.772	4	3.91	0.782	5	3.88	0.776	5
Adequate experience of project participants	3.73	0.746	10	3.73	0.746	10	3.76	0.752	6	3.74	0.749	6
Adequacy of communication and coordination among parties	3.81	0.762	6	3.95	0.790	2	3.60	0.720	10	3.74	0.748	7
Realistic project time imposed in contract duration	3.81	0.762	6	3.91	0.782	3	3.60	0.720	11	3.73	0.746	8
Completeness of design documents	3.65	0.730	14	3.86	0.772	4	3.71	0.742	8	3.73	0.746	9
Commitment and involvement of all parties to the project	3.69	0.738	12	3.59	0.718	15	3.73	0.746	7	3.69	0.737	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

Top management's enthusiastic support was ranked third by all survey respondents, with a weighted average RII equal to 0.796. High-level top management support in providing necessary resources and authority helps to cross organisational boundaries and during restructuring activities [29].

3. Cost Performance

Table VI shows the ranks, mean scores, and relative importance indices of the top 10 CSFs of cost performance. As shown in Table VI, *stability in the price of materials* was ranked first by all groups of respondents, with a weighted average RII equal to 0.860. The contractor group also ranked it first, with an RII equal to 0.894. This finding suggests that this factor is more important to contractors than others because the acceleration of material prices affects the profit rate of entrepreneurs [13]. In addition, this finding is consistent with results found by [30], who indicated that the fluctuation of prices of materials is the key factor leading to high construction costs.

Effective project cost control mechanisms was ranked second, with a weighted average RII equal to 0.847. Budget baseline, cost variance, and cash flow analysis are among the most frequently used cost control techniques. A study conducted by [31] indicated that better cost performance is associated with the utilisation of those control techniques to determine any deviation from the original value.

Competitive tendering process was ranked third by all survey respondents, with a weighted average RII equal to 0.845. Competitive tendering is a significant stage in the procurement process. It allows the client to select the most qualified bidders not only for the bid price but also with strong technical strength, enough operation experience, and advanced management skills [32]. To summarise, failure to put in place competitive tendering in the process results in a high potential for a loss of value.

4. Quality Performance

Table VII summarises the ranks, mean scores, and relative importance indices of the top 10 CSFs of quality performance. According to Table VII, *determining quality in construction* was ranked first by all groups of respondents, with a weighted average RII equal to 0.767. It was also viewed in a similar way by the consultant group. Contractors play a significant role in determining the quality of a project. Their primary contribution is the standard of workmanship and conformance to specifications [33].

Conformance to specification was ranked second by all survey respondents, with a weighted average RII equal to 0.761. This factor is important because it is related to client satisfaction. Owners usually seek to implement their projects according to required specifications [13]. When products or services fail to comply with established specifications, quality will not be delivered successfully. Likewise, a defect denotes non-conformity of the facility at the time of handing over [34].

TABLE VI
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR COST PERFORMANCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Stability in the price of materials	4.04	0.808	3	4.27	0.854	2	**4.47**	**0.894**	**1**	**4.30**	**0.860**	**1**
Effective project cost control mechanisms	3.96	0.792	4	4.14	0.828	5	4.44	0.888	2	4.23	0.847	2
Competitive tendering process	4.19	0.838	2	4.23	0.846	3	4.24	0.848	3	4.22	0.845	3
Adequate tender sum	**4.42**	**0.884**	**1**	**4.41**	**0.882**	**1**	3.93	0.786	7	4.18	0.836	4
Certainty of cash flow of the project	3.92	0.784	7	4.18	0.836	4	4.20	0.840	4	4.12	0.823	5
Mode of financing and payment for completed works	3.92	0.784	6	3.95	0.790	10	3.98	0.796	5	3.96	0.791	6
Adequate experience of project participants	3.81	0.762	9	4.00	0.800	8	3.80	0.760	9	3.85	0.770	7
Completeness of design documents	3.85	0.770	8	4.05	0.810	7	3.71	0.742	13	3.83	0.766	8
Effective contract administration and management	3.77	0.754	11	4.09	0.818	6	3.69	0.738	14	3.81	0.761	9
Adequacy of scopes and specifications	3.73	0.746	12	3.95	0.790	9	3.76	0.752	11	3.80	0.759	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

TABLE VII
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR QUALITY PERFORMANCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Determining quality in construction	3.65	0.730	11	**4.09**	**0.818**	**1**	3.82	0.764	2	**3.84**	**0.767**	**1**
Conformance to specification	3.77	0.754	4	4.09	0.818	2	3.69	0.738	4	3.81	0.761	2
Competency of the project manager	3.77	0.754	3	3.64	0.728	15	3.80	0.760	3	3.75	0.751	3
Adequate communication among related parties	3.85	0.770	2	3.77	0.754	6	3.62	0.724	9	3.72	0.744	4
Top management sponsorship to project team	3.46	0.692	17	3.73	0.746	7	**3.87**	**0.774**	**1**	3.72	0.744	5
Effective cooperation between parties taking part in the project	3.73	0.746	5	3.68	0.736	11	3.67	0.734	6	3.69	0.738	6
Commitment and involvement of all project participants	**3.88**	**0.776**	**1**	3.64	0.728	13	3.60	0.720	11	3.69	0.738	7
Availability of competent staff	3.62	0.724	12	3.82	0.764	4	3.64	0.728	7	3.68	0.735	8
Effective teamwork to promote quality issues in the project	3.65	0.730	9	3.68	0.736	9	3.58	0.716	13	3.62	0.725	9
Management commitment to continual quality improvement	3.69	0.738	7	3.55	0.710	16	3.60	0.720	10	3.61	0.723	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

Competency of the project manager was ranked third by all survey respondents, with a weighted average RII of 0.751. This result proves to be closer to [25], who found that a project manager's competence, such as technical capability and effective leadership, is observed to be the most significant factor at almost all levels of the quality performance rating.

5. Health and Safety Performance

Table VIII summarises the ranks, mean scores, and relative importance indices of the top 10 CSFs of health and safety performance. As shown in Table VII, *safety equipment acquisition and maintenance* was ranked first by all groups of respondents, with a weighted average RII of 0.727. This critical factor is observed as an essential element because its proper provision results in an effective safety programme, leading to a small number of the incidents occurring on the construction project [35].

Top management support was ranked second, with a weighted average RII of 0.714. This finding concurs well with [36], who indicated that demonstrating a genuine interest in employees' safety is the management's active role that in turn helps to promote a positive attitude among the project team. In addition, the willingness of top management to support authority and resources helps in crossing administrative restrictions and streamlining activities [29].

Adequacy of budget allocated for safety was ranked third, with a weighted average RII of 0.647. The amount of budget allocated to safety is one of the project expense components. At the outset of the project, a clearly defined, complete budget for safety initiatives stated in the contract helps the project's health and safety programme to run smoothly. In contrast, budget constraints can affect the safety promotion programme [37], resulting in poor a health and safety culture.

6. Environment Performance

Table IX shows the ranks, mean scores, and relative importance indices of the top 10 CSFs of environment performance. As shown in Table IX, *budgeting allowed in a contractual arrangement for implementing environmental management activities* was ranked first by all groups of respondents, with a weighted average RII of 0.669. It was ranked at the same position by all parties as the first one. This factor is crucial because budgeting is of considerable concern to all project participants and is part of the project planning process to accomplish the initially developed objectives.

Utilisation of up-to-date technology was ranked second, with a weighted average RII of 0.633. This factor is important because the use of new tools and equipment helps to minimise the risks from hazards and environmental pollution to public health within a long-term policy. In addition, this finding is scarcely distinguishable from [38], who indicated that possession of modern technology is a critical factor for success in today's business. It provides a company with competitive opportunities and advantages in the marketplace [39].

TABLE VIII
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR HEALTH AND SAFETY PERFORMANCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Safety equipment acquisition and maintenance	**3.62**	**0.724**	**1**	**3.64**	**0.728**	**1**	3.64	0.728	2	**3.63**	**0.727**	**1**
Top management support	3.46	0.692	2	3.45	0.690	2	**3.69**	**0.738**	**1**	3.57	0.714	2
Adequacy of budget allocated for safety	3.12	0.624	5	3.41	0.682	3	3.22	0.644	4	3.24	0.647	3
Positive personal attitude of project participants towards safety management	3.23	0.646	4	3.32	0.664	4	3.18	0.636	5	3.23	0.645	4
Sufficient safety resource allocation	3.04	0.608	9	3.05	0.610	7	3.22	0.644	3	3.13	0.626	5
Effective coordination, control and management of sub-contractors	3.31	0.662	3	2.73	0.546	18	3.04	0.608	8	3.04	0.608	6
Proper planning and organising of safety working environment on site	3.12	0.624	6	2.95	0.590	9	3.02	0.604	9	3.03	0.606	7
Interrelation between the employee and supervisor	3.00	0.600	12	2.91	0.582	11	3.11	0.622	6	3.03	0.606	8
Implementation of safety management system by legislation	3.04	0.608	8	3.09	0.618	6	2.96	0.592	13	3.01	0.603	9
Historic, human and psychological climate	2.92	0.584	14	2.86	0.572	13	3.04	0.608	7	2.96	0.593	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

TABLE IX
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR ENVIRONMENT PERFORMANCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Budgeting allowed in a contractual arrangement for implementing environmental management activities	**3.35**	**0.670**	**1**	**3.41**	**0.682**	**1**	**3.31**	**0.662**	**1**	**3.34**	**0.669**	**1**
Utilisation of up-to-date technology	3.08	0.616	2	3.00	0.600	8	3.29	0.658	2	3.16	0.633	2
Adequacy of cooperation among project participants	2.88	0.576	9	3.32	0.664	2	3.11	0.622	6	3.10	0.619	3
Sufficient auditing activities	3.00	0.600	7	3.23	0.646	3	3.07	0.614	8	3.09	0.618	4
Use of environmentally friendly equipment	3.00	0.600	8	2.95	0.590	11	3.18	0.636	3	3.08	0.615	5
Involvement of environmental management initiatives by management	3.08	0.616	3	3.14	0.628	5	3.04	0.608	9	3.07	0.615	6
Effective supervision among project parties	3.04	0.608	5	2.95	0.590	10	3.13	0.626	4	3.06	0.612	7
Involvement by clients on environmental management plan	3.04	0.608	4	2.91	0.582	12	3.13	0.626	5	3.05	0.611	8
Use of modular materials in the project	3.00	0.600	6	3.05	0.610	7	3.07	0.614	7	3.05	0.609	9
Sufficient provision of environmental management training to all staff	2.85	0.570	11	3.18	0.636	4	3.00	0.600	10	3.00	0.600	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

TABLE X
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR PRODUCTIVITY

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Completeness of drawing documents	**3.88**	**0.776**	**1**	**3.91**	**0.782**	**1**	**3.73**	**0.746**	**1**	**3.81**	**0.763**	**1**
Availability of construction materials	3.38	0.676	6	3.86	0.772	2	3.69	0.738	2	3.64	0.729	2
Competent supervisors	3.50	0.700	3	3.73	0.746	3	3.56	0.712	6	3.58	0.717	3
Adequate communication among related parties	3.50	0.700	3	3.50	0.700	8	3.64	0.728	3	3.57	0.714	4
Clear and timely inspection	3.46	0.692	5	3.55	0.710	5	3.62	0.724	4	3.56	0.712	5
Effective planning and scheduling	3.54	0.708	2	3.55	0.710	6	3.56	0.712	6	3.55	0.710	6
Specification and standardisation	3.35	0.670	7	3.64	0.728	4	3.56	0.712	8	3.52	0.704	7
Availability of skilled worker	3.31	0.662	8	3.45	0.690	12	3.51	0.702	9	3.44	0.688	8
Effective site management and supervision	3.19	0.638	11	3.50	0.700	9	3.51	0.702	10	3.42	0.684	9
Management-labor relationship	3.27	0.654	9	3.45	0.690	11	3.44	0.688	11	3.39	0.679	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

TABLE XI
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR RISK MANAGEMENT

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Accurate measurement and pricing of bill of quantities	4.08	0.816	2	**4.23**	**0.846**	**1**	**4.18**	**0.836**	**1**	**4.16**	**0.833**	**1**
Certainty of the cash flow of the project	4.00	0.800	3	3.91	0.782	5	4.04	0.808	4	4.00	0.800	2
Timely payment on contract and extra work	3.88	0.776	7	3.91	0.782	6	4.09	0.818	3	3.99	0.798	3
Financial stability of project participants	**4.23**	**0.846**	**1**	3.86	0.772	8	3.87	0.774	7	3.97	0.794	4
Availability of funds as planned throughout the project duration	3.88	0.776	6	4.00	0.800	3	4.00	0.800	5	3.97	0.793	5
Absence of defective materials	3.88	0.776	4	3.73	0.746	12	4.11	0.822	2	3.96	0.791	6
Effective control of third party delays	3.88	0.776	5	3.50	0.700	16	4.00	0.800	6	3.85	0.770	7
Accurate anticipation of exchange rate fluctuation and Inflation	3.81	0.762	9	4.14	0.828	2	3.69	0.738	9	3.83	0.766	8
Completeness of design documents	3.73	0.746	10	3.95	0.790	4	3.73	0.746	8	3.78	0.756	9
Adequacy of communication and coordination among parties	3.81	0.762	8	3.73	0.746	13	3.64	0.728	12	3.71	0.742	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

Adequacy of cooperation among project participants was ranked third, with a weighted average RII of 0.619. Success in implementing environmental management activities requires participants to be part of the same team and work closely together to solve problems and make process improvements. This result corroborates the study of [40] which showed that lack of subcontractor cooperation and lack of client support are the major barriers to implementing environmental management in construction projects.

7. Productivity

Table X summarises the ranks, mean scores, and relative importance indices of the top 10 CSFs of the productivity group. As shown in Table X, *completeness of drawing documents* was ranked first for all parties, with a weighted average RII equal to 0.763. This factor is crucial because it has a high impact on productivity, with incomplete drawing documents preventing a project from progressing smoothly because of delays to revisions or clarification of drawings and specifications [41].

Availability of construction materials was ranked second by all survey respondents, with a weighted average RII of 0.729. Managing materials is essential for achieving desired productivity and is considered as a critical factor for project success. Frequently, the type and quantity of materials needed for the project are specified explicitly in the design and specification documentation with the material purchasing schedule. However, work cannot be conducted without necessary materials that are available on the market. This result is consistent with many researchers [41]–[43] who have indicated that many projects are either on hold or behind schedule because of difficulties in obtaining construction materials, resulting in low productivity and the possibility of project delays.

Competent supervisor was ranked third, with a weighted average RII of 0.717. This critical factor is observed as an essential element because supervisors handle monitoring and enforcing proper key controls to ensure that the quality of production meets that in the works specification. Many previous studies concluded that this is a critical factor that influences productivity in the construction industry [41], [43]–[45].

8. Risk Management

Table XI shows the ranks, mean scores, and relative importance indices of the top 10 CSFs of risk management. As shown in Table XI, *accurate measurement and pricing of bill of quantities (BoQ)* was ranked first by consultant and contractor groups, with a weighted average RII equal to 0.833. The schedule of prices may comprise a series of quantities and rates. It is important to the consultant as the third party,

particularly in the tendering process, because the BoQ can be used as a tool for analysing a reasonably fair price of tenders submitted [46] and helps to prevent risk from the fluctuation of prices within the contract. In addition, it is of benefit to the contractor on the basis of payment.

Certainty of the cash flow of the project was ranked second, with a weighted average RII of 0.800. Project cash flow is of the greatest concern to all interested parties. According to [47], projects that fail to generate income may create cash flow difficulties for owners, resulting in delayed payments to support expenses, especially for contractors.

Timely payment on contract and extra work was ranked third, with a weighted average RII of 0.798. It is central to the project that clients have adequate project finance for both contract sum and variation work. In addition, timeliness of the client's payment is the primary expectation of all parties concerned. This level of importance concurs with the study by [48], who indicated that owners need to focus on the responsibility for making payments on time to contractors as a practical solution to eliminate delays in the project.

9. Human Resource

Table XII shows the ranks, mean scores, and relative importance indices of the top 10 CSFs of the human resource group. As shown in Table XII, *adequate communication among the project team* was the most significant factor in human resource during the procurement phase. It was ranked first by all groups of respondents, with a weighted average RII equal to 0.715. Communication concerns the sufficiency of communication channels and their effectiveness to provide adequate information between various groups and levels involved in a project [10]. This result proves to be closer to [14], who remarked that construction is a people business and thus, communication is the key to a successful project.

Need for collaboration was ranked second by all survey respondents, with a weighted average RII equal to 0.707. The project team comprises large numbers of participants with diverse knowledge and skills. A successful project requires the strong collaboration and commitment of those interested parties. Contractors, consultants and client representatives need to work together in partnership to ensure that project objectives are achieved. In addition, this factor helps to create mutual trust and improves the quality of products or services for the project.

Adequacy of compensation level was ranked third, with a weighted average RII of 0.705. Sufficient financial compensation is essential for all parties. Financial shortage in the payment to the contractor, for instance, may cause slow work activities and consequently, result in delays to the completion of the project.

10. Client Satisfaction

Table XIII shows the ranks, mean scores, and relative importance indices of the top 10 CSFs of client satisfaction. As shown in Table XIII, *adequate cost control measures* was ranked first as the most important for both client and contractor groups, with a weighted average RII equal to 0.804.

TABLE XII
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR HUMAN RESOURCE

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Adequate communication among the project team	3.38	0.676	4	3.68	0.736	9	3.64	0.728	2	**3.58**	**0.715**	**1**
Need for collaboration	3.38	0.676	3	3.82	0.764	2	3.49	0.698	3	3.54	0.707	2
Adequacy of compensation level	3.23	0.646	9	3.64	0.728	12	**3.64**	**0.728**	**1**	3.53	0.705	3
Legal requirement/compliance	3.35	0.670	5	**3.86**	**0.772**	**1**	3.40	0.680	11	3.49	0.699	4
Availability of employee motivation system	**3.50**	**0.700**	**1**	3.68	0.736	7	3.36	0.672	17	3.47	0.695	5
Commitment of the project team	3.42	0.684	2	3.55	0.710	15	3.44	0.688	7	3.46	0.692	6
Spirit of cooperation among project team	3.27	0.654	7	3.77	0.754	6	3.42	0.684	9	3.46	0.692	6
High efficiency of project organisation	3.19	0.638	11	3.77	0.754	4	3.42	0.684	8	3.44	0.688	8
Availability of skilled personnel	3.31	0.662	6	3.50	0.700	18	3.47	0.694	6	3.43	0.686	9
Proper administration and disciplinary procedures to all employees	3.19	0.638	10	3.45	0.690	19	3.47	0.694	4	3.39	0.677	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

Clients are always satisfied when their perceptions of the product or service match or exceed their expectations. This finding concurs well with [26], [49], who indicated that employing adequate cost control measures to manage and control project costs so that they stay within the project budget is considered to be the important factor for client satisfaction.

Accurate project cost estimates in accordance with plans and specifications was ranked second by all survey respondents, with a weighted average RII equal to 0.796. This factor is important to both consultants and contractors. For the consultant, it helps to control project-purchasing decisions, specify the approaches, and identify potential contractors. For the contractor, this factor helps to determine and control monetary resources to complete project activities [50].

Professionalism of services of the project team was ranked third, with a weighted average RII of 0.761. This factor is crucial for the client because proactive attitudes towards attaining professionalism of service and delivering faithful service to the customer the first time are much more valued by the customer than active measures taken to remedy drawbacks after their occurrence [51].

TABLE XIII
SUMMARY OF MEAN SCORE, RANK AND RELATIVE IMPORTANCE INDEX OF CSFS FOR CLIENT SATISFACTION

Critical individual factor	Client representatives			Consultants			Contractors			Weighted average		
	MS	RII	R	MS	RII	R	MS	RII	R	MS	RII	R
Adequate cost control measures	**3.85**	**0.770**	**1**	4.00	0.800	2	**4.13**	**0.826**	**1**	**4.02**	**0.804**	**1**
Accurate project cost estimates in accordance with plans and specifications	3.65	0.730	9	**4.14**	**0.828**	**1**	4.09	0.818	2	3.98	0.796	2
Professionalism of services of project team	3.77	0.754	3	3.86	0.772	6	3.80	0.760	4	3.81	0.761	3
Timeliness of service	3.69	0.738	6	3.82	0.764	10	3.80	0.760	3	3.77	0.755	4
Effective coordination between client and project parties	3.73	0.746	4	3.82	0.764	9	3.73	0.746	5	3.75	0.750	5
Completeness of product/service	3.73	0.746	5	3.95	0.790	3	3.64	0.728	9	3.74	0.748	6
Effective planning and scheduling of the project	3.62	0.724	11	3.82	0.764	13	3.69	0.738	8	3.70	0.740	7
Participation and commitment of the project teams	3.65	0.730	8	3.73	0.746	17	3.69	0.738	7	3.69	0.738	8
Good communication at all level	3.81	0.762	2	3.82	0.764	10	3.56	0.712	15	3.69	0.738	9
Client orientation	3.62	0.724	12	3.68	0.736	20	3.71	0.742	6	3.68	0.736	10

Note: MS = Mean Score, RII = Relative Importance Index, R = Rank

C. Degree of Agreement among the Respondent Groups

In this study, Spearman's rank correlation was used to determine whether there was a significant level of agreement among the three groups of participants including CR, CD, and CS. Equations (4) and (5) were used for this purpose.

Table XIV shows the degree of agreement between any two groups of project participants with respect to the ranking of the nine major performance categories during the procurement phase. The results of the computation of Spearman's rank correlation coefficients indicate that there is a strong positive degree of agreement between client representatives and contractors, with a coefficient of 0.950 (p = 0.000), between client representatives and consultants, as well as between consultants and contractors with a coefficient of 0.700 (p = 0.036) and 0.750 (p = 0.020), respectively.

TABLE XIV
SPEARMAN RANK CORRELATION BETWEEN PARTICIPANTS FOR NINE MAJOR PERFORMANCE GROUPS

Participants	*rs*	*t*	Reject *Ho*?	Significance (2-tailed)
Clients representatives and consultants	0.700	2.593	Yes	0.036*
Consultants and contractors	0.750	3.000	Yes	0.020*
Client representatives and contractors	0.950	8.050	Yes	0.000**

Note: *rs*=Spearman's rank correlation coefficient; *t* = *t*-statistics;
H_0 = null hypothesis; * Correlation is significant at the 0.05 level (2-tailed);
** Correlation is significant at the 0.01 level (2-tailed).

D. Analysis of Variance (ANOVA)

ANOVA was used to investigate the perception of survey participants on the most CSFs. A one-way ANOVA test was performed to determine whether the mean scores among the various groups of respondents were statistically significant.

Table XV shows the results of the ANOVA, analysed using the SPSS, for the most CSFs in each performance group. At a 95% confidence interval, the null hypothesis, H_0, is accepted because the significance level is greater than 0.05 in each case. Therefore, it can be inferred that all groups of survey respondents (CR, CD, and CS) share the same opinion on the importance of the most CSFs that influence the performance of the project during the procurement phase.

TABLE XV
ANOVA TEST ON THE MOST CRITICAL SUCCESS FACTORS

Performance Group	Critical success factors	*F*	*Sig*
Time	Proper procurement programming of materials	0.527	0.592
Cost	Stability in price of materials	1.701	0.188
Quality	Determining quality in construction	0.922	0.402
Health and safety	Safety equipment acquisition and maintenance	0.005	0.995
Environment	Budgeting allowed in implementing environmental management activities	0.056	0.946
Productivity	Completeness of drawing documents	0.256	0.775
Risk management	Accurate measurement and pricing of bill of quantities	0.124	0.883
Human resource	Adequate communication among the project team	0.580	0.562
Client satisfaction	Adequate cost control measures	0.875	0.420

V. LIMITATIONS AND SUGGESTIONS FOR FUTURE DIRECTIONS

Successful project management is a challenging matter and involves many issues with a variety of factors. Identification of CSFs at the outset of the project can help project participants to define significant factors that should be given special attention to ensure the success of the project. Moreover, CSFs can be considered to be a means to improve the effectiveness of the project through the entire phase of the project life cycle. This paper provides insight into the CSFs influencing construction project performance for different objectives, focusing on the procurement phase in the framework of project management. However, the current study was limited to capturing the perception of professionals and practitioners on CSFs only in the context of the Thai construction industry. As a result, the findings might not be generalised to other countries' economies. In future research, it would be interesting to ascertain and compare the perceived CSFs across countries. A number of possible future studies using proposed approach are also strongly recommended. More information on this field would help us to establish a greater degree of agreement on the CSFs influencing the project performance for different objectives in the construction industry.

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