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RESEARCH PAPER

The Major Causes of Construction Delays Identified Using the Delphi Technique: Perspectives of Contractors and Consultants in Thailand

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Abstract

At present, in the Bangkok Metropolitan Area of Thailand, numerous construction projects are in process or have recently been brought to completion. In pursuing this work, contractors regularly face construction delay problems, many of which are likely to have been avoidable. The research objective is to survey and prioritize the factors leading to construction delays from the perspective of both the consultants and the contractors. Data were collected via a survey instrument and the Delphi technique was used as the research methodology. To identify the factors that lead to construction delays relevant to the study context, a panel of experts comprising 18 construction public company leaders and 17 project engineers and 17 project consultants, 1 from each of the largest construction contractor and consultant companies in Thailand, and 20 academics in the field of construction were invited to share their opinions. Eventually, 13 factors leading to construction delays were identified from the data collected from the expert panel. A questionnaire was generated using a Likert scale with a range of 1–5 based on the factors suggested by the experts' opinions. A total of 17 respondents from the contractor companies and 17 respondents from the consultant companies responded to the questionnaire. The numeric value of the responses was computed using the Delphi technique. The responses reached constancy at the second round of data collection. According to the statistical analysis, a Shortage of qualified labor was the most important factor leading to construction delays, according to both the contractors' and the consultants' perspectives with a mean value of 4.65 and 4.53, respectively. Change orders made by owners were the second most important factor according to both the contractors and the consultants with a mean value of 4.24 and 4.28, respectively. In addition, insufficient financial liquidity on the part of the contractor ranked as the third most important reason according to both the contractors and the consultants with a mean value of 4.18 and 4.12, respectively. The outcomes are applicable to the causes of construction delay in the Bangkok Metropolitan Area of Thailand, but may not be applicable to other settings. A review of the literature suggests significant differences in relation to such matters as the regulatory environment, societal practices and expectations, economic considerations, the environment, technology, and religion across settings may have an impact on what causes construction delays.

Keywords Delphi technique · Contractors · Consultants · Construction delay · Construction

1 Introduction

Many countries are experiencing economic growth, and the economic prosperity of large cities is spreading to smaller towns in rural areas. In this context, new construction projects have emerged at an accelerated rate to support a higher standard of living for the relatively wealthy living in urbanized areas [1]. Many people have moved from rural to urbanized areas for work to secure a higher income. As a result, it is the responsibility of relevant parties from the public and the private sectors to build construction

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facilities to support growing demand from urban populations [2]. New construction projects, for instance, residences, shopping malls, and public transportation, have been built in an effort to meet that demand. Construction companies have attempted and failed to successfully handle many projects of various sizes simultaneously given the challenges of juggling responsibilities and resources to complete work on schedule. In particular, large construction projects in urban areas often suffer from delays during construction and in these cases such delays are considered a high-priority issue. Many construction companies have been fined by project owners for exactly this reason [3]. Some construction contractors have even abandoned projects in the face of significant fines at the risk of losing their credibility and thus of undermining their chances of securing new contracts. Many factors can be implicated in construction delays [4]. For example, large-scale business and residential construction projects in dense urban areas are subject to multiple and complex factors that can cause construction delays [5], among which are changes in regulations and the environment [6] and the need to use new and unfamiliar construction technology. The construction delay problem is, thus, relatively complex and depends on many factors, which differ depending on the context.

There are currently many construction projects under way in the Bangkok Metropolitan Area of Thailand, some of which are owned by government agencies and others by the private sector. The kinds of projects most likely to have construction delays in the Bangkok Metropolitan Area are large-scale in nature, such as shopping centers and high-rise residential buildings [4]. In general, regardless of the kind of project, delays are perceived as arising from multiple causes, including inconvenient foreign labor laws and construction regulations, accustomed by compromising owners [7], and an inability on the part of contractors to use modern construction tools [8]. Moreover, traffic congestion and dense urban building in the area are also considered to be contributing factors.

In regard to some of the key players in executing large-scale construction projects, the contractor and the consultant each plays a pivotal role. Project engineers employed by the contractor and consultant play important roles and gain deep experience related to project time line [9]. Therefore, they are valuable sources of information in relation to determining the factors most implicated in construction delays.

The author of the present study saw construction delay as a significant waste of financial and time resources for every party involved and with this preliminary research seeks to establish a basis for minimizing or even avoiding delays altogether to prevent such losses from continuing. The author, therefore, undertook the research reported herein with the idea that construction delays should be avoidable and manageable [10]. Hence, the objective of this research is to identify the factors most implicated in leading to construction delays according to the perspectives of consultants and contractors. The data for analysis were collected via a questionnaire instrument administered to appropriate respondents [11], comprising consultant and contractors from the 17 largest contractor and consultant companies for construction in the Bangkok Metropolitan Area. The questionnaire was sent to a project engineer at each company by face to face interview.

To prioritize the factors leading to construction delays, the Delphi technique was used to analyze the data as collected from the empirical perspectives of the contractors and consultants. This technique is widely used in business planning forecasts [12], and many researchers have used it successfully in construction management contexts. The concept of this method is as follows. (i) An expert panel comprising 5–20 experts is recruited from various parties related to the main topic. (ii) The data are calculated to find the average, mean, and mode values, as well as the quartile range. (iii) The outcome is checked to establish the consensus value: the experts are polled until their responses show constancy. (iv) The final results are forecast to the main point for decision [13]. The Delphi method is a predictive tool that can be used to facilitate executive decision making. The method relies on an iterative process to obtain data from experts. Some researchers may send questionnaires or conduct interviews multiple times until the experts' answers reach consensus and become stable. The Likert scale questionnaire with a range of 1–5 was adopted in this research [14]. Hence, this method is appropriate and reliable for research purpose [15].

The results of this research, i.e., the identification and prioritization of the major factors leading to construction delays in the Bangkok Metropolitan Area can provide a basis for positive change in the construction industry in Thailand. Specifically, construction contractors, consultants, and project owners can all benefit from knowing which factors to be most cognizant of and which to consider most carefully in relation to taking appropriate preventive steps so that they do not threaten the timely delivery of any given construction project.

2 Relevant Literature Review

Delays in construction projects are considered a major problem given that they inconvenience both project owners and construction contractors, involving both parties in financial loss and necessitating new plans and schedules to be drawn up. In a more specific sense, construction contractors may find themselves paying fines for delays, and it is worth noting that those fines are then not sufficient to

ensure that contractors remain on schedule. The factors leading to construction delays vary across countries and even among cities in a given country. Societal, economic, environmental, and regulatory differences, together with relative adaptability to new construction technology, are held to be responsible for differences in the factors most implicated in construction delays [6, 16]. The literature includes accounts from key professionals and related parties responsible for managing aspects of a construction project and their views on the factors that cause delays. The results suggest that delays arise from multiple factors. Construction contractors, consultants, owners or clients have direct and rich experience relevant to construction delays and should, therefore, be treated as valuable sources of data pertaining to the factors that lead to construction delays [7]. In particular, contractors and consultant project engineers experienced these problems extensively in real situations [17]. Therefore, the factors suggested by these respondents were added to the list of questions in the questionnaire. In addition, factors obtained directly from the database in the reviewed literature were also included in the questionnaire [18]. The data were collected either by direct interview or questionnaire correspondence with respondents with expertise either as practitioners in the construction industry or as researchers in the field [10]. The questionnaire responses were collected and analyzed using various tools, and statistical computation was used for the data analysis [9].

Construction delays constitute a problem that numerous countries have in common. Thus, the literature includes studies with surveys used as the data-collection instrument with the goal of determining the factors that lead to construction delays in many countries. The factors found differed considerably across countries. In a study focused on India, which relied on a 45-construction-delay-factor questionnaire administered to clients, contractors, and designers, late delivery of materials was reported as the most important factor leading to construction delays [19]. For a survey study in Saudi Arabia with a 73-factor questionnaire and a sample of 15 project owners, 23 contractors, and 19 consultants on large construction projects, the results indicated that change orders made by the project owner constituted the major factor leading to construction delays [20]. Poor planning on the part of the contractor was reported as a major factor leading to construction delays in Malaysia based on a 28-factor questionnaire with answers from 150 consultants, contractors, and clients in the construction industry [21]. A lack of financial liquidity on the part of the contractor was identified as a major factor leading to construction delays in Saudi Arabia's public construction work, for which 211 people in the industry provided responses to a 50-factor questionnaire [22]. A university in north Saudi Arabia employed a 27-factor questionnaire based on the opinions of a university director who was in charge of a construction project. The questionnaire was applied to case studies, and nine major factors were identified as being principally responsible for construction delays: delays in checking design documents, late progress payments to the contractor, poor performance by the contractor, an under-qualified contractor, an inexperienced contractor, inadequate human resources, a shortage of consultant staff, material transport issues, and bidder process issues [8]. According to a research study conducted in Ghana based on a 37-factor questionnaire administered to architects, site and project managers, quantity surveyors, land economists, and civil, structural, and mechanical engineers, delayed payment to contractors and suppliers was the key factor leading to construction delays [23]. According to a study conducted in Egypt, inexperience on the part of the construction consultant is the most important factor contributing to construction delays. In that study, a 99-factor questionnaire developed based on the opinions of construction experts was administered to respondents comprising representatives of and specialists from private construction enterprises [24]. According to the results of a study conducted in four cities in the Republic of Benin, poor financial ability on the part of the contractor constituted the major factor leading to construction delays. The researchers designed the questionnaire by interviewing experts associated with numerous construction projects. The experts' opinions were used to generate a questionnaire, which was subsequently administered to a sample of respondents consisting of owners, contractors, architects, and consultants [25]. A study in Pakistan was carried out with a 27-factor questionnaire developed in reference to the opinions of professional construction experts and administered to a sample of customers, consultants, and contractors involved in 50 construction projects. In this study, domestic politics was of prime importance in bringing about construction delays, for example, political protests [6], terrorism, and other domestic politics-related matters [26]. According to a study focused on Australia, the climate is a major factor leading to construction delay [27] such that rain or snow causes construction delays because planned work cannot take place in those conditions. In a study on a residential construction project in Jordan, with respondents comprising contractors, consultants, and the project owners, change orders from the project owner and the contractor's limited financial liquidity were found to be the main factors contributing to construction delays [5]. Researchers in China focused on establishing the main contributing factors to construction delays in the four cities of Shanghai, Beijing, Shenzhen, and Chongqing. The sample consisted of 115 contractors, consultants, and clients associated with various building construction projects who responded to a 37-factor

questionnaire. The results were dissimilar across the cities given that they were situated far apart from each other and in vastly different environments [28]: In Shanghai, the major contributing factor was the acceptance of low bids; in Beijing, late progress payments; in Shenzhen, communication problems [29]; and in Chongqing, poor subcontractor performance [30]. For a study on Lebanon, researchers developed and administered a survey to 11 owners, 10 architect/engineers, and 15 contractors to determine what they considered to be the major causes of construction delays. The questionnaire comprised 64 causes of delay grouped into ten core themes. The owners were of the opinion that a cash flow problem was the major contributing factor to construction delays; the design architect/engineers pointed to the unavailability of the blueprint as the main cause; and the contractors took the view that changes to the project design and procrastination over making decisions on the part of owners constituted the chief cause [31]. According to a study in Iran, a lack of skilled workers, poor management skills on the part of supervisors, and inaccurate assessments of the workload and the equipment needed were the main factors driving construction delays [3]. In addition, in a literature review of 47 articles in which 1,057 causes of construction delay are covered, 80% of the factors implicated were related to the process, labor conflicts [32], and the administration of construction [11].

In one study [33], Delphi surveying was used to prioritize coping capacity, flood vulnerability, and exposure indicators in Brazil. The researchers achieved a consensus with 21 from 26 indicators. The final results were collected within two rounds of data collection. The aspect of coping capacity—consisting of infrastructure exposure and human vulnerability—was found to be the most important factor. Canada adopted the Delphi technique to calculate the causes of deterioration in water supply pipelines, with 16 factors from an initial list of 30 obtained by consensus within three rounds of data collection. The factors with the highest average represented priority values for various causes [34]. The Delphi survey technique was also used to identify and prioritize the benefits of integrating building information modeling (BIM) and sustainability practices into construction projects [35]. The Delphi technique has also been used to guide decision making regarding identifying factors implicated in flood events in large basins in Brazil, with the data analyzed based on three rounds of data collection [36]. The Delphi method has also been used in Pakistan to identify the main factors implicated in construction accidents. Thirty-two key indicators as reviewed in the literature and based on experts' knowledge were considered. The answers from databases were sent to groups of academics, customers, safety officials, and contractors by interview. Two rounds were completed with data collection by the interview. All the outcomes were validated for consensus. The final results showed the three highest-priority factors as follows: (i) weak safety regulations and weak enforcement of those regulations by the government sector; (ii) insufficient financial support available to develop safety measures and no incentive for employers to implement safety management; (iii) inadequate training and safety resources provided by contractors [37].

3 Research Methodology

The Delphi technique used to survey contractors and consultants in Thailand to establish and prioritize the major causes of construction delays is described in this section. The scope of this study is large construction projects such as shopping malls and residential projects in the Bangkok Metropolitan Area. The research procedure is presented conceptually as a flowchart in Fig. 1.

First, based on feedback provided by a focus group the causes of construction delays for the case study were established by consulting with 18 heads of construction projects at public organizations, 34 project engineers, 1 from each of 17 large construction contractor companies and 17 large construction consultant companies, and 20 academic experts in the construction field. All the members of the focus group were based in Thailand. The experts were divided into three groups, and opinions were taken once from every group. The author collected the experts' opinions—which were based on direct experience of the factors leading to construction delays at large construction sites such as those for shopping malls and large-scale residential buildings in the Bangkok Metropolitan. Through a process of analysis and elimination, a final list of 13 factors leading to construction delays was created based on the experts' opinions. Some of these 13 factors matched the key factors reported in the reviewed literature, whereas others were newly identified. The list of 13 factors leading to construction delays is presented in Table 1.

The 13 causes of delays in Table 1 were identified specifically in relation to large construction projects such as shopping malls and residential construction projects in the Bangkok Metropolitan Area of Thailand. Nine of the factors matched the key factors identified in the context of other countries in the reviewed literature. The matched factors suggest similar conditions in regard to regulations, society, economics, environment, religion, and the technology available. However, in the list based on the experts' opinions, four factors—Inadequate machinery maintenance, Volatile economic conditions leading to increases in the price of materials, Insufficient space at the construction site to facilitate utility systems, and Below-standard safety

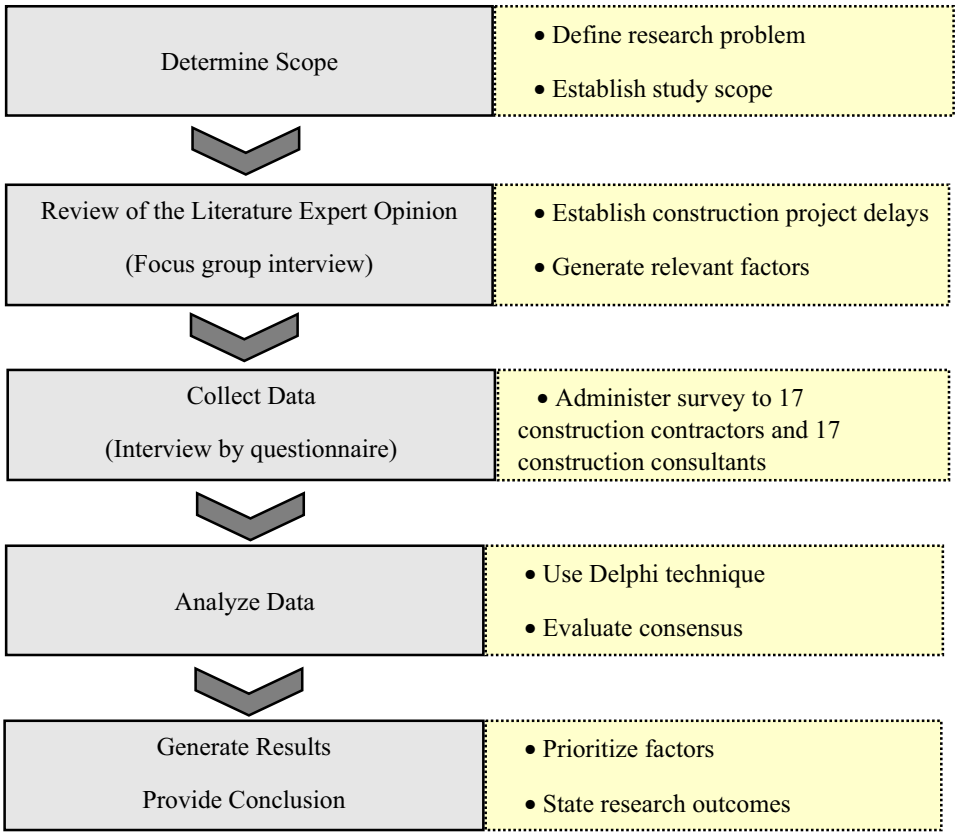

Fig. 1 Research procedure

Table 1 Factors leading to construction delays in the Bangkok Metropolitan Area

Factor leading to construction delays	Country	References
1. Change order by owner	Jordan, Saudi Arabia, and Lebanon	[12, 16, 26]
2. Unavailability of blueprint	Lebanon	[26]
3. Lack of work skills and experience	Saudi Arabia and Egypt	[19, 21]
4. Incorrect specification of delivered materials	Saudi Arabia	[19]
5. Shortage of qualified labor	Saudi Arabia	[19]
6. Inadequate machinery maintenance		
7. Contractor's lack of financial liquidity	Jordan, Saudi Arabia, and Benin	[12, 18, 19, 22]
8. Domestic environmental problems	Australia and Pakistan	[23, 24]
9. Working communication problems	China	[25]
10. Delay in transporting material from production site to construction area	India and Saudi Arabia	[15, 19]
11. Volatile economic conditions leading to increased material price		
12. Insufficient space at construction site to facilitate utility systems		
13. Below-standard construction safety and operation management system		

and operation management systems—were not among the key factors identified in the reviewed literature.

The questionnaire was generated using these 13 factors. Direct interviews based on questionnaires with the respondents were carried out with one questionnaire set per company. The researcher engaged 2 respondents from each of 17 of the largest construction and consultant contractor companies in Thailand for a total of 34 respondents. One project engineer and one consultant from each company were interviewed. Within the scope of this study, project engineers were defined as professionals directly responsible for the project management of the construction

including ensuring that the project timeline was met. Project engineers gain rich experience and develop significant knowledge of the construction process, including the causes of construction delays; therefore, they were appropriate respondents for this research study. Five Likert-scale rating questions for each factor leading to construction delays were used in the questionnaire. A rating scale of 1, 2, 3, 4, and 5 for each factor leading to construction delays represented "very little importance," "little importance," "moderately important," "important," and "very important," respectively. The respondents rated the factor in question by choosing a number on the scale. The values of the answers provided by the respondents were computed using the Delphi technique and the data collection process was repeated until the responses showed constancy. Factors with a high average value were ranked as high-priority in terms of leading to construction delays. Factors with a low average value were ranked as low priority.

The Delphi method is a structured interactive tool used for the purpose of making predictions by relying on experts' opinions. The combined value of the respondents' answers collected via interviews based on the questionnaire instrument was calculated according to statistical principles. The Delphi calculation steps are described below:

1. The researcher met with 72 experts after the questionnaire was developed to define a suitable average score criterion for each question. The researcher and the experts all agreed on the average of three for each item. Because three on the Likert scale means "moderately important," any factor with an average lower than three was not considered to be a significant cause of construction delays. The calculation is given in detail as follows:

   a. Calculate the sub-range of the class interval where

   $$\frac{\text{Maximum scale value} - \text{minimum scale value}}{\text{All number of scales}} = \frac{5-1}{5} = 0.8.$$

   b. Add the sub-range value to the initial score in each class interval. The scores are added into five levels by defining the range of measurement as:

- Level 1: Interval of 1.00–1.80 is of "very little importance".
- Level 2: Interval of 1.81–2.60 is of "little importance".
- Level 3: Interval of 2.61–3.40 is of "moderate importance".
- Level 4: Interval of 3.41–4.20 is "important".
- Level 5: Interval of 4.21–5.00 is "very important".

2. The respondents' answers were computed to find the average value for various questions. Their outcomes must be not less than three scores as defined by the experts. The average score was calculated from the total score divided by the number of respondents (17 in this case).
3. The answers were analyzed to find the mode value. Each set could have only the maximum number of duplicates within the two groups. The factor did not have a mode value when the most duplicated ones existed in more than two groups. For easy understanding, the data were arranged in descending order before consideration.
4. The median value of the 17 respondents' answers was calculated. The answer has calculated to the middle position by the formula $\frac{N+1}{2}$, where N is the number of 17 respondents. The middle position is decimal; therefore, the position between the middle values was taken into the average.
5. The differential value of the mode and median should not be over 1. This calculation shows the bias of the respondents' answers when this value was more than 1.
6. The last step is to calculate the value of the inter-quartile range. The data from the respondents' answers were sorted in descending order. The computation focused on quartiles 1 and 3 because this range covered all the information. The inter-quartile range was from quartile 3 (Q3) minus quartile 1 (Q1). The calculation formula of the Q1 and Q3 positions was $\frac{K}{4}\ (N+1)$ when K is the quartile sequence, as Q1 means K is equal to 1, and N is the number of all 17 respondents. The outcome of the position was a separation between Q1 and Q3, and the average of the data covering these positions was calculated. Then, we established the data of quartile 3 minus 1 as the inter-quartile range result of this data group. The inter-quartile range outcome should not be over 1.5. Excessive bias in the respondents' responses will show inconsistency in the data when the inter-quartile range value is over 1.5.

All the numeric data of any given factor were calculated statistically to test whether it met the statistical criteria. The statistical criteria consisted of an average value of 3 or below as defined by the experts, a differential value of the mode and the median of no more than 1, and an inter-quartile range of no more than 1.5. Some factors did not meet the statistical criteria. Therefore, for those factors, there was no possibility of reaching a consensus; i.e., it was not possible to satisfy the condition of invariability of data. The Delphi technique required the researcher to carry out

polling until the responses showed constancy, whereby the same respondent repeatedly responded to the questions asked on the questionnaire.

Eventually, the valid factors leading to construction delays that passed consensus were the desired outcome of this research. The factors driving construction delays were prioritized from the highest to the lowest mean value. The outcomes of this ranking indicated the most significant factors leading to construction delays from the contractors' and consultants' perspectives in relation to large construction projects such as shopping malls and residential buildings situated in the Bangkok Metropolitan Area of Thailand.

4 Results

The results of the survey data analysis focused on prioritizing the factors leading to construction delays from the contractors' and consultants' perspectives are presented in this section. The attitude outcomes from the contractors and consultants are sorted and organized to identify their priorities. For convenience, 13 factors driving construction delays are abbreviated as P1–P13 signifying P1: Change order by owner, P2: Unavailability of blueprint, P3: Lack of working skill and experience, P4: Incorrect specification of delivered materials, P5: Shortage of qualified labor, P6: Inadequate machinery maintenance, P7: Contractor's lack of financial liquidity, P8: Domestic environmental problems, P9: Working communication problems, P10: Delay of material transport from production site to construction area, P11: Volatile economic conditions leading to price increases of materials, P12: Insufficient space at the construction site to facilitate utility systems, and P13: Below-standard construction safety and operation practices.

4.1 Prioritizing the Contractors' Perspective on Factors Leading to Construction Delays

After the data had been collected from the 17 construction contractors, their answers in response to the items on the questionnaire were computed using the Delphi technique. The statistical values calculated for further analysis were the average, median, and mode values, as well as the inter-quartile range. The survey of data with the Delphi method required the same respondents to respond to the same questionnaire repeatedly until their responses showed constancy. In this study, the response data showed that constancy was achieved within the second round of data collection. The average value for each factor represented its importance weighting, and these weightings were ranked in descending order. The non-consensus value occurred when collecting the data in the first round with the factors of P4 and P10, each of which had an inter-quartile range over 1.5. Table 2 shows the statistical values and priorities for the first-round data collection with descending importance weighting.

Table 2 shows that no consensus values were found for two factors: Incorrect specification of delivered materials (P4) and Delay of material transport from production site to construction area (P10). The inter-quartile range value of each of these two factors was over 1.5. The difference between the median and mode of all the factors passed the criterion of less than or equal to 1. In addition, the average value of all the factors was above 3, which was consistent with the defined criterion. The priority ranking based on average value showed that Shortage of labor (P5) was first in the priority ranking with an average score of 4.53, whereas Change order by owner (P1) ranked second with an average score of 4.12. Unavailability of blueprint (P2), Lack of working skill and experience (P3), and Contractor's lack of financial liquidity (P7) ranked third with an average score of 3.94. Incorrect specification of delivered materials (P4), Inadequate machinery maintenance (P6), Working communication problems (P9), Delay of material transport from production site to construction area (P10), and Insufficient space at the construction site to facilitate utility systems (P12) ranked 4th, 5th, 6th, 7th, and 8th with an average score of 3.88, 3.76, 3.59, 3.47, and 3.41, respectively. Three factors ranked in the 9th place—domestic environmental problems (P8), Volatile economic conditions leading to an increase in materials price (P11), and Below-standard construction safety and operation practice (P13)—with an average score of 3.35. In the second round of the survey, the responses obtained were more stable. Their statistical values and priority rankings by average score are shown in Table 3.

According to Table 3, the respondents' answers were more stable for the second round of data collection as compared to the first round. All 13 factors passed the consensus value. In terms of other important statistics, the average value, the differential of the median and mode values, and the inter-quartile range all met the defined criteria. The Shortage of labor (P5) factor was still first in the priority rank with an average score of 4.65. Then, Change order by owner (P1), Contractor's lack of financial liquidity(P7), Lack of working skill and experience (P3), Unavailability of blueprint (P2), and Incorrect specification of delivered materials (P4) ranked 2nd, 3rd, 4th, 5th, and 6th with an average score of 4.24, 4.18, 4.06, 3.88, and 3.82, respectively. Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (P10) ranked 7th with an average score of 3.76. Working communication problems (P9) ranked 8th with an average score of 3.59. Domestic environmental problems (P8) and Below-standard construction safety and

Table 2 Statistical values and priorities with first-round data collection from the construction contractors

Factor	Rank	Mean	Median	Mode	Median–mode	Inter-quartile range	Consensus
P1	2	4.12	4	4	0	1	Passed
P2	3	3.94	4	4	0	1.5	Passed
P3	3	3.94	4	3	1	1.5	Passed
P4	4	3.88	4	5	1	2	Unpassed
P5	1	4.53	5	5	0	1	Passed
P6	5	3.76	4	4	0	1.5	Passed
P7	3	3.94	4	4	0	1.5	Passed
P8	9	3.35	4	4	0	1.5	Passed
P9	6	3.59	4	4	0	1	Passed
P10	7	3.47	4	4	0	2	Unpassed
P11	9	3.35	4	4	0	1.5	Passed
P12	8	3.41	3	3	0	1.5	Passed
P13	9	3.35	3	3	0	1	Passed

Table 3 Statistical values and priorities from the second-round data collection from the construction contractors

Factor	Rank	Mean	Median	Mode	Median–Mode	Inter-quartile range	Consensus
P1	2	4.24	4	4	0	1	Passed
P2	5	3.88	4	4	0	0.5	Passed
P3	4	4.06	4	4	0	1.5	Passed
P4	6	3.82	4	4	1	1	Passed
P5	1	4.65	5	5	0	1	Passed
P6	7	3.76	4	4	0	1	Passed
P7	3	4.18	4	4	0	1	Passed
P8	9	3.35	4	4	0	1	Passed
P9	8	3.59	4	4	0	1	Passed
P10	7	3.76	4	3	1	1	Passed
P11	10	3.29	3	4	1	1.5	Passed
P12	11	3.24	3	3	0	1	Passed
P13	9	3.35	3	3	0	1	Passed

operation practice (P13) jointly ranked 9th with an average score of 3.35. Volatile economic conditions leading to an increase in materials price (P11) and Insufficient space at the construction site to facilitate utility systems (P12) ranked in the 10th and 11th place with an average score of 3.29 and 3.24, respectively.

The statistics and priority rank of the factors leading to construction delays in the first and second rounds of data collection were compared as shown in Table 4. Some factors ranked in the same place in the priority rank, but many others had different positions in the second round. The priority ranking was arranged according to the average scores.

In Table 4, the consensus value of two factors—Incorrect specification of delivered materials (P4) and Delay of material transport from production site to construction area (P10)—did not satisfy the criteria in the first round of data collection. However, the consensus value of all the factors passed the criteria in the second round of data collection. The Shortage of qualified labor (P5) factor was still first in the priority ranking in round 2 with average scores of 4.53 and 4.65 in the first and second rounds, respectively. Change order change by owner (P1) ranked second with average scores of 4.12 and 4.24 in the first and second rounds, respectively. Unavailability of blueprints (P2), Lack of working skill and experience (P3), and Contractor's lack of financial liquidity (P7) shared the third ranking, each with an average score of 3.94. Contractor's lack of financial liquidity (P7) remained in the third rank in the second round with an average score of 4.18. In the second

Table 4 Comparison of average scores and priority rankings of factors leading to construction delays in the first and second rounds of data collection from the contractors' perspective

First round			Factors	Second round		
Rank	Average	Consensus		Consensus	Average	Rank
2	4.12	Passed	P1. Change order by owner	Passed	4.24	2
3	3.94	Passed	P2. Unavailability of blueprint	Passed	3.88	5 (↓)
3	3.94	Passed	P3. Lack of working skill and experience	Passed	4.06	4 (↓)
4	3.88	Unpassed	P4. Incorrect specification of delivered materials	Passed	3.82	6 (↓)
1	4.53	Passed	P5. Shortage of qualified labor	Passed	4.65	1
5	3.76	Passed	P6. Inadequate machinery maintenance	Passed	3.76	7 (↓)
3	3.94	Passed	P7. Contractor's lack of financial liquidity	Passed	4.18	3
9	3.35	Passed	P8. Domestic environmental problems	Passed	3.35	9
6	3.59	Passed	P9. Working communication problems	Passed	3.59	8 (↓)
7	3.47	Unpassed	P10. Delay of material transport from production site to construction area	Passed	3.76	7
9	3.35	Passed	P11. Volatile economic conditions leading to materials price increase	Passed	3.29	10 (↓)
8	3.41	Passed	P12. Insufficient space at the construction site to facilitate utility systems	Passed	3.24	11 (↓)
9	3.35	Passed	P13. Below-standard construction safety and operation practice	Passed	3.35	9

round, Unavailability of blueprint (P2) and Lack of working skill and experience (P3) moved down from shared third place in the first-round rankings to fifth and fourth place with an average score of 3.88 and 4.06, respectively. Incorrect specification of delivered materials (P4) was at the fourth place with an average score of 3.88 in the first round, but moved down to the rank of sixth with an average score of 3.82 in the second-round data collection. Inadequate machinery maintenance (P6) had the same average score at 3.76 in the first and second rounds moved down from fifth place to seventh in the rankings. Delay of material transport from production site to construction area (10) stayed at the same at seventh in the rank in both rounds with an average score of 3.47 and 3.76 in the first and second rounds, respectively. The Working communication problems (P9) factor ranked sixth in the first round but moved down to eighth in the second round with the same average value. The priority ranking of insufficient space at the construction site to facilitate utility systems (P12) moved down from 8 to 11th rank from the first to the second round with an average score of 3.41 and 3.24, respectively. Three factors, P8, P11, and P13, shared ninth place in the first round with an average value of 3.35. In addition, domestic environmental problems (P8) and below-standard construction safety and operation practice (P13) had the same average score of 3.35 and ranked at ninth place in both the first and the second round of data collection. Volatile economic conditions leading to materials price increase (P11) moved down from nine to tenth with an average score of 3.29 in the second round.

4.2 Prioritizing the Consultants' Perspectives on Factors Leading to Construction Delays

The answers from the 17 respondents (consultants) were calculated using the Delphi technique. The statistics of response, i.e., the average, median, and mode values, as well as the inter-quartile range, were analyzed according to the defined criteria. For the average score, the defined criterion was larger than or equal to 3 according to the expert recommendation. For the difference of the median and mode and the inter-quartile range, the defined criteria were less than or equal to 1 and less than or equal to 1.5, respectively. If the statistics did not meet the defined criteria, the factors for which this was the case did not pass the consensus. The survey by means of questionnaire response by respondents was repeated when their calculated data did not pass consensus given that this result implied instability of the survey data. The data survey stopped when all the responses passed the consensus, thereby showing constancy. The average scores for each factor represented its weighting importance, and the weightings were ranked in descending order. In the first round of data collection, the consensus values of the factors P3, P4, and P7 did not pass the defined criteria, as the inter-quartile range of each of these was more than 1.5. Table 5 shows the statistics and priority rankings of the first-round data collection.

In Table 5, three factors have a no-consensus value: Lack of working skill and experience (P3), Incorrect specification of delivered materials (P4), and Contractor's lack of financial liquidity (P7). This was the case, as each

of these factors showed an inter-quartile range value over 1.5. The difference of the median and mode of all the other factors passed consensus as none of these was higher than 1. For the average score, all were well above 3. The priority ranking based on average scores indicated that Shortage of qualified labor (P5) ranked first with an average score 4.47. Change order by owner (P1) followed with the second-place rank with an average score of 4.24. Unavailability of blueprint (P2) and Lack of working skill and experience (P3) shared thirrd rank with an average value of 4.06. Incorrect specification of delivered materials (P4) and Contractor's lack of financial liquidity (P7) ranked in the fourth and fifth place with an average score of 3.88 and 3.82, respectively. Working communication problems (P9) and Below-standard construction safety and operation practice (P13) shared sixth rank with an average score of 3.65. Delay of material transport from production site to construction area (P10) ranked seventh with an average score of 3.47. Volatile economic conditions leading to material price increase (P11) and Insufficient space at the construction site to facilitate utility systems (P12) ranked eighth place with an average score of 3.35. In addition, holding ninth and tenth ranks were Inadequate machinery maintenance (P6) and Domestic environmental problems (P8) with average scores of 3.24 and 3.12, respectively. All responses showed constancy in the second round. The results of the statistics and priority ranking are shown in Table 6.

Table 6 shows the statistics and priority ranking from the second-round data collection. The respondents' responses reached stability, i.e., all the responses for the13 factors leading to construction delays passed consensus. Moreover, the average scores, difference of the median and mode values, and the inter-quartile range each met its defined criteria. Shortage of qualified labor (P5) still ranked first with an average score of 4.53. Change order by owner (P1) ranked second with an average score of 4.18. Lack of working skill and experience (P3) and Contractor's lack of financial liquidity (P7) jointly ranked third with an average score 4.12. Unavailability of blueprint (P2) and Incorrect specification of delivered materials (P4) ranked fourth and fifth with average scores of 4.00 and 3.88, respectively. Below-standard construction safety and operation practice (P13) ranked sixth with an average score of 3.82. Two factors, i.e., Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (P10), jointly ranked seventh with an average score of 3.76. Working communication problems (P9) ranked eighth with an average score of 3.71. Ninth rank was jointly held by two factors, Volatile economic conditions leading to materials price increase (P11) and Insufficient space at the construction site to facilitate utility systems (P12), with an average score of 3.29. Domestic environmental problems (P8) ranked tenth, the lowest position, with an average score of 3.18.

The statistics and priority of the responses in relation to the factors leading to construction delays in the first and second rounds of data collection were compared as shown in Table 7. Some factors still held the same rank, whereas other factors moved up and still others moved down. The priority rankings were sorted corresponding with the average scores.

In Table 7, Lack of working skill and experience (P3), Incorrect specification of delivered materials (P4), and Contractor's lack of financial liquidity (P7) did not pass the defined criteria for consensus in the first round of data collection. All the statistics in the second round passed the defined criteria so that all the factors reached consensus.

Table 5 Statistical values and priorities with first-round data collection from the construction consultants' perspective

Factor	Rank	Mean	Median	Mode	Median–mode	Inter-quartile range	Consensus
P1	2	4.24	4	5	1	1.5	Passed
P2	3	4.06	4	4	0	0.5	Passed
P3	3	4.06	4	4	0	2	Unpassed
P4	4	3.88	4	4	0	2	Unpassed
P5	1	4.47	5	5	0	1	Passed
P6	9	3.24	3	3	0	1	Passed
P7	5	3.82	4	4	0	2	Unpassed
P8	10	3.12	3	3	0	1.5	Passed
P9	6	3.65	4	4	0	1	Passed
P10	7	3.47	4	4	0	1	Passed
P11	8	3.35	4	4	0	1.5	Passed
P12	8	3.35	4	4	0	1	Passed
P13	6	3.65	4	3	1	1	Passed

Table 6 Statistical values and priorities with second-round data collection from the construction consultants' perspective

Factor	Rank	Mean	Median	Mode	Median–mode	Inter-quartile range	Consensus
P1	2	4.18	4	5	1	1.5	Passed
P2	4	4.00	4	4	0	0	Passed
P3	3	4.12	4	4	0	1.5	Passed
P4	5	3.88	4	4	0	1	Passed
P5	1	4.53	5	5	0	1	Passed
P6	7	3.76	4	4	0	1	Passed
P7	3	4.12	4	4	0	1.5	Passed
P8	10	3.18	3	3	0	1	Passed
P9	8	3.71	4	4	0	1	Passed
P10	7	3.76	4	4	0	0.5	Passed
P11	9	3.29	4	4	0	1.5	Passed
P12	9	3.29	3	4	1	1	Passed
P13	6	3.82	4	4	0	1	Passed

Table 7 Comparison of average score and priority ranks of factors leading to construction delay in the first and second rounds of data collection from the consultants' perspective

First round			Factor	Second round		
Rank	Average	Consensus		Consensus	Average	Rank
2	4.24	Passed	P1. Change order by owner	Passed	4.18	2
3	4.06	Passed	P2. Unavailability of blueprint	Passed	4.00	4 (↓)
3	4.06	Unpassed	P3. Lack of working skill and experience	Passed	4.12	3
4	3.88	Unpassed	P4. Incorrect specification of delivered materials	Passed	3.88	5 (↓)
1	4.47	Passed	P5. Shortage of qualified labor	Passed	4.53	1
9	3.24	Passed	P6. Insufficient machinery maintenance	Passed	3.76	7 (↑)
5	3.82	Unpassed	P7. Contractor's lack of financial liquidity	Passed	4.12	3 (↑)
10	3.12	passed	P8. Domestic environmental problems	Passed	3.18	10
6	3.65	Passed	P9. Working communication problems	Passed	3.71	8 (↓)
7	3.47	Passed	P10. Delay of material transport from production site to construction area	Passed	3.76	7
8	3.35	Passed	P11. Volatile economic conditions leading to materials price increase	Passed	3.29	9 (↓)
8	3.35	Passed	P12. Insufficient space at the construction site to facilitate utility systems	Passed	3.29	9 (↓)
6	3.65	Passed	P13. Below-standard construction safety and operation practice	Passed	3.82	6

Shortage of qualified labor (P5) ranked first in both rounds with average scores of 4.47 and 4.53 in the first and second round, respectively. Change order by owner (P1) ranked second in both rounds with an average score of 4.24 and 4.18 in the first and second round, respectively. In the first round, Unavailability of blueprint (P2) and Lack of working skill and experience (P3) jointly ranked third with an average score of 4.06. However, in the second round, P2 fell to fourth with an average score of 4.00, whereas P3 still ranked third with an average score of 4.12. Contractor's lack of financial liquidity (P7) ranked fifth with an average score of 3.82 in the first round, then ranked third with an average score of 4.12 in the second round. Ranking fourth in the first round with an average score of 3.88, Incorrect specification of delivered materials (P4) moved down to fifth with the same average score of 3.88 in the second round. Working communication problems (P9) ranked sixth with an average score of 3.65 in the first round, and then fell to eighth with an average score of 3.71 in the second round. Below-standard construction safety and operation practice (P13) ranked sixth with an average score of 3.65 in the first round and held the same rank in the second round with an average score 3.82. Two factors jointly ranked seventh with an average score of 3.76 in the second round, i.e., Inadequate machinery maintenance (P6) and Delay of material transport from production site to

construction area (P10). In the first round, P6 ranked ninth with an average score of 3.24, then rose to seventh in the second round. P10 remained seventh with an average score of 3.47 in the first round. Volatile economic conditions leading to materials price increase (P11) and Insufficient space at the construction site to facilitate utility systems (P12) shared eighth with an average score of 3.35, but then fell to ninth with an average score of 3.29 in the second round. Finally, domestic environmental problems (P8) remained tenth with an average score of 3.18 in the second round, although its average score was 3.12 in the first round.

5 Discussion

The results of the survey focused on factors leading to construction delays from the perspectives of contractors and consultants are discussed above. The factors were prioritized using the Delphi technique. The priority rankings were sorted according to average scores in descending order. All the factors passed the defined criteria of consensus in the second round of data collection. To gain insights from the results of the analysis, in this section the 13 causes as prioritized by the respondents are discussed. The perspectives were compared in terms of common and different rankings, and the average weight in relation to various factors. The perspectives were compared by discussing the attitudes of the construction contractors and consultants in relation to construction delay causes, as shown in more detail in Table 8.

5.1 Comparison of the Common Rankings of Factors Leading to Construction Delays in the Construction Contractors' and Consultants' Perspectives

The values of the answers of the 17 contractors and 17 consultants were calculated statistically as average, median, and mode values, as well as the inter-quartile range. All the factors had already passed the consensus values. In this section, a comparison of common rankings across the perspectives of the two groups of participants is provided. Table 8 shows the six factors with the same rankings across the two respondent groups: Shortage of qualified labor (P5) ranked first, Change order by owner (P1) ranked second, Contractor's lack of financial liquidity (P7) ranked 3rd, and Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (P10) shared seventh.

The contractors and consultants focused on Shortage of qualified labor (P5) [8] as the common first rank given the Thailand recruitment process, worker income and passion for the job, and contractor's lack of financial liquidity. In the opinion of the contractors, the steps to obtain the documents needed to employ foreign labor work promise are very prolonged, with the process taking a minimum of 45 days to complete. The project may be delayed when there is not a sufficient workforce. Normally, some employees defined as foreign labor do not have a clear contract extension with the company. In such circumstances, those employees promptly return to their home countries when their contracts expire and sometimes even before that point is reached. In addition, construction companies commit to more new projects such that a correspondingly larger workforce is required as soon as possible. Hence, the prolonged document process was important in the top priority given to a Shortage of qualified labor in construction projects. The income and passion for the job of laborer were considered as foundational to the construction project labor shortage and accompanying loss of productivity [32]. In general, Thai laborers preferred to work abroad due to the considerably higher income on offer there. Else, if they had to work domestically, they prefer not to become construction laborer, as this is demanding work with a relatively high level of risk. Financial problems on the part of the contractor [8, 10, 22, 25] were also related to the Shortage of qualified labor. Workers need to return to hometowns or countries or seek employment because contractors have not paid them on time or even failed to pay them at all. Most construction labor agencies abroad from both the government and private sectors express a sense of distrust toward Thai employers concerning securing payment for labor [23]. Some countries, therefore, do not allow members of their labor force to work in Thailand on construction project unless the employer's financial stability has been checked and proven over time—which with the provision of documentation for workers is a lengthy process. The financial stability of the contractor is certainly an important aspect in attracting labor [28]. The consultant perspective focused on the position that daily working progress should accord with the work plan captured in the contract. Labor is very significant in construction operations given that a Shortage of qualified labor leads to delays, which means the contractor is likely to struggle with time and labor resources management [21]. Moreover, the contractors did not have sufficient skill or ability to tackle problems of this nature [32]. As a result, contractors modify some of the work and are held liable for contractual owner delay penalty fines as stated in the construction contractual agreement. As a consequence, the fine payment sometimes affects the cash flow of contractor leading to delays in paying the laborers or even a refusal to pay their wages. As a result, laborers leave their employee and a further shortage of qualified labor occurs. This was the most important cause of

Table 8 Comparison of data from the responses of the construction contractors and the responses of the consultants

Contractor perspective			Factor	Consultant perspective		
Rank	Average	Consensus		Consensus	Average	Rank
2	4.24	Passed	P1. Change order by owner	Passed	4.18	2
5	3.88	Passed	P2. Unavailability of blueprint	Passed	4.00	4
4	4.06	passed	P3. Lack of working skill and experience	Passed	4.12	3
6	3.82	Passed	P4. Incorrect specification of delivered materials	Passed	3.88	5
1	4.65	Passed	P5. Shortage of qualified labor	Passed	4.53	1
7	3.76	Passed	P6. Lack of machinery maintenance	Passed	3.76	7
3	4.18	Passed	P7. Contractor's lack of financial liquidity	Passed	4.12	3
9	3.35	Passed	P8. Domestic environmental problems	Passed	3.18	10
8	3.59	Passed	P9. Working communication problems	Passed	3.71	8
7	3.76	Passed	P10. Delay of material transport from production site to construction area	Passed	3.76	7
10	3.29	Passed	P11. Volatile economic conditions leading to materials price increase	Passed	3.29	9
11	3.24	Passed	P12. Insufficient space at the construction site to facilitate utility systems	Passed	3.29	9
9	3.35	Passed	P13. Below-standard construction safety and operation practice	Passed	3.65	6

construction delays from both the construction contractors' and the consultants' perspectives. Although the attitudes of the contractors and the consultants differed, both held that construction delays was directly affected by the Shortage of qualified labor factor. It had the most serious impact on construction delays because construction is a labor-intensive industry; i.e., the industry relies on a large group of laborers working to achieve a specified goal. Consequently, this cause ranked first in the construction delay priority rankings.

Change order by owner (P1) [10, 20, 31] was ranked second by both groups of respondents, specifically change of design and material specifications ordered by the owner. Most of the contractors received unexpected design and material specification change orders from owner. Normally, the operation must be extended such that it takes longer to complete given the owner's changes. The consultants also considered contractors to be responsible for delays, given poor working efficiency in general [8, 24]. In the contractors' perspective, change orders mean additional costs, including labor costs, and also mean that the project will take longer than specified in the contract. Several contractors reported losing many laborers due to payment postponement. According to the contractors, the owner should extend the project deadline in the contractual agreement when issuing a change order. Although contractors and consultants described the cause differently, they agreed that the factor referring to change orders on the part of the owner is significant in leading to construction delays. This factor had a significant effect on construction delays because it has an impact on the contractor's financing, which leads to a shortage of qualified labor. Moreover, change orders force contractors to reschedule given conditions of labor shortage. As a result, this factor was ranked second by both groups of respondents.

Contractor's lack of financial liquidity (P7) [8, 10, 22, 25] was ranked third by both respondent groups. It was seen as a leading cause of a shortage of qualified labor. It ranked third because some causes were not always related to financial conditions, such as government regulations or a personal preference for labor. This condition impacted construction delays. A major issue affecting the Contractor's lack of financial liquidity is worker performance and verbal contracts between contractors and subcontractors [7]. The consultants considered the contractors to be responsible given poor work performance; therefore, the owners might not pay a contractor on the due date. As a result, the contractor's financial liquidity is impacted such that the contractor it likely to be unable to meet all the financial obligations entailed in running the business—at least not in a timely way. In addition, a contract owner may have a verbal instead of a written contract with a contractor [7]. Thus, the contract owner can change the order without lengthening the completion timeline. A responsible contract owner should send a written change order to the contractor, but this best practice is by no means always followed. Therefore, the contract owner should be held responsible for this problem. However, given this is often not the case, the contractor will not have a sufficient budget to continue and complete the project, thereby giving rise to a construction delay. Although contractors and consultants had different attitudes, these two issues were directly related to the factor of the Contractor's lack of financial liquidity. This factor had a serious impact on delay because

the contractor's lack of financial liquidity leads to a qualified labor shortage. Thus, both groups placed this factor third in the priority rankings.

Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (P10) [8, 19] were ranked seventh by both groups of respondents. Inadequate machinery maintenance is related to the delivery of the material because the machine maintenance can require spare parts and equipment delivered from remote suppliers. Material delivery is difficult in the Bangkok Metropolitan Area due to constant traffic jam conditions. The materials used in machine maintenance must be transported from the production site to the construction area, and traffic jams are so common that they negatively impact machine maintenance, thereby leading to construction delays. In the ideal case**,** machinery should be maintained to be ready to work at all times so that no time is wasted when the need for a repair is suddenly identified. However, the delivery of materials such as steel, brick, and concrete from a production site to the construction area can be delayed due to constant traffic jams, and delays can be lengthy when major machinery has broken down. In the consultants' perspective, delays occur due to the contractor's lack of attention to equipment maintenance and poor handling of material transportation. Consequently, construction is delayed. Factors P6 and P10 also gave rise to construction delays, mainly due to transportation problems. The ways in which the respondents rationalized these factors were inconsistent with actual practice in the transportation business, as the carrier is held responsible financially for delivery delay. Transportation operators mostly operate with good time management; therefore, delivery delays should not cause severe problems to construction time management. However, unforeseen events such as road accidents or unnoticed road construction also cause delays in transportation from time to time. As a result, both respondent groups assigned this factor as seventh in the priority rankings.

The Working communication problems (P9) [30] was also ranked seventh by both the contractors and the consultants. Burmese and Cambodian laborers are generally preferred in the construction industry in Thailand given that they provide cheaper labor than do Thai laborers. Therefore, communication between the laborers and the contractor can be quite difficult with some key information lost in communication. Given that this is the case, it is inevitable that miscommunication will take place and have a negative impact on the construction work. These mistakes take valuable time to recognize and address [29]. In reference to communication between the contractors and the consultants, each party predictably held the other primarily responsible for miscommunication. However, despite this difference, the groups agreed that poor working communication can give rise to construction delays. However, communication problems seem to be temporary, occurring in the early phases of a project. Good communication can develop from lessons learned from earl communication problems. Thus, both groups placed this factor eighth in the priority rankings.

5.2 Comparison of the Different Ranks of a Factor in Construction Delays Between the Contractors' Perspective and the Consultants' Perspective

In this section, factors ranked differently in the contractors' perspectives as compared to the consultants' perspective are discussed. The causes of construction delays were prioritized according to the respondents' answers and using the Delphi technique to calculate the values of the data. The attitudes of the contractors were compared with those of the consultants in terms of differences in ranking the construction delay factors, as shown in Table 8. Seven factors were ranked differently between the contractors and the consultants, namely the following sorted by priority: Lack of working skill and experience (P3), Unavailability of blueprint (P2), Incorrect specification of delivered materials (P4), Below-standard construction safety and operation practice (P13), Volatile economic conditions leading to materials price increase (P11), Domestic environmental problems (P8), and Insufficient space at the construction site to facilitate utility systems (P12). These factors waere described in more detail as follows.

Lack of working skill and experience (P3) [8, 24] was ranked fourth by the contractors and third rank by the consultants. The contractors mentioned that new workers should have more training before beginning the job. In general, delays in construction occurred because of a lack of skill and experience on the part of new workers [32]. The contractors held that the contractor's lack of financial liquidity was more important than P3, because new workers' skills and experience improved in due course with the support of their supervisor but that financial difficulty experienced by a contractor often leads to a breach of contract from which it is difficult to recover. Thus, the contractors ranked P3 fourth. The consultants emphasized that new workers and other staff who were inexperienced in residential and shopping mall building construction led to delays in construction. A lack of skill and experience negatively impacts work repair and reconciliation and can lead to a failure to complete construction on time and extra costs incurred for modifications. This situation means contractors can find themselves with a lack of financial liquidity. Therefore, the consultants ranked P3 and P7 third in the priority rankings.

Unavailability of blueprint (P2) [31] was ranked fifth by the contractors and fourth by the consultants. Generally, consultants perform an inspection according to the construction blueprint. They are, therefore, aware of construction delay problem when construction designs are not ready. Consultants waste time waiting for a designer to edit the work. In some cases, projects have to be operated without construction blueprints. The consultants reported having to reject work when they identified it at a worksite. In such cases, the contractor has to redo the same work with a true blueprint. Therefore, the consultants held the contractors as blameworthy for poor working skill and limited experience on the part of the contractor's officer responsible for approving the blueprint before an operation. Hence, contractors in such situations may be obliged to pay the laborers extra to extend the construction as needed. Against this background, P2 ranked fourth following P3 and P7. Lack of working skill and experience (P3) was ranked fourth by the contractors. Lack of skill and experience of the officer responsible for checking the blueprint before work commenced had a negative impact on the availability of a valid blueprint. Therefore, Unavailability of blueprint (P2) was fifth in the priority rankings from the contractors' perspective.

Incorrect specification of delivered materials (P4) [8] was ranked sixth by the contractors and fifth by the consultants. Their perspectives relied on the same reasoning as explained for the rankings assigned to factor P4. This factor followed Unavailability of blueprint (P2) in the priority rankings in both the contractors' and the consultants' perspectives. The impact of incorrect specification of delivered materials on construction delays was not considered as great as that of Unavailability of blueprint because construction operations can still continue when the correct material is supplied. In most cases, delivery companies are held responsible for this problem, and the contractor has options in regard to ensuring safety and avoiding work interruptions due to the material specification problem. Unavailability of blueprint is considered more difficult to manage, as the contractor must invest more time and money to support workers when work is rejected due to failing to check the suitability of a blueprint before an operation begins.

Below-standard construction safety and operation practice (P13) was ranked ninth by the contractors because most of the workers are foreigners, with relatively few Thai workers included. Most of the workers do not know the safety rules that has to be followed at a construction work site and very few realize the importance of the safety measures required. In particular, the worksite supervisor should educate and control laborers concerning construction safety to avoid below-standard construction safety and operation practice [32]. The workers do not get sufficient communication about safety and operation standard practice [30]. Therefore, factor P13 was ranked ninth following P9, ranked eighth. The consultants placed P13 sixth in the rankings. As they work on behalf of the owner, the control of safety and operations should be in accordance with the standards of the industry. Work accidents can interrupt construction work. This problem can give rise to delays in construction. In addition, people in the neighborhood of a working site can make objections to the work based on their assessment of environmental or safety hazards from the construction site, which can, in turn, cause a delay in operations. Incorrect specification of delivered materials (P4) was ranked fifth by the consultants. Factor P4 occurs frequently due to traffic jams in densely populated area and can, therefore, be implicated in construction delays. However, construction work accidents can be resolved quickly and work delays in such cases are usually short. Therefore, factor P13 ranked sixth and P4 ranked fifth in the consultants' perspective.

Volatile economic conditions leading to materials price increase (P11) ranked tenth in the contractors' perspective. Generally, the construction contract document leads the owner to select and buy the construction material and other equipment themselves. Therefore, Volatile economic conditions leading to material price increase was considered as having only a small impact on the relative financial liquidity of the contractor [28]. However, it does have an effect on the owner's financial condition. In fact, an owner may have already purchased and made agreement with the material suppliers, in which case this factor would have no impact on the owner either. But, there could be a great impact on the material supplier. Yet, this factor was still considered as having an influence on delays in construction. Domestic environmental problems (P8) [26, 27] and Below-standard construction safety and operation practice (13) were ranked ninth, as these was held to be more important than factor P11 in leading to construction delays. In the respondents' view, environmental problems such as rain, flooding, and political protests were more implicit than material price increase, which affected construction interruption.

From the consultants' perspective, factor P11 ranked ninth. Obviously, the consultants' perspective on this factor was similar to that of the contractor. Normally, the owner would have already made an agreement with the material operator. Hence, this factor does not have much impact on delays when compared to Working communication problems [30], and it is number 8 as described above in relation to its impact on construction delays.

Domestic environmental problems (P8) [26, 27] was ranked ninth in the contractors' perspective, a lower ranking than that for Working communication problems [30] because the problem in Thailand's domestic context as

a political protest and climate impact such as raining and flooding could occur from time to time [6]. However, its impact on construction delays is ordinarily only temporary. The occurrence of an environmental incident may be written in the contract as grounds for a time extension. Usually, the contractor arranges overtime work to compensate for time wasted because of these problems. However, a lack of communication may give rise to mistakes that cannot easily be addressed [29]. From the consultants' perspective, Domestic environmental problems (P8) was ranked tenth. When compared to factor P11, the priority ranking of P8 was lower, as the contractors considered that of the two factors economic pressure had a greater impact on construction delays. Thailand has rarely been subject to severe effects from environmental impact [6], such as the climatic factor. In addition, problems from political protest have been largely absent for many years [6]. In the future, worsening economic pressure may result in material suppliers seeking to avoid signing contracts with project owners before project commencement. The consultants focused on problems that could occur in the future in relation to construction delays.

One more factor, P12, was ranked ninth. This factor was also more important than P8 because the Bangkok Metropolitan Area has limited space to install the various facilities. The price of land in this area is high. Therefore, insufficient area to facilitate utility systems can have an impact on the continuity of operations.

Insufficient space at the construction site to facilitate utility systems (P12) ranked 11th from the contractors' perspective. The land in the Bangkok Metropolitan Area is expensive and rarely available to accommodate the installation of utility systems at the work site area. However, a project owner could rent nearby land for installation. In addition, many projects have sufficient space at a construction site for installing the utility system. Thus, this factor was determined as having the lowest impact on construction delays in the contractors' perspective. However, the consultants work on behalf of project owners; therefore, cost savings is a key performance target for them. On this basis, the consultants tended to understand the owner's attitude more readily than the contractor's attitude. The consultants focused on the rent, which is expensive in the focal urban area. As a result, high rental costs for facilitating a utility system may mean owners find themselves with limited financial liquidity, consequently unable to pay the contractor at the agreed price. This, in turn, in the instance reported by one of the consultants, caused the contractor to abandon the project. Hence, factor P12 was ranked ninth in the consultants' perspective such that the consultants considered it as having greater importance in giving rise to construction delays than did the contractors. However, this factor ranked eighth, such that it was not held as having much impact on construction delays when compared to Working communication problems [30] from the viewpoint of the consultants.

5.3 Comparing the Average Weight Difference of Factors in the Construction Contractors' Perspective and the Consultants' Perspective

The priority ranking of various factors is the average difference. The perspectives of the contractors and the consultants were similar in some cases. For instance, Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (P10) had the same average score of 3.76, and Volatile economic conditions leading to materials price increase (P11) had an average score of 3.29. This section describes 13 factors average weight difference of the factor leading to construction delays between the contractors' and the consultants' perspectives.

Change order by owner (P1) had an average value of 4.24 from the contractors' perspective, and a value of 4.18 from the consultants' perspective. A contractor commented that change orders arose from the owner's mistakes in terms of decision making. The consultants' focused on poor contractor work performance as responsible for the owner's submission of change orders. Further, they held that change orders should not cause construction delays. Therefore, the average score from the consultants' perspective was lower than that afforded by the contractors.

For Unavailability of blueprint (P2), the contractors emphasized that a few details missed in the blueprint should not be a significant problem such that construction delays should not arise or should be minimal if the work is carried out by a highly experienced professional. They should have the common sense and ability to solve problems beforehand. The consultants focused on accuracy and confidence in the blueprint (P2), such that the details in the blueprint must be complete. Therefore, the average value from the consultants' perspective was higher than that afforded by the contractors, with values of 4.00 and 3.88, respectively.

In regard to Lack of working skill and experience (P3), the consultants considered this as having a great impact on the ability of the contractor's workers to complete work efficiently and competently. Construction delays should not occur when a contractor's workers have sufficient skill and experience [32]. The contractors held that the ability of the worker ability need not always cause a construction delay. Often, problems in this regard can be addressed the fault quickly such that work is not interrupted in some cases. As a result, in the consultants' perspective, the average score for P3 was 4.12, which was higher than the average value of 4.06 from the contractors' perspective.

Incorrect specification of delivered materials (P4) had an average score of 3.82 and 3.88 from the contractors and the consultants, respectively. Incorrect specification of delivered materials was not a serious problem in the contractors' view because they could temporarily store material until the correct material was delivered. In the consultants' perspective, P4 was about larger problems that may occur from this factor such as sending the wrong formwork of size. For the consultants, a lack of important construction materials causing construction work to be interrupted was an important concern. They were concerned about the redundant transportation of material with the wrong specifications being transported both to and from the construction site, for example. Further, frequent traffic jams in Bangkok would be part of the problem specified in P4. Hence, the average value for factor P4 from the consultants' perspective was higher than the value given from the contractors' perspective.

In regard to Shortage of qualified labor (P5), in the construction process, a significant labor force must work to achieve the specified goal. In general, construction is delayed by the labor shortage problem. From the perspective of the consultants, the cause of this problem is ineffective labor management by the contractor [11]. The average value for P5 from the contractors' perspective was 4.65, which was higher than the value of 4.53 from the consultants' perspective.

Inadequate machinery maintenance (P6) and Delay of material transport from production site to construction area (10) received an average score of 3.76 from both the contractors and the consultants. Their main rationale for the ranking of this factor focused on traffic congestion in Bangkok leading to material delivery delay, consequently giving rise to a delay in construction. In addition, machinery breakdown could cause discontinuous work processes.

Contractor's lack of financial liquidity (P7) had an average score of 4.18 and 4.12 from the contractor's perspective and the consultants' perspective, respectively. A lack of financial liquidity can mean that a contractor is unable to pay laborers, which leads to a shortage of qualified labor and this to work delays. However, a consultant focused on insufficient skill and experience on the part of the contractor, which can cause a lack of financial liquidity because of fines leveled by the owner. Therefore, factor P7 was not always seen as the root cause of the qualified labor shortage. Instead, it could be caused primarily by the contractor's poor skills and limited experience. Thus, this factor had a lower average score from the consultants than from the contractors.

Domestic environmental problems (P8), had an average score of 3.35 and 3.18 from the contractors and the consultants, respectively. According to the contractors, domestic environmental problems in Thailand such as political protests and the climate factor, such as rain and flooding, can occur from time to time. Its impact on causing construction delays, however, are only temporary. In the consultants' perspective, Thailand does not have severe or frequent environmental impact such as the climatic factor problem. In addition, there has been very little in the way of political protests for many years. The consultants, therefore, did not see domestic environmental problems as a likely cause of construction delays [6]. Consequently, the average value of this factor in the consultants' view was lower than that from the contractors' perspective.

Working communication problems (P9) had a 3.59 and 3.71 average value from the contractors and the consultants, respectively. The contractors explained this factor from their experience: many working communication problems were quickly corrected and overall did not give rise to construction delays. Laborers could improve their communication with their supervisor and peers such that the problem could be solved once and for all in that way. From the consultants' perspective, the focus was on the major issues that could be caused by communication problems [29]. They considered such issues as difficult to address such that they would eventually cause construction delays. Therefore, the average value for factor P9 from the consultants was higher than that from the contractors.

Volatile economic conditions leading to materials price increase (P11) had an average value of 3.29 from both the contractors and the consultants. Materials price increase did not directly impact the contractor's financial condition. In fact, owners have usually already entered into agreement with the material supplier and purchased materials [7]. Materials price increase would not affect owners either. However, this factor would have an impact on the material supplier. Still, it impacted the delay in construction, which accounts for the same average score from both respondent groups.

Insufficient space at the construction site to facilitate utility systems (P12) had an average value of 3.24 and 3.29 from the contractors' perspective and the consultant's perspective, respectively. From the contractors' perspective, the focus was on actual experiences pertaining to the space needed to install a utility system. They stated that land in the Bangkok Metropolitan Area is both expensive and hard to come by [28], but a project owner could still rent nearby land for utility installation. Generally, there was sufficient space at the construction site ready for utility installation. Thus, this factor had the least impact on construction delays according to the contractors. The consultants' view was in accord with that of the contractors overall. However, the consultants stressed cases of emergency in which there was no space to install a utility system

at a construction site. Because consultants worked on behalf of the project owner, their responsibilities included helping the owner to realize cost savings. They, therefore understood the owner's attitude to a greater extent than that of the contractor. Thus, they focused on expensive land rent in urban areas as a problem. These causes might lead the owner to lack financial liquidity such that it is no longer possible to pay the contractor at the agreed price [28]. The contractor would, thus, suffer from this factor, too. However, such emergency cases are rare in practice. In the consultants' perspective, the average value for this factor was slightly higher than that of the contractor.

Below-standard construction safety and operation practice (P13) had an average score of 3.35 from both the contractors and the consultant's aspect. The contractors commented that laborers, both Thai and foreigners, should be more intensively trained about safety rules in operation [32]. Mostly, this factor impacted work delays because laborers generally receive inadequate training and communication concerning safety and operation standards. In fact, the contractors saw preventive measures as good training and suggested that their construction foreman or supervisor would be able to prevent this factor from giving rise to construction delays. The consultants' average value of 3.65, which was higher than contractor's aspect. As they work on behalf of the owner, the consultants considered that the control of safety and operations should follow the standard requirements. Major work accidents result in construction work being interrupted, which they held was difficult to resolve. This problem impacted construction delay. In addition, people living in the neighborhood around the construction site were at risk of injury and property damage due to construction site accidents, which also cause construction delays. Moreover, the project owner might lose his public reputation if claims for compensation for loss or damage are not be settled appropriately.

6 Conclusions

The outcomes of this research showed construction contractors' and consultants' respective perspectives on causes of delay in construction. In the first round of data collection, two factors in the contractors' perspective and three in the consultants' perspective did not pass the criteria of consensus value. In the second round, all the factors passed the criteria of consensus, as the responses showed constancy. The first three factors that were similar in both respondent group comprised Shortage of qualified labor (P5), Change order by owner (P1), and contractor's lack of financial liquidity(P7) ranked first, second, and third, respectively. Therefore, these causes were all significant from the perspectives of the contractors and consultants. A comparison was made across the 13 factors representing several viewpoints of the respondents. Some scores showed strikingly similar viewpoints between the groups on some factors, whereas for others the viewpoints were quite dissimilar. In general, the contractors' responses were based on their actual experiences at worksites. They mentioned that every problem could be resolved if they had sufficient cash to hire enough laborers to continue their work. Slow decision making by the owner leading to multiple change orders was the main problem causing construction delays in the contractors' view. Further, contractors sometimes have to abandon some projects that they have already started. In some cases, they are not able to avoid changing the owner's change orders, sic that they find themselves having wasted their time as work may need to be altered significantly. As a result, they lose out financially, especially if they cannot finish on time. Moreover, the contractor will have to cover the daily labor wage. The contractor's lack of financial liquidity linked to the change orders by the owner can led to a shortage of qualified labor.

The consultants report to the owner. Their views were focused on quality and cost-effectiveness in contrast. The contractor is legally obligated to the construction contract and to deliver effective and accurate work to the consultants. Lack of working skill and experience by the contractor's worker results in change orders from the owner. This factor adversely impacts the contractor's financial situation and subsequently leads to a shortage of qualified labor. Other factors also lead to construction delays primarily caused by ineffectiveness including lack of financial liquidity and ultimately causing labor shortages.

The prioritization for each rank and the average scores demonstrate that the views of the contractors and consultants were not vastly different. As contractors and consultants work together, they are aware of the problems that cause delays. However, the outcomes are relevant only to the Bangkok Metropolitan Area of Thailand. These prioritized factors cannot be applied to research carried out in different settings and contexts other than specified in this research. Different conditions, such as regulations, society, economics, technology, religion, and the environment, define the uniqueness of factors leading to construction delays. However, the methodology presented is relevant across contexts, and the results provide outcomes and directions that can provide a basis for advancing research in other contexts.

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