

# Resource Supply Attributes Affecting Delay of High-Rise Building Construction in Thailand

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**Abstract** - Delay is one of the serious problems in the construction industry, particularly in high-rise building construction projects in Thailand. Therefore, this research aims to investigate the major resource supply causes and effects of delay problems in high-rise building construction projects in Thailand. The study employs both quantitative and qualitative study with concurrent mixed method design. Thirty-three resource supply causes and nine effects extracted from the literature review were used as the basis for further analysis. Relative Importance Index technique was used to analyse and calculate to the ranking of resource supply causes and effects of delay in Thai construction projects. The survey results were compared with the interview to unearth the true major causes of delay in Thai high-rise building construction projects. The results showed that the most significant resource supply factors of construction delay were: (1) change orders, (2) financial problem of contractor, (3) slow decision-making, (4) shortage of labour, (5) improper planning, (6) lack of good communication, (7) third party delay such as subcontractors or suppliers, (8) ambiguity of shop drawing designs, (9) shortage of construction materials and (10) late payment by owners. In terms of potential effects, the results indicated that the five most important effects were a delay in obtaining funds and profits for owners and contractors, cost overrun, time overrun, low quality due to hasty work and arbitration. Implications from these findings are further discussed.

**Keywords** - Causes, Effects, Delay, Construction Projects, High-rise Building

## 1. Introduction

The delay problem in the high-rise building construction industry is widely known as a significant factor on a global scale, as well as contributes to unanticipated negative effects on projects. Fundamentally, when projects are delayed, it leads the impacts on the project expectation both in additional costs and extension of time deliverable in the project [1]. Several scholars have mentioned that the causes of delay in many countries. For instance, [2] stated that delay is one of the most important and serious problems which impact the time schedule and related costs in the high-rise building construction projects. [3] defined that the influence of delay factor affects the time overrun which results in either further completion date specified in a contract or the date beyond parties' agreement upon the deliverable of the project goals. [4] mentioned that "the delay as an act or event that extends the time required performing the tasks under a contract"; therefore, he said that delay is a matter that should be considered for the different situations. Even with the advanced of technology and good project management, construction projects still continue to suffer from delay problems and the overdue of completed projects [4]. Consequently, delay is now becoming a major factor of conflict in construction industry and also one of the most difficult to resolve because construction involves large-scale planning [5];[58].

Generally, there are many resource supply factors which cause delay to occur in construction projects, for example slow decision-making from the owners, incomplete shop drawing, contractors' financial difficulties, poor project management, lack of labour, material shortage, change order, communication between main and sub-contractors and external factors [6];[7];[8]. In addition, delay is often interconnected,

making the situation even more complex [9]. All of these factors cause the overall delay of the project expectations. Therefore, delay would result in not only the loss of the owner's revenue due to the lack of availability in scheduling process but also the deterioration of contractors' work due to higher overheads, materials and labour costs [3];[10].

In particular, several previous studies over the last two decades have shown that delay has become the most popular topic in all types of construction projects in many developing countries [8];[11];[12];[13];[14]. In the era of globalization, skyscraper construction projects are regarded as a substantial contribution for developing economy. However, challenges have also equally soared [7];[15]. Thus, the volume, complexity and requirement have also grown over time in high-rise building industry in many countries including Thailand. Interestingly, [10] found that "scarcity of construction materials and human resources has intertwined with existing socio-economic and political problems of developing countries resulting in added pressure on the construction sector". In terms of booming construction industry in developing countries, clients are increasingly concerned about the time schedules and stages of construction and they try to mitigate risks associated with delay by passing the time risk to the contractor along with the heavy liquidated damage for late completion [16].

Reducing the delay problems efficiently can help reduce the time and resources in high building construction projects. Therefore, the objective of this research is to explore the major causes of delay in high-rise building construction in Thailand and identify the potential effects of such delay. Due to the dearth of such studies from the perspective of those involved in high-rise building construction projects in Thailand [17], this research attempts to answer the questions of what causes delay in high-rise building construction in Thailand and what effects of such delay is, which can help the Thai Construction Industry to create solutions to the delay problems in construction or develop a comprehensive guideline to mitigate effects of such delay. In addition, this study can provide the knowledge on critical causes of delay of construction in Thailand, in which studies on this topic are highly limited [18].

The paper is structured with a literature review on the construction of high-rise buildings, resource supply causes and effects of delay after the introduction section. Next, the methodology of the study is

deliberated. Empirical research using a survey and interviews are elucidated to verify the results from both methods of investigation. Finally, the conclusion and practical implications are discussed in the last part of the paper.

## 2. Literature Review

### 2.1 Construction of High-Rise Buildings

The high-rise building or skyscraper is a tall building or structure that is used as a residential, office tower, and hotel, additionally in some areas, the skyscraper is used as a symbol for such countries, for example The Empire State Building in New York, The Burj Khalifa in Dubai and The PETRONAS Twin Towers in Malaysia [19]. According to [20], a high-rise building is a multi-storey structure where the height is set between 75 feet (23 meters) and 100 feet (30 meters) or more than 100 feet in order to fully utilise tight space for accommodation and business.

In globalization and modern business era, the high-rise building is one of the most significant elements to achieve in terms of economy and urbanization in many developed countries. The skyscrapers were built in large countries and have been raised continuously in order to stimulate commercialism [20]; [21]; [22]. There are many reasons why tall buildings are given an emphasis in modern urbanization. According to [23], the two main reasons are apparently to accommodate influx of people immigrating to urban areas for work and to save commuting time which can help increase productivity and reduce fuel consumption and provide more public facilities to raise the quality of life.

The globalization processes have substantial influence on the spreading of skyscrapers in major cities nowadays. At the same time, the globalization has also been established as an implementation for a new innovation to improve an opportunity and openness of the modern business particularly from the Western culture [22];[24];[25];[26]. In addition, [22] stated that the outcome of skyscrapers expansion is shown as the growth of wealth in economic benefits in terms of global tourism and political views that represent the promotion of places through the symbols of prosperity in cities. For instance, Dubai is known as the city of prosperity from the expansion of skyscrapers in order to express the aspiration of the wealth. Identically, Shanghai wanted to boost its status and communication into a centre of the global commercialism in terms of world economic,

industrial furtherance and scientific advancement. Consequently, Shanghai improved economy growth rapidly and became the hub of economic, commercial, financial and industrial either China or mighty countries due to the explosion of a number of skyscrapers so that could gain more confidence and attach foreign investors into Shanghai [27].

Undoubtedly, in the last two decades in globalization era, there are a number of skyscrapers that have been completed in the world continuously. Particularly, [28] noted that 106 tall buildings of 200 meter's height were completed around the world in 2015 which became a new setting record for annual high-rise building completions. Asia outperformed other regions as it achieved the number of 81 from the 106 completed skyscrapers in 2015. As a result, it seems that the trend of high-rise buildings is still growing continuously either in developed or developing countries because of limited space in the crowded cities and improving rural area into the modern city. At the same time, the trend towards of high-rise buildings in Thailand has continually evolved in, particularly in capital city, Bangkok.

There were 44 completed skyscrapers after the turn of 21<sup>st</sup> century and it is also estimated that in 2020, 23 high-rise buildings will be completed. Moreover, Thailand has a mega project of skyscraper named The Super Tower, which will become the tallest building in South-East Asia and will be recognized as the top-ten tallest skyscraper according to [29]. The Super Tower will be the new centre of business and also becoming one of Bangkok's most important economy hubs upon completion because it will be located in the centre of Bangkok and easily accessible by mass transit [30]. Hence, the expansion of skyscrapers is becoming popular in many developing countries including Thailand which helps to contribute to the rapid expansion of the economy in the ASEAN region, as well as becoming a leader of commercialism and business. In order to complete the high-rise building project within expectations, the construction will encounter an obstacle that is the delay problem in project. Delay is the most significant problem among construction industry and become a global phenomenon as several researchers have studied [2];[3];[31];[32]. Similarly, delay and poor performance in Thailand construction were the most common problems as scholars mentioned [7];[33];[34];[35]; [36].

## 2.2 Causes of Delay

As previously stated delay is mostly known as a major problem in the whole construction industry as well as becoming a global phenomenon. Thus, the examination of delay causes can help accomplish the project's expectation as several scholars studied. For example, [3];[13] argued that the issues of delay are time overrun either beyond the contract date agreement or beyond the date that each party have agreed upon for project deliverable, and therefore, in both cases, a delay would lead to costly damage in the project. [2] defined that the delay is one of the most and serious problems which lead to time overrun as well as related exceeding costs in high-rise building construction industry. However, delay is caused by many factors in construction project, which are based on experiences, perceptions and situation in each project within difference countries.

The causes of delay can be influenced by many factors from different countries. In order to identify the major causes of delay, the delay is categorized into different resource supply groups according to factors causing the delay in which numerous researchers have studied. For instance, [13] classified the delay causes in Egyptian by categorizing seven resource supply groups as: owner related, consultant related, contractor related, material related, labour & equipment related, project related and external factor related. Similarly, [3] investigated causes of delay in Saudi Arabia by listed seventy-three causes of delay categorized into nine resource supply groups as: owner, contractor, consultant, design, project, materials, equipment, labour and external factors. At the same time, [37] studied the factors affecting delay in Indian construction project by separating attributes affecting delay into six resource supply groups which were project related, site related, process related, human related, authority related, and technical issues. Consequently, these factors were utilised in the questionnaire in Thailand in order to analyse the major causes of delay in Thai construction projects.

## 2.3 Effects of Delay

Delay problems are significant in construction industry. From previous research of the effects of delay factors, it is also important to understand the consequences and outcomes arising from delay causes. According to [38], the utmost serious problem from the delay in construction industries is either cost or time overrun in construction projects. For example, [39] suggested that the time and cost overrun are a critical effect from delay problem in construction project occurring from change

orders in scope of working on site, incompleteness of design during the tender, contractual claims and delay in costing modification and additional works in the project. Similarly, [40] demonstrated that the causes of cost overrun in Ghana construction sector are delay in payment between owners and contractors, variations, inflationary cycle and the postponement in time schedule.

Moreover, the effects of delays and disruptions have been explored by other scholars, for instance, a study by [41] revealed that six major effects of delay process in Nigerian construction industry which were time overrun, cost overrun, dispute, arbitration, abandonment and litigation. In addition, the study from Malaysia by [1] revealed the same six effects by [41] studied in Malaysian construction industry. Hence, all of these effects are critical damage caused by the delay and

disruption in construction projects.

However, the overall delay in construction projects can occur from several factors which are either caused by owner's responsibility or contractor's responsibility. As a result, the overlapping nature of delay effect has different influence on each party involved in the construction project even though the usual problem is time and exorbitant costs [42]. Delay has huge effects on each party who participate in construction projects, especially in high-rise building projects. In this research, the main problems of delay were categorized into six related factors in order to identify the actual delay and impact of delay related to high-rise building projects in Thailand.

Based on the literature review, the following tables (Table 1 and 2) on causes and effects of delays were formed to be used in research design.

Table 1. List of Causes of Delay Categorized into Six Resource Supply Groups

Resource Supply Category	Resource Supply Attributes Affecting Delay	Source
<b>1. Owner related</b>	R1 Change order	[1];[8];[13];[43]
	R2 Slow decision-making	
	R3 Unclear with shop drawing design	
	R4 Late payment by owner	
	R5 Negotiation of contracts	
<b>2. Consultant related</b>	R6 Contract management	[14];[37];[44]; [45]
	R7 Preparation and approval of drawing	
	R8 Lack of knowledge and expertise by consultant	
	R9 Delay in approving major change	
	R10 Late in review and approving design documents by consultant	
	R11 Poor communication Between consultant	
<b>3. Contractor related</b>	R12 Improper planning	[13];[46];[47];[48]
	R13 Improper site management	
	R14 Lack of experience	
	R15 Third party delay such as sub contractor or supplier	
	R16 Lack of good communication	
	R17 Financial problem of contractor	
	R18 Frequent change of sub-contractor because of their inefficient works	
	R19 Shortage of construction materials	
<b>4. Materials related</b>	R20 Change in material types and specification during construction	[3];[37];[46]
	R21 Delay in manufacturing of special materials	
	R22 Delay in procurement of supplier's materials and delivery	
	R23 Damage in ordered materials	

<b>5. Labour related</b>	R24 Shortage of labour	
	R25 International labour problems, e.g. communication and legal	[3];[37]
	R26 Low productivity level of labour	
	R27 Unqualified workforce such as dispute or strike	
	R28 Weather hot, rain, etc.	
<b>6. External related</b>	R29 Change in government regulations	
	R30 Transportation, traffic jam and restriction	[7];[46];[49];[50]
	R31 Location of site working	
	R32 Delay in performing final inspection and certification by a third party	
	R33 Effect of social and culture in company/organization or working with other parties)	

Table 2. List of Effects of Delay

Effect of Delay	Source
1. Time overrun	[1];[43];[47]
2. Cost overrun	
3. Disputes	
4. Arbitration	
5. Abandonment	
6. Negative social impact such as neighbour	
7. Low quality of work due to hurry	
8. Idling resources	
9. Delay in getting either funds or profits by both of clients and contractors	

### 3. Methodology

#### 3.1 Research Design

This research utilized both qualitative and quantitative methods, concurrent mixed method design, to answer the research questions and explore the causes and effects of delay in high-rise building construction projects in Thailand. For qualitative method, the survey was then conducted to rate the importance of causes and effects of delay. For qualitative method, interview was conducted to gather in-depth information and discover the main causes and effects of delay in high-rise building construction projects in Thailand. The research process was shown in Figure 1.

#### 3.2 Population and Sample

The research utilized the population of workers involved in the

construction projects in Bangkok. The sample used in the interview was project managers and consultants who worked in Noble Ploenchit project which is located in Bangkok, Thailand. For the survey, the sample was 51 professionals engaged in private construction firms in Thailand who have vast experience working in construction industry. The 51 professionals were project engineers, architects, consultants, project owners, construction managers and project managers. The top-three ranking response was from project engineers (34.78%), consultants (30.43%) and project managers (26.09%). The others were project owners (10.87%), following by construction managers (6.52%) and architecture (2.17%). In addition, 52.17% of the sample had more than ten years of experience in construction industry, following by the equal percentage of two to five years and five to ten years at 19.56%. Moreover, five owners, five consultants, and five contractors were selected purposively to attend the in-depth interviews.

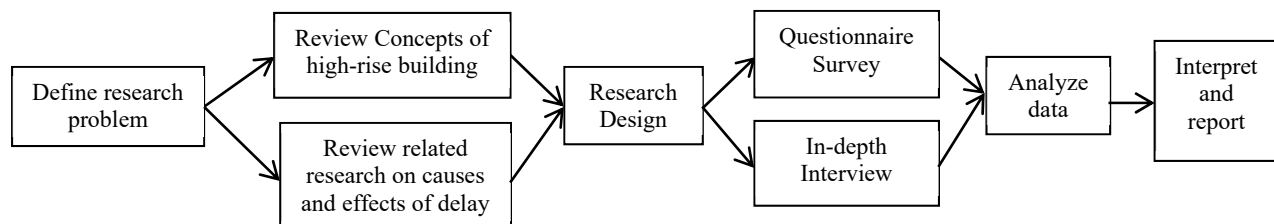


Figure 1. Research Process

### 3.3 Research Instrument

Questionnaire was created based on the literature review [51] of different resource supply causes and effects of delay and employed to examine the several issues associated with the delay problems in Thai construction projects. The questionnaire was divided into three sections. The first section focused on the background of respondents. The second section focused on the causes of delay categorized into six main resource supply groups which were owner related, consultant related, contractor related, material related, labour related and external factor related. The third section focused on the effects of delay factors. Likert scale ranging from (1 = not at all important, 2 = slightly important, 3 = moderately important, 4 = somewhat important, and 5 = extremely important) was used to rank the importance of delay from the resource supply causes and effects in high-rise building construction projects in Thailand. Moreover, the interview form was created to gather the data concurrently.

### 3.4 Data Collection and Analysis

In this research primary data was gathered through interview and survey. Secondary data was collected through previous research and case study. For the data analysis, content analysis was performed on the data collected from the interview. The Relative Importance Index was adopted for data analysis of the data gathered from the survey. The relative importance index (RII) was evaluated as follows:

$$RII = \frac{\sum W}{A * N}$$

W = weighting given to each factor by the respondents (ranging from 1 to 5), while A is the highest weight (5 in this research) and N is the total number of respondents in this research.

The RII was transformed into the relative importance delay such as subcontractor or supplier with RII=0.80.

Significantly, the results signified that the greatest causes of resource supply affecting delay in Thai construction projects were originated from owner related factors followed by the contractor and labour related factor. Nevertheless, it seems that the external factors had the lowest frequency scores. Thus, it is interesting to compare the causes of delay as acknowledged from the survey with the interview in

indices of each delay and effect factor to define the ranking of different resource supply causes which was essential for respective factors as perceived by the respondents. In addition, the perspectives were arranged in upwards order of ranking in which attribute with the highest RII indicated the most important resource supply causes and effects of delay, while the attribute with lowest ranking indicated that the least important effect of delay in Thai construction projects.

## 4. Results

### 4.1 Relative Importance Index (RII) Ranking of Causes of Delay

The results from Relative Importance Index showed in Table 3 revealed that the seven most important resource supply affecting delay which account more than 80% were change orders, financial problem of contractor, slow decision-making, shortage of labours, improper planning from contractor, lack of good communication between each party and third party delay such as subcontractor or supplier. Based on the ranking, the results indicated that the most critical resource supply attributes affecting the delay as perceived by owner related were: (1) change orders with RII=0.86 followed by, (2) the slow decision-making with RII=0.84, (3) ambiguity of shop-drawing design with RII=0.78 and (4) late payment by owner with RII=0.77.

Meanwhile, the most important causes of resource supply affecting delay as recognized by consultants were: (1) delay in approving major changes with RII=0.77, (2) preparation and approving of drawing with RII=0.76 and (3) lack of knowledge and expertise by consultants with RII=0.72.

Simultaneously, the most crucial causes of resource supply delay as realized by contractors were: (1) financial problems of contractor with RII=0.85 followed by, (2) improper planning with RII=0.83, (3) lack of good communication with RII=0.82 and (4) third party order to investigate the true major causes of delay in Thai high-rise building construction projects.

Even though the three common relationships as owners, consultants and contractors played significant roles in delay causes in Thai construction projects, there were other issues that also influenced the delay from respondent's perspective which were as shortage of labour with RII=0.84, shortage of construction materials with RII=0.78, transportation, traffic jam and restriction

with RII=0.73 and both change in special materials during the construction and delay in manufacturing of special materials with the equal frequency of RII=0.72.

On the other hand, the results indicated that there were 14 causes which were not the necessary resource supply factors affecting delay in Thai construction with the frequency lower than 0.70 percentages. The 14 causes were, negotiation of contracts, contract management, improper site management, international labour problems such as communication and legal issues, location of site, delay in performing final inspection and certification by a third party, late in reviewing and approving design documents by consultants, poor communication between consultants and other parties, delay in procurement of supplier's materials and delivery; hot weather, rain, effects of social and culture in company/organization or working with other parties; change in government regulations, unqualified workforce such as dispute or strike and damage in ordered materials.

Table 3. Ranking of Causes of Delay in Thai Construction Projects from RII Analysis

Cause of Delay	RII	Ranking
R1 Change order	0.86	1
R17 Financial problem of contractor	0.85	2
R2 Slow decision-making, R24 Shortage of labour	0.84	3
R12 Improper planning	0.83	4
R16 Lack of good communication	0.82	5
R15 Third party delay such as subcontractor or supplier	0.80	6
R3 Ambiguity of shop drawing design, R19 Shortage of construction materials	0.78	7
R4 Late payment by owner, R9 Delay in approving major change	0.77	8
R7 Preparation and approval of drawing	0.76	10
R18 Frequent change of subcontractor because of their inefficient works	0.74	12
R30 Transportation, traffic jam and restriction	0.73	13
R8 Lack of knowledge & expertise by consultant, R14 Lack of experience, R20 Change in material types and specification during construction, R21 Delay in manufacturing of special materials	0.72	14
R26 Low productivity level of labours	0.70	15
R5 Negotiation of contracts, R6 Contract management such as	0.67	26

communication and legal, R31 Location of site, R32 Delay in performing final inspection and certification by a third party		
R10 Late in reviewing and approving design documents by consultants, R11 Poor communication Between consultants and other parties	0.65	28
R22 Delay in procurement of supplier's materials and delivery	0.63	29
R28 Hot weather, rain, etc., R33 Effect of social and culture in company/organization	0.61	30
R29 Change in government regulations	0.60	31
R27 Unqualified workforce such as dispute or strike	0.59	32
R23 Damage in ordered materials	0.55	33

#### 4.2 Relative Importance Index (RII) Ranking of Effects of Delay

Based on the ranking, the most important effect in construction delay as perceived by respondents was delay in obtaining the funds and profits by either owner or contractor with RII=0.94. Furthermore, this is closely followed by the cost overrun with RII=0.90, and then time overrun with the RII value of 0.88. According to the table above, time is a crucial factor in every phase of construction and it can also increase in the final cost which means that more money has to be spent. Hence, it can be seen that that loss the personal benefits for both owner and contractor is the most essential effect of the delay issue in construction projects in Thailand. Undeniably, the investor wants the funding and business profits to turnover as soon as possible. Therefore, if the project is delayed, it means that they cannot gain the money back. Effects of delay in Thai construction project with medium importance were low quality of work due to haste with RII=0.77, arbitration with RII value of 0.75, disputes with value of RII=0.73 which had equal frequency with negative social impact from neighbour. Project abandonment was ranked the second least important with RII=0.69. Finally, the least important effect of delay in Thai construction was idling resources with RII value of 0.62, as shown in Table 4.

Table 4. Ranking of Effects of Delay in Thai Construction Projects from RII Analysis

Effect of Delay	RII
Delay in obtaining funds or profit by either owner or contractor	0.94
Cost overrun	0.90
Time overrun	0.88
Low quality of work due to haste	0.77
Arbitration	0.75
Disputes	0.73
Negative social impact from neighbor	0.73
Abandonment	0.69
Idling resources	0.62

### 4.3 Interview Results

The results from the interview, as shown in Table 5, revealed the main resource supply causes and effects of delay. From the owner's perspective, resource supply causes that affect delay were ambiguity in both processes of tendering and shop drawing and slow decision-making in terms of approving design and special materials. This means that the owner's decision has huge influence on when the project should begin, thus the details should be finalized as soon as possible. While, the main effects of delay were interruption in getting either funds or profits by both of clients and contractors and cost turnover. The personal benefits of both owners and contractors are the most essential effect. From the consultant's perspective, the main causes of resource supply that affects delay

were the approval of the design and shop drawing. Whereas, the main effects of resource supply that affects delay were time overrun due to the forecasting and planning of the master construction, including unforeseen of the weather, political and location. In addition, design changes and slow decision-making were the most critical factors of resource supply that affects delay related to the owners and consultants who have the power in the decision-making process. From the contractor's perspective, the two most significant causes of resource supply that affects delay were shortage of labour, lack of experience from project manager and external factors such as weather, politics and location. While, the main effects were low quality of work due to hurry and quality of the contractor firm in term of manpower and facilities.

Table 5. Causes and Effects of Delay Conducted from Interview

Interviewee	Cause of delay	Effect of delay
<b>Owners</b>	Ambiguity in both processes of tendering and shop drawing and slow decision-making in terms of approving design and special materials	Interruption in getting either funds or profits by both of clients and contractors and cost turnover. The personal benefits of both owners and contractors are the most essential effect.
<b>Consultants</b>	Approval of the design and shop drawing	Time overrun due to the forecasting and planning of the master construction. Unforeseen of the weather, political and location.
<b>Contractors</b>	Shortage of labour, lack of experience from project manager and external factors such as weather, politics and location	Low quality of work due to hurry and quality of the contractor firm in term of manpower and facilities.

As compared with the survey findings, the interview results showed that the factors of resource supply that affects delay which were ambiguity of shop drawing and shortage of labour played a large role in delay of Thai construction projects. However, the interview results did not indicate that the financial problem of contractors was an enormous factor of delay, which is contrary to the survey results which showed that the

financial problem of contractor was a major factor of delay with the second ranking of RII.

## 5. Discussion

The six factors of resource supply causes of delay are discussed from the analysis of RII to compare with the results from the interview in order to examine the major causes of delay in Thai high-rise



building construction projects. Results of effects of the delay problems in Thai high-rise building construction projects are then discussed. Finally, each effect is linked with the causes of resource supply to find the possibility of relationship between causes of resource supply and effects of delay in Thai construction projects. It answers both research questions and provides accurate insights of the causes and effects of Thai high-rise building construction projects.

From the data analysis, the change orders during construction are the most important delay factor which was obtained from both the survey and interview. Similarly, the change orders are one of the most significant problems [52];[47];[43]. Essentially, the change orders are an inherent portion of the construction industry. As change orders of various forms depend on the decision of the project's owner, all participants should be involved during the project progress meetings in order to find a solution to prevent changes in operation and avoid conflicts. Furthermore, the third most important factor in RII ranking is the slow decision-making from the owners which results in delay in Thai construction projects. This is the same as the study in Hong Kong by [8]. Since the owner has the largest influence on decision-making, if owner cannot determine various procedures that can cause disruption in construction process, delay can occur which affects task scheduling. Slow-decision making can lead to increase in the final cost and time wasting, resulting in time and cost overrun in the project.

However, ambiguity of shop drawing design and late payment by owner is also an important factor in construction process [45];[44]. In terms of ambiguity of the shop drawing design, it is caused by the above two main factors which are change orders and slow decision-making. Thus, it indicates that if the owner cannot determine the project's requirement, it would affect other parts implicitly. In respect of delay in payment, which is one of the main delay issues in construction industry, it can cause a major delay which affects each party in the construction process, particularly the main contractor. Delay in payment can affect activities in the construction projects. Consequently, task progress might be delayed or even ceased if the payment is prolonged by the owner [44].

Consultants, moreover, play a key role when the owner has already determined the design and shop-drawing. The delay from consultant related factor is approving a design and documents for the contractor on time to meet the expectation. Similarly, the results showed that the delay issues from consultants were approval of the design, shop-drawing and change process. Therefore, the project consultants should be fully aware of the requirements by explaining project objectives from the owner clearly to ensure that the contractor understand the specifications, shop-drawings, schedule and cost budget so that all the owner's requirement will be achieved and handed over to client on time [53]. This is consistent with the factor of lack of knowledge and expertise from consultants. Since, the consultants are an intermediary who coordinate and communicate between the owner and the contractor. Therefore, the consultants should have technical experience and managerial knowledge to ensure that the objectives are clear and can be accomplished while meeting the client's requirements [53].

Contractors, furthermore, are a key variable in the construction process that can cause delay problems in construction projects. The results in this study showed that there were four main resource supply causes ranking in top-ten of Relative Importance Index which were financial problems, improper planning, lack of good communication and delay from third party such as subcontractor. Undoubtedly, the financial problem is the most critical delay factor. This is due to the contractor's lack of the financial liquidity which can occur from mismanagement of cash flow of contractor or late payment by the owner. In addition, it will affect to their subcontractors who signed the contract agreement under the contractor's conditions. As a result, it will have an impact on the financial stability of subcontractors which will affect their ability to maintain their work progress, ultimately leading to bankruptcy [44].

Improper planning and lack of good communication were also major delay of the resource supply causes. Improper planning can cause many serious problems to the contractor and affect the owner's or client's expectation. Contractors with inadequate experience cannot plan and manage the project properly and it may lead to disastrous consequences [1]. Therefore, the

project manager should make sure that planning is properly understood and agreed by the project sponsors and key stakeholders in order to ensure that each perspective from each participant is in agreement and would be seen in the same direction.

Delay caused by the third party such as subcontractors and suppliers can be attributed to late payment from contract's parties, inadequate experience of third party and improper planning and coordination between the main contractor and the third party. Hence, the main contractor should ensure that the contract must be comprehensive to subcontractors. Additionally, the penalties should be specified in case of delay or abandonment of work from subcontractors.

Besides, the material related factor received low ranking except for shortage of construction materials which showed the highest ranking in this section. Based on RII ranking, it can be inferred that shortage of material is a significant resource supply cause in the construction delay. Since Thailand has a growing construction industry, demand for material exceeds supply. This results in the shortage of basic materials in construction projects such as sand, cement, steel and concrete. In terms of special materials in construction projects, the result showed that it can cause the delay. This issue can be solved by appropriate purchase planning allowing for time lag between order placements and material delivery.

In addition, shortage of labour is one of the main resource supply factors which can affect delay in projects. Both quality and quantity of labour can have a major impact in Thai construction. There are two main causes of shortage of labour. First, a number of construction workers in Thailand are principally illegal workers who have migrated from neighbouring countries such as Myanmar and Cambodia. Big groups of foreign workers would migrant to work in Thailand due to political and economic instability in their home country and higher salary in Thailand [54]. However, there is a big issue with illegal workers because most come to work in Thailand irregularly. [55] argued that "the number of migrant workers from Myanmar who entered Thailand irregularly and are still in or have completed the regularization process is around 1.2 million. In comparison, the number of unskilled migrant workers who come to work in

Thailand through official state-run programs is only 36,650". As a result, illegal workers are often caught by the Thai immigrant officials and deported; therefore, this resource supply causes delay problems due to shortage labour in Thai construction projects.

For the external factors, they have the lowest ranking. The results showed that the transportation, traffic jam and location of site had the highest ranking in this section even though it was not the main resource supply that affects delay in this research. As the research was conducted on the high-rise building construction projects in Bangkok which is the capital city and the centre of tourism, business and economy of Thailand, the construction process can be quite difficult and complex and various external factors can cause delay.

Previous study in Thailand discovered the most important resource supply effects of delay were cost overrun and time overrun. However, this study uncovered surprising results in which the number one ranking of effect was the delay in obtaining funds or profits by either the owner or contractor. This means that the majority of respondents believed that the most important effect was caused by financial problems and late payment of each project participants whether it is the owner or the main contractor. This matches with the second most important resource supply cause of delay which is financial problem by contractor and the tenth most important resource supply cause of delay which is late payment by the owner.

Both time and cost overrun are the effects in construction in Thailand even though they are not the most important. These effects result from the top ten most significant resource supply causes of delay which were discussed earlier in which five causes belong to owner related and contractor related factors which are change orders, slow decision-making, shortage of labour, improper planning, ambiguity of design. There were some researchers who argued that cost overrun occurs more than the extension of time [11]. The reason can be the change orders in the deliverables, requirement and mistake, and discrepancies in the contract document can be the cause of cost overrun [1]. However, when time is past the prediction, it will affect to overall cost which was estimated

before the project started. Therefore, time overrun can lead to cost overrun.

## 6. Conclusion

The delay problem is a significant in construction industry, particularly in the high-rise building construction projects in the globalization era. Principally, this research revealed 33 essential resource supply causes and 9 effects of the delay problems in Thai construction projects. In this research, the questionnaire survey was designed and distributed among the major groups of project participants (owners, consultants, contractors and project engineers). The results from survey showed that the ten most significant resource supply causes of delay were: (1) change orders, (2) financial problem of contractor, (3) slow decision-making, (4) shortage labors, (5) improper planning, (6) lack of good communication, (7) third party delay such as subcontractors or supplier, (8) unclear with shop drawing design, (9) shortage of construction materials and (10) late payment by owner. On the other hand, the results from the interview showed that design change, shortage of labour, and delay in procurement were generally problems in construction projects.

Additionally, delay causes from resource supply related to the owner were change orders in the approving process of design and special materials and slow decision-making. The important delay causes from resource supply related to the main contractor were shortage of labour and lack of experience of project manager. However, from the interview, the financial problem was not found as the major resource supply cause of delay, which showed a strong contrast from the RII results indicating that financial problem was the second most important resource supply cause of delay from the survey. It can be seen that the contractor's financial problem might occur in some companies when there is insufficient cash flow to support construction expenses, particularly those of subcontractors. As a result, work progress can be delayed due to insufficient cash to pay the subcontractors which will lead to the delay caused by third party such as subcontractor and supplier.

The results indicated that the top five effects were delay in obtaining funds and profits by owner or contractor, cost overrun, time overrun, low quality

work due to haste and arbitration. It can be seen that both time overrun and cost overrun are the universal effects from the delay problems which have an inherent impact on every project. These results are more likely to be the same as the research conducted in other countries [1];[45]; [47];[56]. It can be said that these two effects occur concurrently and may affect each project participant in terms of contract through claims on the additional principle and extra time connected with the construction delay. The effects of delay are different for different parties. The common concerns are loss of wealth, time and capacity [56]. For example, from the owner's point of view, delay means the loss of income due to incomplete construction or inconvenience of service facilities. From the contractor's perspective, delay means the loss of extra money to spend on equipment, materials and more money spent to hire the labour over the contract period and loss of time to begin a new project.

The most important resource supply delay factor is related to the owner. The change orders and slow decision-making from the owner are the most significant delay. Nevertheless, the main contractors also play a key role in the delay issues whether it is financial problem, shortage of labour or improper planning. Therefore, it is clear that the major resource supply causes of delay in Thai construction project are related to the project owner and contractor. The consultants are less likely to contribute to the delay factor in line with RII results. It may seem that the role of the consultants is related to some delay factors which are approving design or documents. However, this role will mostly be the main duty of the owner. That is the reason why consultants contribute less to the delay of Thai construction in this research.

Moreover, delay in obtaining fund and profit by either owner or contractor has the highest ranking of effects of delay in Thai construction projects, following by time overrun and cost overrun. It can be seen that these three effects are the critical factors which occur from change orders, financial problem, slow decision-making and lack of readiness of labour and facilities. All of these delay factors have the utmost influence on time overrun as well as cost overrun. These factors can be said to be the main cause of delay of obtain funds and profits by either owner or contractor. Moreover, if

the project cannot be completed due to the protracted delay issue, the ultimate serious effects can be disputes, arbitration and project abandonment. However, these serious effects do not often occur in high-rise building construction projects in Thailand which can be inferred from the low importance index from respondents' experience. The reason is that if the project is delayed, the contractor will find out the reason why the project has the delay issue and discuss with the authority in order to identify the solution which is acceptable for each party.

The results of this study revealed that there are a number resource supply causes and effects of delay problems in Thai construction projects. The most important resource supply causes of delay are linked to effects of delay. Therefore, decreasing the delay in construction project in Thailand is essential. In order to reduce the delay in construction project, it is suggested that each party should work together from the beginning of project. The meeting for all project participants can help them have clear objectives and work towards the same goal. This process might help all parties to be in agreement which can prevent change orders and design change which are the most significant causes of delay. The whole project planning should be completed before the project starts in order to reduce the changes during the construction. At the same time, to reduce delay caused by improper planning, shortage of labour and materials during the construction, project managers should have a master plan which is a comprehensive plan.

Moreover, the master plan should have a subordinate plan to forecast the progress of time schedule monthly and weekly in order to follow up and monitor that the task is being done on schedule. Furthermore, this method might help the project staff to check if there are sufficient materials and labour to achieve the requirement. Additionally, the work progress must be reviewed to track the project progress to predict what problem can cause the delay and check what task is not completed. It is essential for contractors to monitor problems during the construction because they can prevent delay problems by monitoring the progress closely. Thus, good relationship between each party is necessary to complete the project without the delay problems. Each party should have mutual agreement and work in the same direction.

The future study should be more balanced in terms of role and position of three main parties who have authority in decision-making - owners, consultants and main contractors with the larger sample size. The interview on the resource supply causes and effects of delay, moreover, should include the owner's opinion apart from project managers and consultants' views since there is a different factor in the delay issue. Moreover, the future study should incorporate the integration among partners. In addition, it should focus on the material suppliers and customers which were not explored in this study. The integration of supply chain in the construction projects needs to be further studied as it can help reduce the cause of delay and it is a key issue that needs to be emphasized [57].

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