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CAUSES OF DELAY IN CONSTRUCTION PROJECTS

BY

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Abstract

The construction industry is struggling by numerous recorded incidents of delay due to improper planning and/or implementation of required construction measures. Globally, researchers have concluded that the construction environment is overloaded with more frequent delays when compared to other labor enforced industries. Over the past decade, infrastructure and project development in developing countries have experienced major growth. Since there are huge investments on construction activities that all of a sudden happen in a very narrow considerable construction period, it is expected that construction fields suffer from severe delays during construction. Construction stakeholders need to enforce huge efforts to facilitate the smooth flow of construction projects. The aim and objective of this project is to identify the most significant delay attributes affecting the construction industry. After a review of the literature, a list of 42 delay attributes were gathered and presented in a survey questionnaire. The survey was distributed through online website and sent to various experts in the construction industry. 179 complete responses were received and analyzed by importance index, Spearman's rank correlation, T-Test, risk mapping and factor analysis. As a result, it was found "low productivity of labor", "delay in decision making", "changes to the project by owner", "delays related to sub-contractors work", and "unqualified workforce" were ranked as the most significant delay attributes in construction industry respectively.

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1 Introduction

1.1 Overview

A lot of research has been performed on identifying delay attributes to improve the overall the construction industry performance. Due to the transitory nature of the industry, consideration of influential delay attributes in implementation of a work activities, are unique from country to country. This study was conducted to identify the most influential delay attributes affecting the construction industry.

1.2 Statement of the Problem

Construction industry main focus has always been on the superstructure, infrastructure, and oil and gas industry. Huge emphasis was diverted towards travel, tourism and transportation for the development of infrastructure projects in developing countries, which attracted a lot of foreign construction contractors, consultants, suppliers and diversified workforce to interfere and to be evolved in such huge investment. Reducing worksite delays in such projects require knowledge and attention. Therefore, it is important to identify the influencing delay attributes affecting construction projects.

1.3 Objectives

The main objective of the project is to identify major delay attributes affecting construction projects. Data were accumulated using an online survey to measure the differences and significance of the attributes according to industry experts. These results of the data analysis can be used to help owners, international contractors, and many other construction stakeholders to reduce the impact of delays on the construction sites.

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1.4 Methodology

The steps followed for the entire project are summarized below:

- Review of relevant literature to identify and draft a list of delay attributes affecting construction projects.
- Gathering data by the means of a 5-point Likert Scale survey questionnaire based on importance and frequency.
- Analysis of data was executed based on various statistical analyses such as: importance index, Spearman's Rank Correlation, T-Test, risk mapping matrices and factor analysis.
- Results were discussed and analyzed. Final conclusions and recommendations were made.

1.5 Project Organization

This project comprises of five chapters:

A. Chapter 1 presents the introduction to the research done. This is composed of the overview, objectives, problem statement, methodology and the project organization.
B. Chapter 2 includes the literature review of earlier work performed by other researchers.
C. Chapter 3 is a discussion of the research methodology used in the project.
D. Chapter 4 discusses the collected data and presents the results.
E. Chapter 5 summarizes the results obtained in the project along with major conclusions and recommendations for further work.

2 Literature review

Numerous studies and researches contributed in defining the concept of construction delay. According to research, Construction delay could be referred to as not achieving desired project duration upon contract agreement [1]. Or it could be considered as an unforeseen uncertainty in the construction phase of projects [3, 6]. Another research defined delays as challenges during projects execution [4]. Many others had identified delays as "time overrun, which caused extension of time to complete construction projects", resulting in project completion date other than planned or expected [4-8, 21].

According to many studies, there is always a need in each developing country to explore, identify and examine causes of delays in construction; it was found that 70% of construction projects failed to meet planned completion date in KSA [25]. Others stated that delays are almost occurring in most of construction projects although effect of each delay varies from project to project [6]. The delays in construction are common globally and considered to be most endless difficulties occurrence [4, 6, 34]. In developing countries, construction employs high margin of the economy of these countries [21-36], whenever time equals money in construction, delays may result in late completion, increased cost, loss of productivity and quality of construction projects [1]. In Nigerian construction projects, it was found that 80% cost overruns were due to time overruns [30], as well as it was identified that 55% time overrun in India were construction projects [11].

Remarkable worldwide researches were developed along the history of construction aiming to point out concerns of delay factors in construction projects that will be studied to identify construction delay factors. As many of previous studies conducted ranking causes of delay according to relative importance index or their means using respondent results yield from survey or questionnaire using 5 points Likert Scale.

Research performed by Gunduz et al [1] proposed to provide decision aid tool that uses fuzzy logic incorporated with relative importance index to measure the probability of time overrun factors in construction projects before bidding. With the help of literature review and interviews, the authors came out with 83 delay factors classified into 9 groups. Using relative importance index to rank responses of Interview questionnaire filled by 64 experienced construction professionals to assess delay factors importance with 5 points Likert Scale that resulted in top 5 factors ;

- "Lack of experience of contractor"
- "Deficiency in planning and scheduling"
- "Poor site management and supervision"
- "Changes to the project by owner"
- "Delays due to material delivery"

A study conducted by Hossen et al. [3] developed a questionnaire survey of 32 delay factors with the help of literature. The authors developed risk assessment map via combined analytic hierarchy process (that includes data obtained from survey about frequency and Relative Importance Index procedure), to study construction delays in nuclear power plants.

Research performed by Luu Truong Van et al. [4] rated 28 construction delay factors in Vietnam through 6 different categories based on mean values developed using questionnaire consisting

distributed among 220 participants out of whom 169 had responded. From the completed questionnaires and further conducting factor analysis, it was concluded that "project conditions" is the most prevailing of the 6 factors affecting performance in the construction industry. The authors have concluded that the factors relating to owner and contractor have the highest impact on the project completion.

A study conducted by Marzouk et al. [5] developed a survey based on 43 delay factors categorized under 7 categories. The authors developed risk map assessment using Importance Index, Severity Index, and Frequency Index to study the construction delays in Egypt.

A study conducted by Gardezi et al. [6] used relative importance index to rank 27 delay factors in Pakistani construction industry.

Another study conducted by Aziz [5] ranked 99 delay factors grouped into 9 groups using Relative Importance Index.

Alinaitwe et al [8] established a survey to collect responses based on 5 point Likert scale about 20 factors of delay in Uganda's Public Sector Construction Projects.

Mahamid [9] resulted out with study to develop a risk matrix for factors affecting road projects, using collected survey data to rate 45 factors in terms of frequency and severity.

Relative importance index and Factor Analysis were used in order to evaluate 45 delay factors in Indian construction projects using results gathered from survey questionnaire by Doloi et al [11].

Gidado et al [12] identified 83 factors from literature. By means of a survey questionnaire distributed to 60 respondents involved in construction, the authors have validated and ranked the factors based on the perspectives of 3 groups' owner, consultant, and contractor.

Khoshgoftar et al [13] investigated 28 factors that cause construction delays in Iran construction industry developed from literature review. The most significant factors in the study were:

- “Delay of financing and payments by owner”
- “Poor site management and supervision”
- “Deficiency in planning and scheduling of project”
- “Lack of contractual management“
- “Poor communication and coordination with other parties”

Enshassi et al [14] carried out a survey to study level of importance of 63 delay factors in Gaza strip construction industry using relative importance ranking.

The authors concluded that the most significant factors in the study were:

- “The location”
- “Restriction at job site cation”
- “Country political situation”.
- “Delay of financing and payments by owner”.

Samxbasivan et al [19] conducted a survey questionnaire to study 28 delay factors resulted from literature review using relative importance, which affect the Malaysian construction industry. The author concluded that the top factors were:

- “Deficiency in planning and scheduling of project”
- “Poor site management and supervision”
- “Lack of experience of contractor”
- “Delays related to sub-contractors work”
- “Delay of financing and payments by owner”

In UAE, a research was conducted by applying relative importance ranking to data obtained from survey questionnaire that used to rate 44 delay factors importance in construction based on 4 point Likert rate, as well as the use of Spearman rank correlation coefficient to examine association level among ranking sets. The research was developed by Faridi et al [20].

Assaf et al. [21] research identified 73 delay factors from literature which are required for delay factor in KSA large construction projects. By means of a survey questionnaire addressed to 47 respondents, the authors have used severity, frequency, and frequency importance index also called importance index to rank the attributes.

Many other researches were conducted using Relative Importance Index to survey questionnaire based on 5 points Likert Scale. Frimpong et al [23] followed a procedure to evaluate 26 factors that affect construction of water projects in Ghana; a similar procedure was applied by Odeh et al [24] to capture 28 factors delay traditional contracts in Jordan, likewise Chan et al [27] assessed 83 attributes steps in Hong Kong.

On the other hand researches were conducted using severity, frequency, and importance index to rank to survey questionnaire based on 5 points Likert Scale by Al-Khalil et al [26] to rank 60 factors delay construction projects in Saudi Arabia, and by Kaming et al [28] to rank 31 construction delay factors in Indonesia.

A recent study conducted by Al Jurf et al [32] showed that the most significant delay factor based on Relative Importance ranking are delays related to material delays that influence Residential Construction Projects in Qatar among 42 other factors, such as “shortage of construction materials in local market” and “escalation of construction materials prices”.

Through an extensive literature review on topics related to delay factors in construction projects, a draft checklist of 42 delay attributes were collected. Table 1 below covers the list of factors with their corresponding references.

Table 1 - List of 42 delay attributes and their corresponding literature references

1. Delays related to Owner or owner representative:	References
Delay in decision making	[1] [5] [6] [9] [10] [11] [12] [13] [16] [17] [18] [19] [20] [21] [23] [24] [26] [27] [29] [32]
Suspension of work	[1] [5] [7] [9] [12] [16] [17] [21] [26] [32]
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	[1] [4] [5] [7] [9] [10] [12] [15] [21] [23] [32]
Delay in delivering construction site to contractor	[1] [4] [5] [7] [9] [10] [11] [12] [16] [17] [21] [26]
Delay of financing and payments by owner	[1] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [15] [16] [17] [18] [19] [20] [21] [23] [24] [26] [27] [30] [32]
Changes to the project by owner	[1] [2] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [16] [17] [18] [19] [20] [21] [24] [25] [26] [27] [28] [29] [30] [32]
Type of project bidding and award	[4] [5] [7] [12] [21] [30]
Unrealistic enforced contract duration	[5] [6] [7] [9] [10] [11] [12] [13] [18] [20] [21] [22] [24] [26] [32]
Lack of experience of owner (or owner representative) in construction projects	[1] [4] [7] [15] [18]
Delay by owner in handing over process or approval of completed work	[11]
2. Delays related to Consultant:	
Lake of experience of consultants	[1] [4] [5] [7] [12] [15] [16] [17] [18] [21] [26] [27]
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	[1] [5] [6] [7] [9] [10] [11] [12] [13] [16] [17] [18] [19] [20] [21] [24] [25] [26] [27] [29] [30] [32]
Mistakes or discrepancies in documents or specifications issued by consultant	[5] [6] [7] [8] [9] [10] [11] [12] [13] [17] [18] [19] [20] [21] [24] [27] [29] [30] [31] [32]
Poor communication and coordination with other parties	[5] [7] [9] [10] [11] [12] [13] [16] [17] [18] [19] [20] [21] [24] [26] [27] [29] [32]
Delay in inspection	[1] [4] [6] [7] [9] [10] [11] [12] [13] [16] [17] [18] [20] [21] [23] [24] [26] [29] [30] [32]
3. Delays related to Contractor:	
Difficulties in financing the project by contractor	[3] [4] [5] [6] [7] [9] [10] [11] [12] [14] [15] [16] [17] [18] [20] [21] [23] [26] [27] [29] [31] [32]
Poor site management and supervision	[1] [2][3] [5] [6] [7] [8] [9][10] [11] [12][13] [15] [16] [18] [19] [20] [21] [23] [24] [26] [27] [30]
Deficiency in planning and scheduling of project	[1] [2] [5] [6] [7][8] [11] [12] [13] [14] [16] [17] [18] [19][21] [23] [24] [28] [29] [32]
Rework due to errors during construction	[1] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [19] [20] [21] [23] [24] [30] [32]
Delays related to sub-contractors work	[1] [3] [5] [7] [11] [12] [13] [16] [18] [19] [20] [21] [24] [26] [27] [30] [32]
Lack of experience of contractor (Poor qualification of contractors' staff)	[1] [5][7] [11] [12] [13] [15] [16] [17] [19] [20] [21] [22] [26] [27] [31] [32]
Inappropriate construction methods	[1] [6] [7] [9] [10] [11] [12] [13] [15] [16] [17] [18] [19] [20] [21] [24] [26] [30] [32]
Poor communication and coordination with other parties	[1] [2] [4] [7] [8] [9] [10] [11] [12] [13] [16] [17] [18] [19] [20] [21] [24] [26] [27] [29] [32]
Unsafe practice at site (Poor safety conditions on site)	[2] [11] [14] [17] [18] [26] [32]
4. Delays related to Material:	

Shortage of construction materials	[1] [2] [5] [6] [7] [8] [9] [10] [12] [13] [15] [16] [17] [19] [20] [21] [23] [24] [26] [27] [28] [29] [30] [32]
Delays due to material delivery	[1] [3] [5] [7] [11] [12] [16] [17] [20] [21] [22] [23] [25] [26] [27] [29] [30] [32]
Changes in material types and specifications during construction	[1] [5] [7] [12] [16] [17] [20] [21] [26] [27]
Inflation and escalation of material prices	[1] [3] [5] [6] [7] [8] [9] [10] [11] [12] [14] [15] [16] [17] [21] [22] [23] [26] [28] [29] [32]
5. Delays related to Labor:	
Shortage of labors	[1] [4] [5] [6] [7] [9] [10] [12] [16] [17] [18] [19] [20] [21] [23] [24] [26] [27] [28] [29] [32]
Unqualified workforce	[1] [2] [5] [6] [7] [12] [13] [14] [16] [17] [18] [20] [21] [22] [26] [27]
Low productivity of labor	[1] [5] [7] [8] [11] [12] [16] [18] [19] [20] [21] [24] [27] [28] [32]
6. Delays related to Construction site:	
Shortage of equipment and/or equipment failure	[1] [2] [3] [4] [7] [8] [9] [10] [11] [12] [13] [15] [16] [17] [18] [20] [21] [23] [24] [26] [27] [28] [29] [32]
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	[1] [4] [5] [7] [9] [10] [11] [12] [13] [14] [18] [19] 20] [21] [23] [24] [25] [26] [27] [31]
Restriction at job site (Poor site access, traffic congestion)	[1] [5] [7] [8] [9] [10] [11] [12] [14] [18] [21] [26] [28] [29]
Lack of site utilities or services such as (water, electricity, etc.)	[1] [2] [5] [7] [12] [18] [21]
Accident during construction	[1] [5] [7] [8] [11] [12] [14] [21] [32]
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	[1] [5] [7] [9] [10] [12] [13] [19] [21] [24] [26] [29]
7. Delays related to External:	
Weather effect (heat, rain, etc.)	[1] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [17] [18] [19] [20] [21] [23] [24] [25] [26] [28] [30] [32]
Changes in government regulations and laws	[1] [3] [4] [5] [6] [7] [11] [12] [13] [17] [19] [21] [24] [26] [31]
Delay in performing final inspection and certification by a third party	[1] [3] [5] [7] [21] [26]
Global financial crisis	[1] [7] [12] [18] [23] [25]
Force Majeure (earthquake, etc.)	[1] [4] [5] [6] [7] [8] [9] [10] [12] [18] [21]

3 Chapter 3 Research Methodology

3.1 Introduction

The methodology followed in this project will be presented in this chapter. Figure 1 below illustrates the systematic process used in this study. This study has adopted qualitative research technique by first; establishing a draft list of 83 delay factors collected from literature review, the number of factors was revised based on discussions with industry experts and a recommendation of 42 factors were taken into account in the study. To identify the influence of delay factors affecting the construction industry, a quantitative procedure was adopted by developing a survey questionnaire, and applying analysis to the survey data using statistical methods, which will be discussed in the paragraphs below.

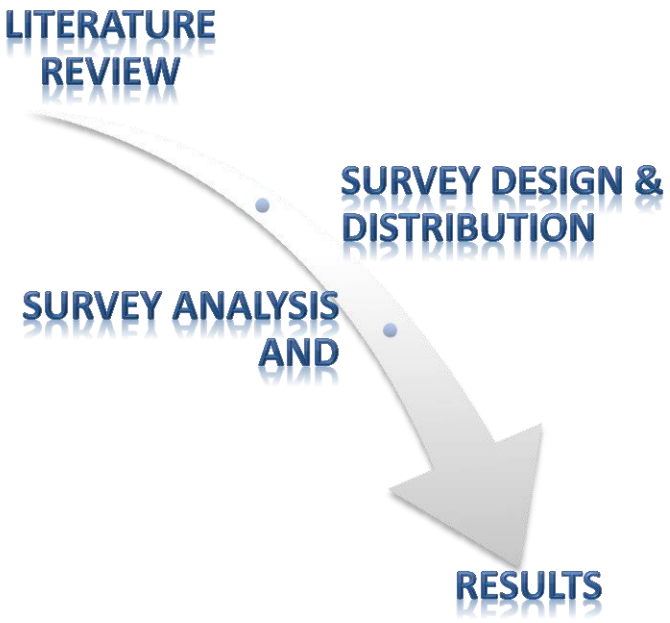

Figure 1 - Chart of Project methodology process

3.2 Survey Design

In order to gather the necessary data required to conduct data analysis, survey questionnaire approach was adopted as a means of gathering required information. Research conducted aiming to investigate perceptions of the respondents on the influencing delay attributes prevailing in the construction industry. A ranking comparison was applied between respondents based on their location, organization type, job designation, industry type, total construction experience, and based on size of the company they represent. For a convenient method of distribution the questionnaire was designed to be run through website.

The survey is composed of two sections:

1) Participants information, which would help in categorizing the respondents into different groups for the purpose of comparisons.

2) Evaluation of delay factors by respondents. This section is composed of 42 delay factors affecting construction projects identified from literature search.

The respondents were requested to evaluate the attributes based on a 5 point Likert Scale (1=Very Low, 2=Low, 3=Moderate, 4= high, 5=Very High):

- Importance (the delay impact on construction project) and;
- Frequency (How often the attribute is implemented or considered).

For an example, for the first Cause of Delay factors" Delay in decision making", the respondent was asked to evaluate the:

- Importance: What is the impact of "Delay in decision making" on construction projects?
- Frequency: How often is "Delay in decision making "considered or does it occurs in construction projects?

The survey was sent to several contacts that play key roles in the construction industry. A total of 179 completed surveys were received. According to Cochran [38], 151 survey sample size is the required sample size to satisfy 7.5% margin of error, and a confidence level of 95%, with an unknown or huge population size number and unknown percentage of response.

3.3 Cronbach's Alpha

One of the concerning aspects when a research is developed based on Likert Scale survey questionnaire data is internal consistency of the questionnaire, so in order to measure internal consistency, a recommended approach by various researchers, Cronbach's Alpha coefficient of reliability will be applied [37]. Cronbach's Alpha coefficient is actually used in this search aiming to confirm that the criterion associated with Likert Scale actually measures the hypothesis, which is importance and frequency of delay attributes in the construction industry), that were aimed to measure. Values of Cronbach Alpha fall between 0 and 1. "A value of 0.7 is considered to be acceptable and 0.8 or higher indicates good internal consistency" [37]. With the help of Statistical Package for social sciences (SPSS v.20) Cronbach Alpha value for the survey data was obtained, coefficient value of ***0.932*** which was found for the study showing a high consistency.

3.4 Ranking Approach

3.4.1 Relative Importance Index (RII)

Earlier mentioned, the Relative Importance Index (RII) [1] was chosen to assess and rank each delay attribute importance based on responses scores collected from the survey. Gunduz et al [1] used the relative importance index to analyze factors that delays Turkish construction projects. It was also implemented by many others as it was earlier discussed in literature review. 5 point Likert Scale was applied to rate the importance of the attributes and Relative Importance Index was applied using the following equation:

$$\mathbf{RII} = \frac{\sum \mathbf{w}}{\mathbf{A(N)}}$$

Equation 1 - RII equation

Where,

W = weight given to each attribute by the respondent (1 to 5).

A = the highest weight (in this case is 5).

N = total number of respondents

The value of the RII ranges from 0 to 1, a higher value indicates that the attribute is more significant compared to others.

3.4.2 Frequency Adjusted Importance Index (FAII)

A similar yet inventive ranking approach adopted in this research to rank delay attributes in construction industry, the Frequency Adjusted Importance Index (FAII or FII), also used by Yahya [36] to rank the project success factors in the Middle East & UAE. This technique considers both the importance and the frequency in its formula resulted from responses scores using the 5 point Likert Scale. In order to find the FAII, the Relative importance index and the Frequency index (FI), both are required to be measured and calculated referring to responses data collected in survey. Frequency index (FI) values will be calculated based on the following equation:

$$\mathbf{FI\%} = \frac{\sum \mathbf{w}}{\mathbf{A(N)}} \times \mathbf{100}$$

Equation 2 - FI equation

Where,

W = weight given to each factor by the respondents (1 to 5).

A = the highest weight (in this case is 5).

N = total number of responses.

And as earlier mentioned; based on both the FI% and the RII equations, the frequency adjusted importance index will be calculated as follows:

$$\mathbf{FAII} = \mathbf{RII} \times \mathbf{FI\%}$$

Equation 3 - FAII equation

3.5 Spearman's Rank Correlation

Other concerning aspects during the analysis of data are the accurateness and precision, which what will be accomplished using Spearman's Rank Correlation Factor [20]. Spearman's rank correlation coefficient defined as "a non-parametric test or distribution free tests, it does not require the normality of the distribution or the homogeneity of the data which is considered as a big advantage over other approaches" [36]. In this research, the Spearman's' Correlation Coefficient was used to evaluate the correlation amongst 2 different measures, for example, it was used to check the correlation between the RII and FII for total collected responses. As well as it will be considered in measuring accuracy and the relationship in comparing responses based on location, organization type, job designation etc. Assumption of no multicollinearity between attributes was made. It can be calculated by applying the following equation.

$$\mathbf{r = 1 - \left[\frac{6 \sum d^2}{n^3 - n}\right]}$$

Equation 4 - Spearman's Rank Correlation equation

Where,

r = Spearman rank correlation coefficient between two parties

d = difference between ranks assigned to variables for each cause, and

n = is the number of pairs of rank (in the research it is equal to the number of attributes which is 42). The Spearman's correlation assess in developing a measures of relationship between different parties regarding different factors strength. According to some studies developed for the similar topics, "The correlation coefficient varies between +1 and −1, where +1 implies a perfect

positive relationship (agreement), while −1 results from a perfect negative relationship (disagreement)" [20, 37].

3.6 T – Test

The T-Test is used to check how close or related 2 different groups are. It is a governing tool to examine between the means of two unrelated groups whether there is a significant difference or not [36, 37]. In other words to examine group means independence, that mean in any individual group cannot exist in the other group. The significant level (alpha value) is set to be 0.05. Hypothesis set to be based on result of group's significance value (ρ-value). If the value is greater than 0.1, the group variance can be treated as the same and no significant difference exists. However, if the value is less than 0.1 then a significant difference exists [36, 37].

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Equation 5 - T - Test equation

Where,

$\overline{x_1}$= Mean of first set of values

$\overline{x_2}$ = Mean of second set of values

s_1= Standard deviation of first set of values

s_2= Standard deviation of second set of values

n_1 = Total number of values in first set

n_2 = Total number of values in second set

3.7 Risk mapping:

Risk map is used in order to improve the understanding of risk associated with each delay factor, by illustrating the nature of impact of risks resulted from the attribute that is presented as a matrix. Risk mapping matrix is a visual tool used to present risk associated with delay factors importance and frequency. Data will be plotted on scatter plot chart using mean values of data from respondents, horizontal axis represent the impact mean values, and vertical axis represent the frequency means values [9]. Table 2 below represents the scale used to plot mean values of importance and frequency of occurrence

Table 2 Scale used to present factor's risk related to Importance and Frequency of occurrence

Scale (values between)	X-axis (Importance)	Y-axis (Frequency)
0 to 1	Very low (VL)	Very low (VL)
1 to 2	Low (L)	Low (L)
2 to 3	Moderate (M)	Moderate (M)
3 to 4	High (H)	High (H)
4 to 5	Very high (VH)	Very high (VH)

Characteristics of zones shown in Figure 2 below are as follows [9, 14]:

- Green zone: risks can be ignored in this zone due to low level of impact.
- Yellow zone: risks requires moderate level of attention and long term plans of rectification due to moderate level of occurrence that may not happen during construction.
- Red zone: risks require an immediate and high level of control as there impact and occurrence are critical.

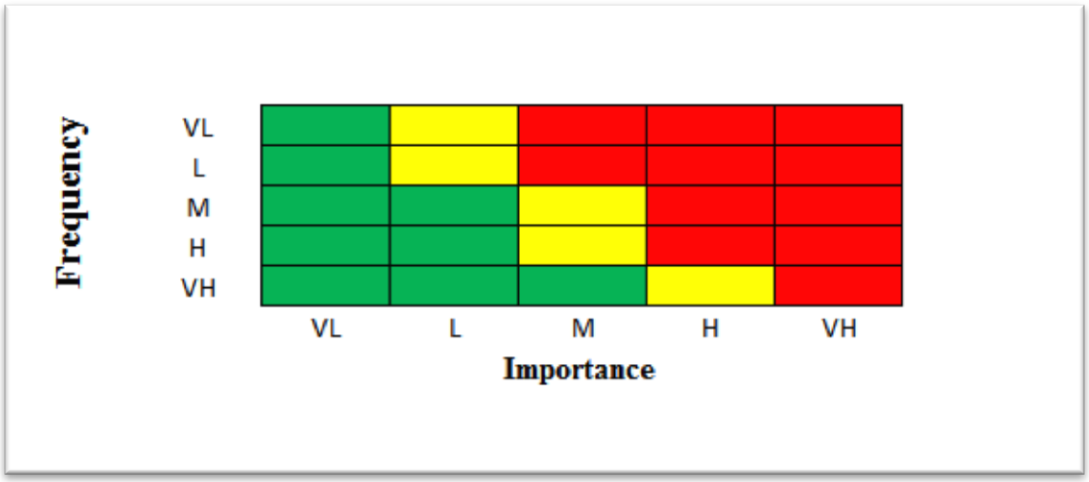

Figure 2 Scale used to present factor's risk related to importance and frequency of occurrence

3.8 Factor Analysis

Factor Analysis, a dimension reduction technique [37], is a technique statistically used to categorize a set of variables under smaller number of hypothetical variables called factors. In this study, delay factors are 42 factors, grouped under 7 major groups, it is possible to that large number of variables to be represented by smaller number of factors. This procedure was used by Doloi et al [11] in their research to investigate factors affecting delays in Indian Construction industry. Factor analysis technique requires a check of the adequacy of the survey data to run the technique, and for that purpose it is required to conduct both Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity [37]. “KMO value ranges between 0 to 1, with minimum value of 0.7 is recommended, while a value closer to 1 indicates compact correlation and is desired for reliable factor analysis results” [37]. Factor analysis was used in this study to identify and interpret factors correlation that influenced delay attributes in construction industry. Statistical Package for social science (SPSS v. 20) was used to conduct the factor analysis.

4 Chapter 4 Data Collection and Results

4.1 Introduction

This chapter presents data collected from the survey that will summarize the profiles of the respondents and the analysis results. Developing the questionnaire was through Survey Monkey website. An online website tool was employed in developing, distributing the questionnaire, and finally collecting responses. The questionnaire link was sent out by emails or via professional networks. Only the complete responses were chosen to proceed with analysis, resulting with 179 completed questionnaires were chosen out of 196 in total.

4.2 Respondents Profile

Respondents profiles are presented based on location, organization type, job designation, type of industry, total construction industry experience, and size of company.

4.2.1 Respondents location

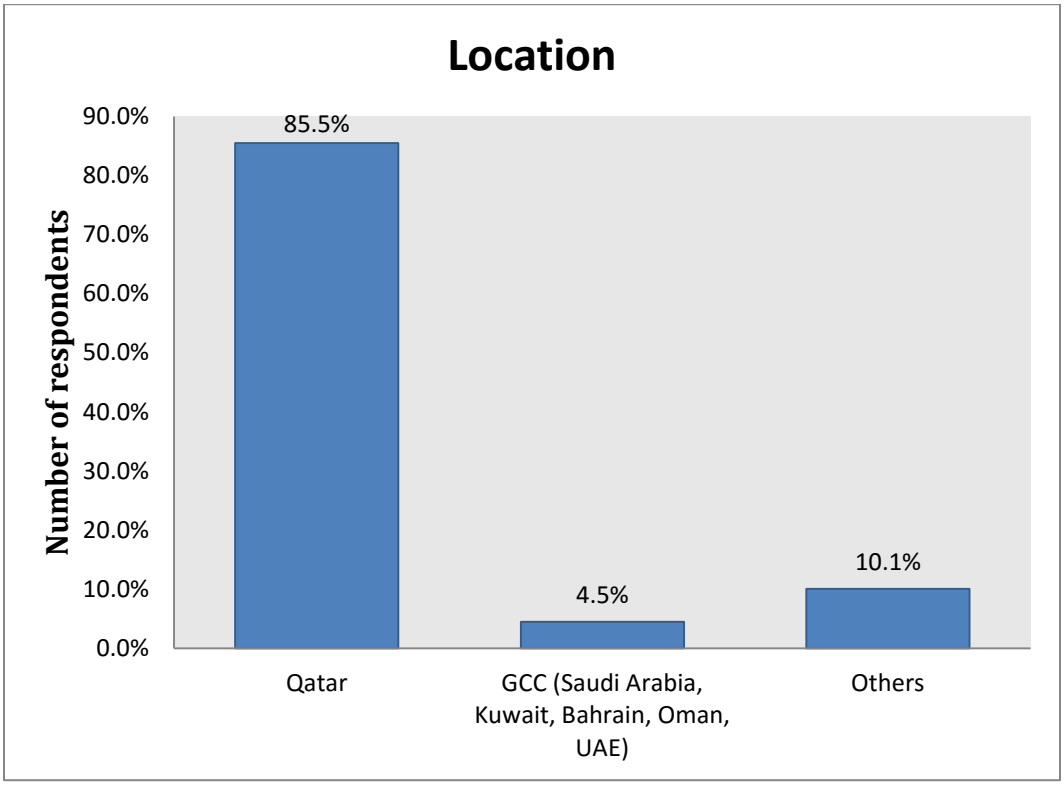

Figure 3 - Number of respondents based on location

From Figure 3 that shows location of the respondents, as well as it shows the actual number of survey participants. Participants from Qatar represents majority of the respondents constituting 85.5% of the total numbers. The rest of participants represent a number of 26 equivalents to 14.5 % of individuals from other parts of the world such as GCC, Palestine, Turkey, Iraq, Iran, India, Azerbaijan, and USA.

4.2.2 Respondents Organization Type

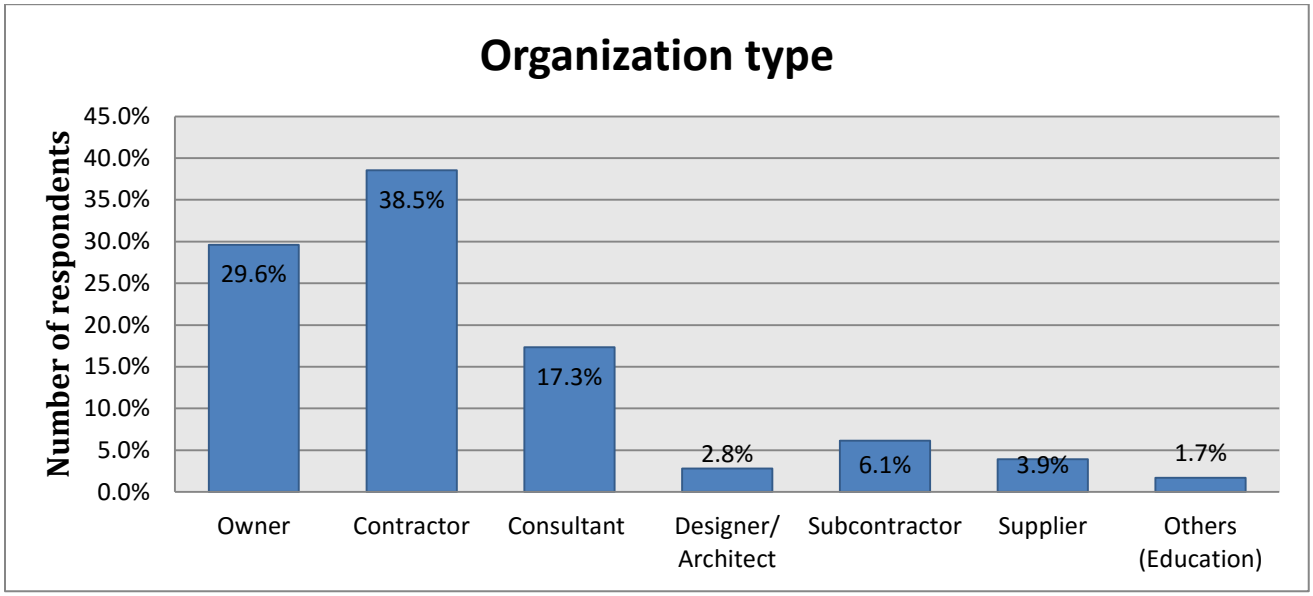

Figure 4 - Number of respondents based on Organization type

The participant from various organizations represents various fields that are related to construction, such as owner, contractor consultant, designers, subcontractors, suppliers, and others (education, etc.). Contractors are the largest portion of respondents with 69 numbers of responses. Owners, the second largest contributors of the survey form almost 30% of the total participants. Third large number of contribution with 31 responses is the consultants who are involved with firms specialized in construction consulting services. The numbers of respondents based on organization type are shown in Figure 4.

4.2.3 Respondents Job Designation

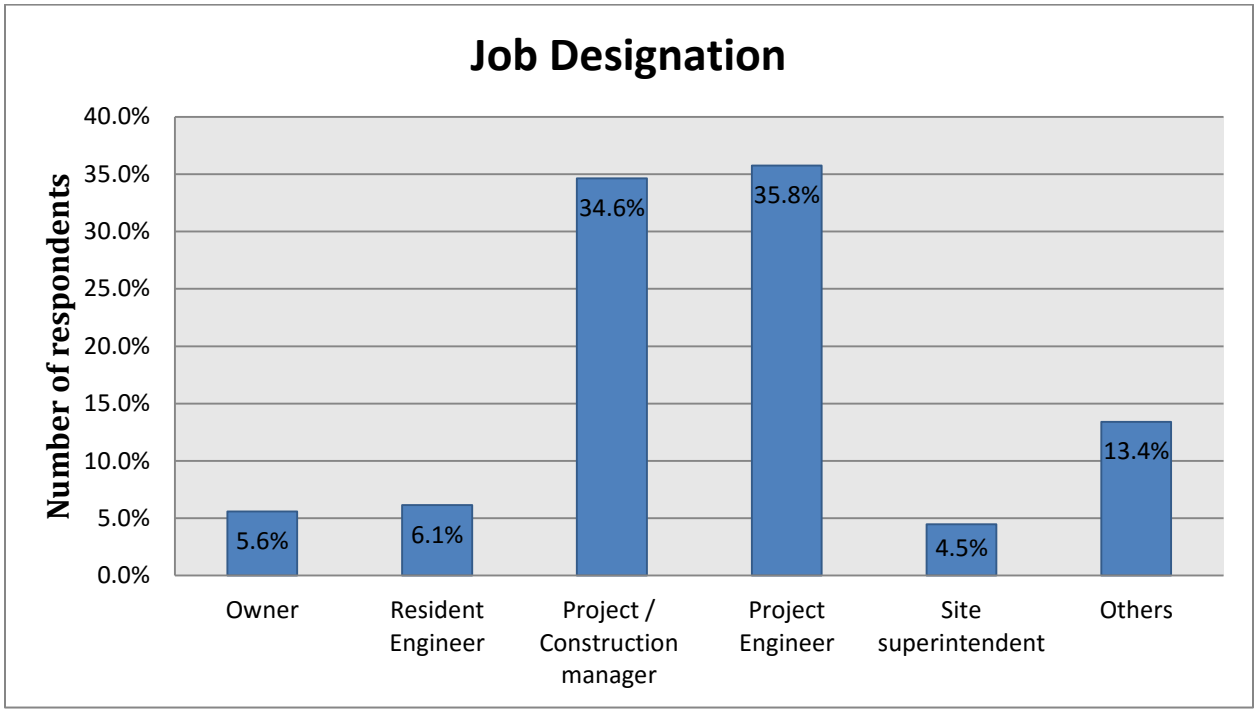

Figure 5 - Number of respondents based on Job Designation

Figure 5 represents the actual numbers of the job designation held. Out of 179 respondents, there were 10 owners or owner representatives, 11 resident engineers, 62 project or construction managers, 64 project engineers, 8 site superintendents, and 24 others such as (Quality Engineer, Legal Council, QA Engineer, Cost Engineer, construction Environmental Specialist, Planning Engineer, HSE Manager, Country Managers, Academicians, and many others).

4.2.4 Respondents Industry Type

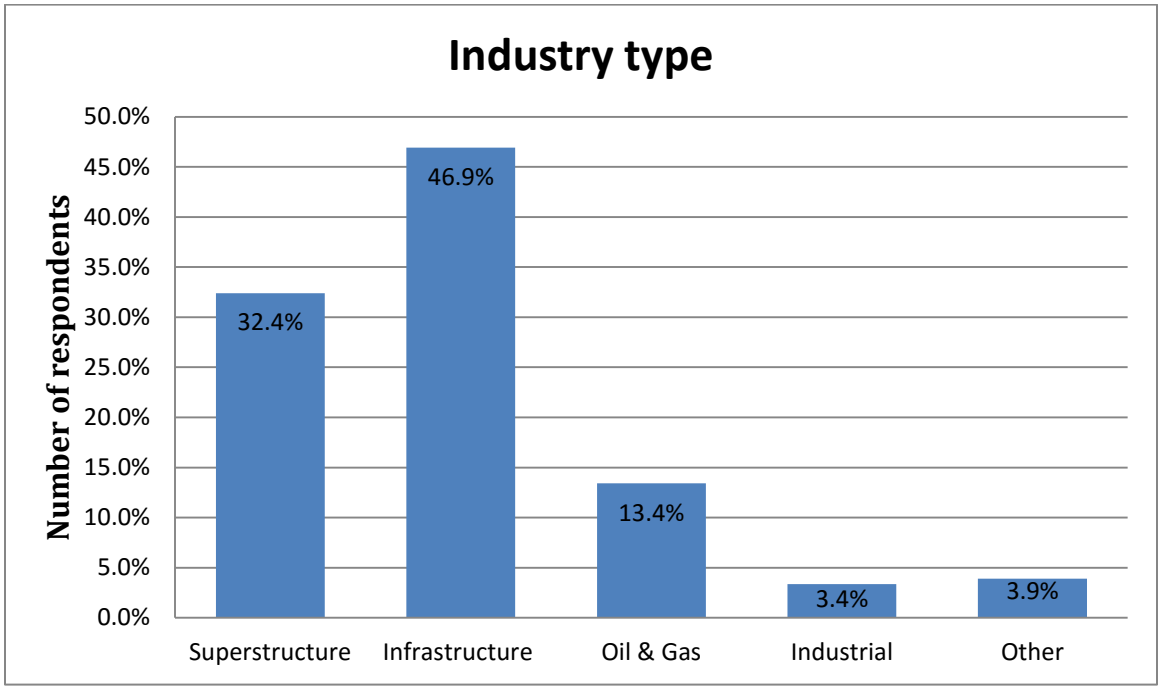

Figure 6 - Number of respondents based on type of industry

From Figure 6 participants involved in infrastructure construction projects holds significant portion of participants with almost 47 % of responses, followed by superstructure construction projects with 32.4% of responses. The remainders are involved in oil & gas with 31.4%, 3.4 % are from industrial industry and 3.9% are others.

4.2.5 Respondents Total Years of Construction Experience

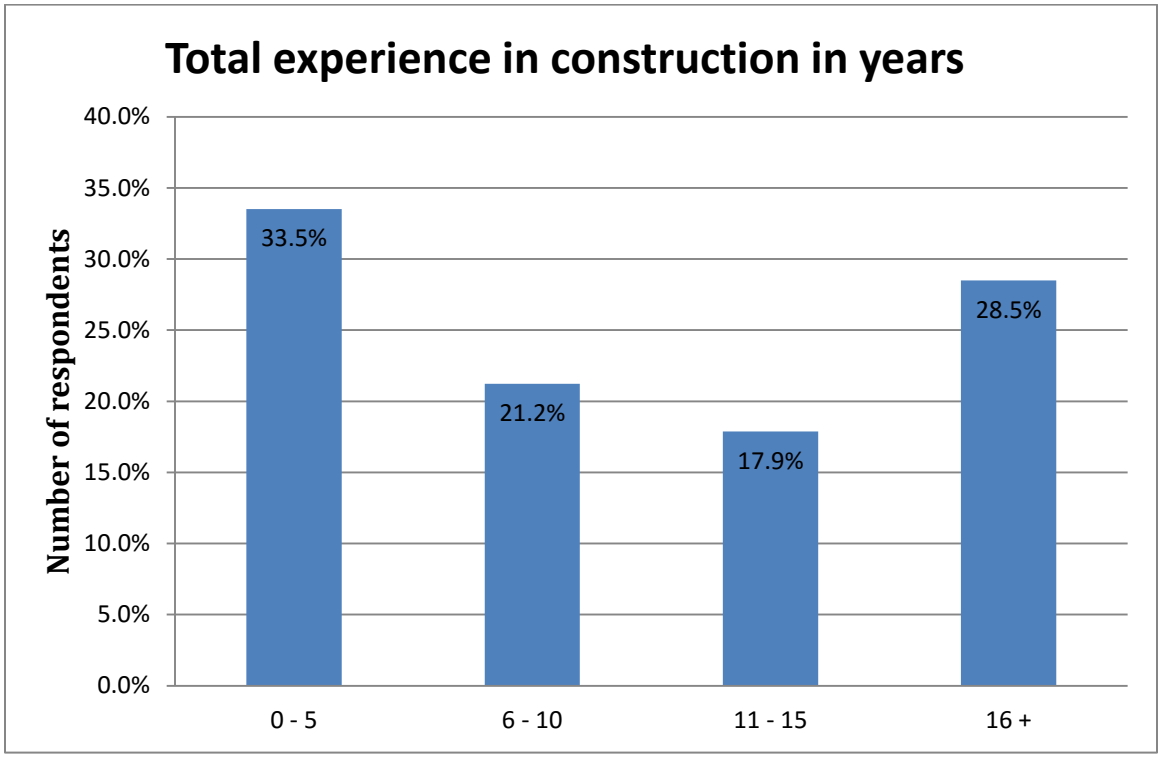

Figure 7 - Number of respondents based on Years of experience in construction

As shown in Figure 7 participants were categorized based on total years of work experiences in construction based on 4 groups, which are 0 to 5 years, 6 to 10, 11 to 15 and more than 16 years. A percentage of 54% of responses, yielded from professionals who have been practicing their trades in the construction for more less than 10 years as seen from Figure 7. On the other hand, a percentage of 46% of professionals' responses fall into categories of more than 10 years of work experience.

4.2.6 Respondents based on company size

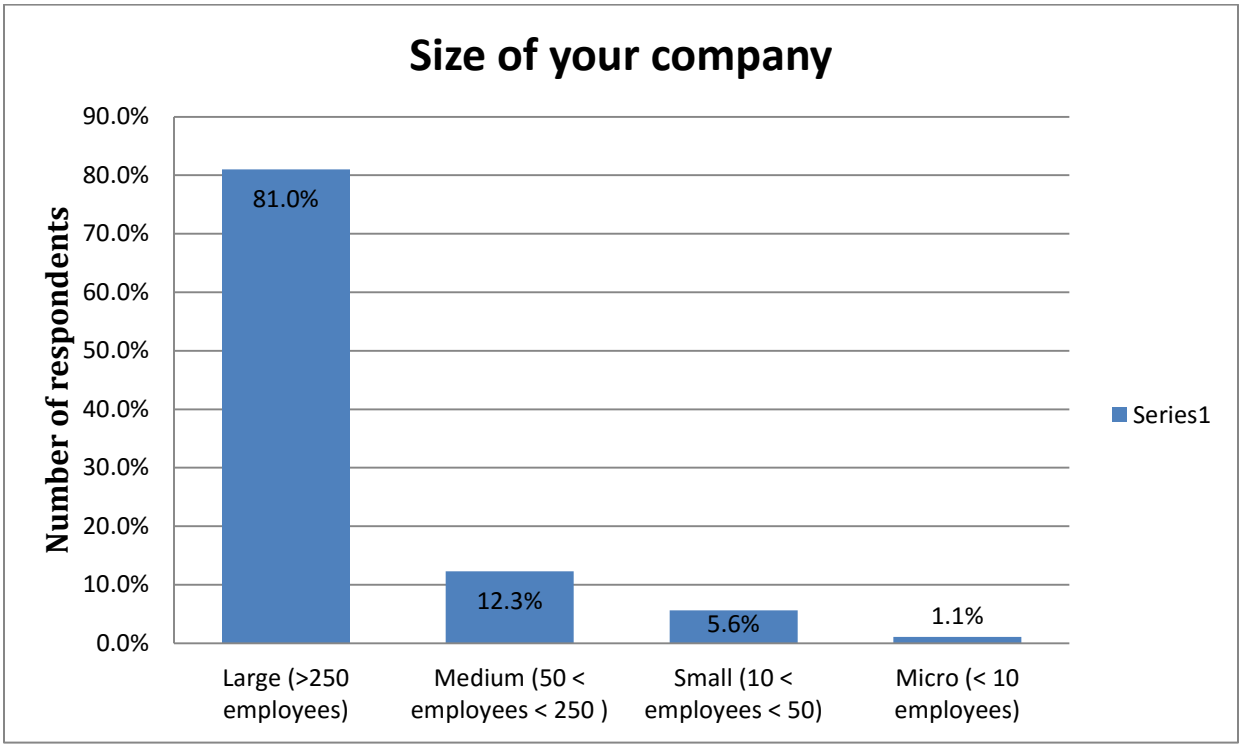

Figure 8 - Number of respondents based on company size

Figure 8 illustrates the number of respondents' based on company size they are employed in. Majority of respondents fall into the category of large company size with a percentage of 81%.

4.3 Evaluation of construction delay attributes

One of the objectives of this study is to get the perceptions of the construction industry professionals about causes of delay influencing construction projects. Survey participants rated each individual delay attribute importance and frequency based on a 5 - point Likert Scale. Participants were asked to evaluate the importance that will assess the impact of the construction projects delay attribute on construction projects. Frequency was rated in order to decide on how often the attribute is performed or executed in construction projects. Table 3 presents the raw data of the survey showing the importance and Table 4 shows the raw data of the survey frequency values provided by the respondents. Data collected was analyzed to develop the RII and FAII values of each attribute. Delay attributes were ranked in an ascending order based on the RII and FAII values which what will be shown and discussed later. RII or FAII higher values, indicates higher importance level of the delay attribute and vice versa. For example delay factor with Rank 1 corresponds to the highest attribute influence while the lowest rank of 42th indicates the least significant as perceived by the group of participants. As well as the domestic data collected for all responses represented in Table 5, where delay factor codes (O, CS, C, M, L,S, and E) represents delays related to owner or owner representative, delays related to consultants, delays related to contractor, delays related to material, delays related to labor, delays related to construction site, delays related to external respectively.

Table 3 - impact ratings of attributes by respondents

Delays related to owner or owner representative	1	2	3	4	5	Response Count
Delay in decision making	3	6	26	52	92	179
Suspension of work	14	14	40	52	59	179
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	6	24	57	50	42	179
Delay in delivering construction site to contractor	18	27	68	29	37	179
Delay of financing and payments by owner	9	21	46	40	63	179
Changes to the project by owner	5	16	40	45	73	179
Type of project bidding and award	33	36	78	23	9	179
Unrealistic enforced contract duration	13	20	39	65	42	179
Lack of experience of owner (or owner representative) in construction projects	12	21	46	70	30	179
Delay by owner in handing over process or approval of completed work	13	18	84	41	23	179
Delays related to Consultants	1	2	3	4	5	Response Count
lack of experience of consultants	13	18	41	67	40	179
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	3	17	45	71	43	179
Mistakes or discrepancies in documents or specifications issued by consultants	10	23	75	42	29	179
Poor communication and coordination with other parties	1	18	56	66	38	179
Delay in inspection	12	33	77	35	22	179
Delays related to Contractor	1	2	3	4	5	Response Count
Difficulties in financing the project by contractor	9	10	50	72	38	179
Poor site management and supervision	1	9	44	53	72	179
Deficiency in planning and scheduling of project	2	13	53	74	37	179
Rework due to errors during construction	15	27	64	40	33	179
Delays related to sub-contractors work	3	14	54	74	34	179
Lack of experience of contractor (Poor qualification of contractors' staff)	8	15	71	46	39	179
Inappropriate construction methods	13	40	77	38	11	179
Poor communication and coordination with other parties	4	27	57	67	24	179
Unsafe practice at site (Poor safety conditions on site)	21	34	66	27	31	179
Delays related to Material	1	2	3	4	5	Response Count
Shortage of construction materials	6	9	36	52	76	179
Delays due to material delivery	1	11	39	87	41	179
Changes in material types and specifications during construction	6	15	54	73	31	179
Inflation and escalation of material prices	15	33	72	44	15	179
Delays related to Labor	1	2	3	4	5	Response Count
Shortage of labors	9	6	51	43	70	179
Unqualified workforce	1	16	43	82	37	179
Low productivity of labor	4	13	35	80	47	179
Delays related to Construction site	1	2	3	4	5	Response Count
Shortage of equipment and/or equipment failure	8	18	49	80	24	179
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	10	24	47	41	57	179
Restriction at job site (Poor site access, traffic congestion)	14	29	85	37	14	179
Lack of site utilities or services such as (water, electricity, etc.)	22	39	62	39	17	179
Accident during construction	21	32	42	59	25	179
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	29	36	70	34	10	179
Delays related to External	1	2	3	4	5	Response Count
Weather effect (heat, rain, etc.)	17	25	60	58	19	179
Changes in government regulations and laws	25	33	69	35	17	179
Delay in performing final inspection and certification by a third party	12	38	67	48	14	179
Global financial crisis	23	31	67	34	24	179
Force Majeure (earthquake, etc.)	37	21	21	25	75	179

Table 4 - Frequency ratings of attributes by respondents

Delays related to owner or owner representative	1	2	3	4	5	Response Count
Delay in decision making	7	24	85	33	30	179
Suspension of work	72	49	26	26	6	179
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	8	27	71	39	34	179
Delay in delivering construction site to contractor	64	47	37	21	10	179
Delay of financing and payments by owner	28	72	28	26	25	179
Changes to the project by owner	16	25	49	56	33	179
Type of project bidding and award	66	46	44	15	8	179
Unrealistic enforced contract duration	27	32	64	33	23	179
Lack of experience of owner (or owner representative) in construction projects	35	33	69	30	12	179
Delay by owner in handing over process or approval of completed work	19	30	76	32	22	179
Delays related to Consultants	1	2	3	4	5	Response Count
lack of experience of consultants	28	63	49	23	16	179
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	16	29	71	33	30	179
Mistakes or discrepancies in documents or specifications issued by consultants	18	44	80	13	24	179
Poor communication and coordination with other parties	11	33	73	30	32	179
Delay in inspection	37	62	38	26	16	179
Delays related to Contractor	1	2	3	4	5	Response Count
Difficulties in financing the project by contractor	18	44	74	32	11	179
Poor site management and supervision	11	32	81	40	15	179
Deficiency in planning and scheduling of project	11	32	82	37	17	179
Rework due to errors during construction	24	48	66	20	21	179
Delays related to sub-contractors work	6	28	52	61	32	179
Lack of experience of contractor (Poor qualification of contractors' staff)	17	39	78	32	13	179
Inappropriate construction methods	33	66	48	26	6	179
Poor communication and coordination with other parties	13	35	79	36	16	179
Unsafe practice at site (Poor safety conditions on site)	32	35	65	26	21	179
Delays related to Material	1	2	3	4	5	Response Count
Shortage of construction materials	15	31	74	41	18	179
Delays due to material delivery	7	37	78	40	17	179
Changes in material types and specifications during construction	22	41	72	34	10	179
Inflation and escalation of material prices	29	39	75	23	13	179
Delays related to Labor	1	2	3	4	5	Response Count
Shortage of labors	23	29	71	43	13	179
Unqualified workforce	10	25	71	43	30	179
Low productivity of labor	6	23	44	42	64	179
Delays related to Construction site	1	2	3	4	5	Response Count
Shortage of equipment and/or equipment failure	28	46	74	24	7	179
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	35	73	41	23	7	179
Restriction at job site (Poor site access, traffic congestion)	34	39	71	24	11	179
Lack of site utilities or services such as (water, electricity, etc.)	73	45	34	23	4	179
Accident during construction	81	42	36	16	4	179
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	72	38	49	14	6	179
Delays related to External	1	2	3	4	5	Response Count
Weather effect (heat, rain, etc.)	38	44	65	18	14	179
Changes in government regulations and laws	78	51	31	14	5	179
Delay in performing final inspection and certification by a third party	31	72	46	21	9	179
Global financial crisis	75	58	36	7	3	179
Force Majeure (earthquake, etc.)	129	23	18	3	6	179

Table 5 - statistical data results for data collected from all responses

Delay factor code	Impact MEAN	Impact MODE	Impact standard deviation	Frequency MEAN	Frequency MODE	Frequency standard deviation
O1	4.251	5	0.941	3.307	3	1.028
O2	3.715	5	1.224	2.134	1	1.192
O3	3.547	3	1.092	3.358	3	1.089
O4	3.223	3	1.225	2.251	1	1.217
O5	3.709	5	1.206	2.709	2	1.287
O6	3.922	5	1.114	3.363	4	1.193
O7	2.659	3	1.076	2.179	1	1.152
O8	3.575	4	1.175	2.961	3	1.220
O9	3.475	4	1.108	2.726	3	1.155
O10	3.240	3	1.040	3.045	3	1.126
CS1	3.575	4	1.156	2.642	2	1.159
CS2	3.749	4	0.982	3.179	3	1.162
CS3	3.318	3	1.068	2.894	3	1.119
CS4	3.682	4	0.939	3.218	3	1.128
CS5	3.123	3	1.063	2.564	2	1.222
C1	3.670	4	1.032	2.855	3	1.028
C2	4.039	5	0.950	3.089	3	0.990
C3	3.732	4	0.909	3.095	3	1.004
C4	3.274	3	1.175	2.810	3	1.165
C5	3.682	4	0.927	3.475	4	1.062
C6	3.520	3	1.062	2.916	3	1.032
C7	2.966	3	0.988	2.475	2	1.056
C8	3.447	4	0.978	3.039	3	1.024
C9	3.073	3	1.227	2.827	3	1.226
M1	4.022	5	1.065	3.089	3	1.067
M2	3.872	4	0.855	3.128	3	0.977
M3	3.603	4	0.980	2.827	3	1.054
M4	3.061	3	1.050	2.732	3	1.104
L1	3.888	5	1.121	2.966	3	1.101
L2	3.771	4	0.898	3.324	3	1.084
L3	3.855	4	0.966	3.754	5	1.169
S1	3.525	4	0.996	2.642	3	1.025
S2	3.620	5	1.218	2.408	2	1.063
S3	3.045	3	0.999	2.659	3	1.117
S4	2.944	3	1.145	2.106	1	1.144
S5	3.196	4	1.227	1.994	1	1.104
S6	2.777	3	1.104	2.128	1	1.132
E1	3.207	3	1.110	2.587	3	1.160
E2	2.922	3	1.149	1.978	1	1.086
E3	3.078	3	1.030	2.469	2	1.067
E4	3.028	3	1.192	1.911	1	0.962
E5	3.447	5	1.604	1.514	1	0.979

4.3.1 II Ranking

Table 6 below shows both RII values and ranking of delay attributes developed based on importance scale values by responses from all the participants. The values were calculated using Relative importance index (RII) as per Equation 1 - RII equation

Table 6 - RII values and ranking of delay attributes by all respondents.

Delays related to owner or owner representative	RII%	RI rank
Delay in decision making	85.00	1
Suspension of work	74.30	11
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	70.90	20
Delay in delivering construction site to contractor	64.50	29
Delay of financing and payments by owner	74.20	12
Changes to the project by owner	78.40	4
Type of project bidding and award	53.20	42
Unrealistic enforced contract duration	71.50	18
Lack of experience of owner (or owner representative) in construction projects	69.50	23
Delay by owner in handing over process or approval of completed work	64.80	28
Delays related to Consultants		
lack of experience of consultants	71.50	18
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	75.00	9
Mistakes or discrepancies in documents or specifications issued by consultants	66.40	26
Poor communication and coordination with other parties	73.60	13
Delay in inspection	62.50	32
Delays related to Contractor		
Difficulties in financing the project by contractor	73.40	15
Poor site management and supervision	80.80	2
Deficiency in planning and scheduling of project	74.60	10
Rework due to errors during construction	65.50	27
Delays related to sub-contractors work	73.60	13
Lack of experience of contractor (Poor qualification of contractors' staff)	70.40	22
Inappropriate construction methods	59.30	38
Poor communication and coordination with other parties	68.90	24
Unsafe practice at site (Poor safety conditions on site)	61.50	34
Delays related to Material		
Shortage of construction materials	80.40	3
Delays due to material delivery	77.40	6
Changes in material types and specifications during construction	72.10	17
Inflation and escalation of material prices	61.20	35
Delays related to Labor		
Shortage of labors	77.80	5
Unqualified workforce	75.40	8
Low productivity of labor	77.10	7
Delays related to Construction site		
Shortage of equipment and/or equipment failure	70.50	21
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	72.40	16
Restriction at job site (Poor site access, traffic congestion)	60.90	36
Lack of site utilities or services such as (water, electricity, etc.)	58.90	39
Accident during construction	63.90	31
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	55.50	41
Delays related to External		
Weather effect (heat, rain, etc.)	64.10	30
Changes in government regulations and laws	58.40	40
Delay in performing final inspection and certification by a third party	61.60	33
Global financial crisis	60.60	37
Force Majeure (earthquake, etc.)	68.90	24

From Table 6, it was found that the top 5 ranked delay factors based on RII values are as follows:

1. Delay in decision making (Delays related to owner or owner representative).
2. Poor site management and supervision (Delays related to Contractor).
3. Shortage of construction materials (Delays related to material).
4. Changes to the project by owner (Delays related to owner or owner representative).
5. Shortage of labors (Delays related to Labor).

4.3.2 FI Ranking

Frequency of delay attributes in construction projects are represented in Table 7, as per the responses from all the participants. Frequency Index (FI) Equation 2 - FI equation was used to come up with the FI values.

From Table 7, it was found that the top 5 ranked delay factors based on FI values are as follows:

1. Low productivity of labor (Delays related to Labor).
2. Delays related to sub-contractors work (Delays related to Contractor).
3. Changes to the project by owner (Delays related to owner or owner representative).
4. Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner (Delays related to owner or owner representative).
5. Unqualified workforce (Delays related to Labor).

Table 7 - FI values and ranking of delay attributes by all respondents.

Delays related to owner or owner representative	FI%	FI rank
Delay in decision making	66.15	6
Suspension of work	42.68	36
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	67.15	4
Delay in delivering construction site to contractor	45.03	34
Delay of financing and payments by owner	54.19	25
Changes to the project by owner	67.26	3
Type of project bidding and award	43.58	35
Unrealistic enforced contract duration	59.22	16
Lack of experience of owner (or owner representative) in construction projects	54.53	24
Delay by owner in handing over process or approval of completed work	60.89	13
Delays related to Consultants		
lack of experience of consultants	52.85	27
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	63.58	8
Mistakes or discrepancies in documents or specifications issued by consultants	57.88	18
Poor communication and coordination with other parties	64.36	7
Delay in inspection	51.28	30
Delays related to Contractor		
Difficulties in financing the project by contractor	57.09	19
Poor site management and supervision	61.79	11
Deficiency in planning and scheduling of project	61.90	10
Rework due to errors during construction	56.20	22
Delays related to sub-contractors work	69.50	2
Lack of experience of contractor (Poor qualification of contractors' staff)	58.32	17
Inappropriate construction methods	49.50	31
Poor communication and coordination with other parties	60.78	14
Unsafe practice at site (Poor safety conditions on site)	56.54	20
Delays related to Material		
Shortage of construction materials	61.79	11
Delays due to material delivery	62.57	9
Changes in material types and specifications during construction	56.54	20
Inflation and escalation of material prices	54.64	23
Delays related to Labor		
Shortage of labors	59.33	15
Unqualified workforce	66.48	5
Low productivity of labor	75.08	1
Delays related to Construction site		
Shortage of equipment and/or equipment failure	52.85	27
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	48.16	33
Restriction at job site (Poor site access, traffic congestion)	53.18	26
Lack of site utilities or services such as (water, electricity, etc.)	42.12	38
Accident during construction	39.89	39
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	42.57	37
Delays related to External		
Weather effect (heat, rain, etc.)	51.73	29
Changes in government regulations and laws	39.55	40
Delay in performing final inspection and certification by a third party	49.39	32
Global financial crisis	38.21	41
Force Majeure (earthquake, etc.)	30.28	42

4.3.3 FAII Ranking

Frequency Adjusted Importance Index has been evaluated by combining the RII and FI (importance & frequency); it is also called Frequency Importance Index, as shown above Equation 3 - FAII equation was used to conduct the ranking.

From Table 8 - FAII values and ranking of delay attributes by all respondents., it was found that the top 5 ranked delay factors based on FI values are as follows:

1. Low productivity of labor (Delays related to Labor).
2. Delay in decision making (Delays related to owner or owner representative).
3. Changes to the project by owner (Delays related to owner or owner representative).
4. Delays related to sub-contractors work (Delays related to Contractor).
5. Unqualified workforce (Delays related to Labor).

Table 8 - FAII values and ranking of delay attributes by all respondents.

Delays related to owner or owner representative	FAII	FAII rank
Delay in decision making	56.242	2
Suspension of work	31.713	32
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	47.643	10
Delay in delivering construction site to contractor	29.029	35
Delay of financing and payments by owner	40.203	19
Changes to the project by owner	52.758	3
Type of project bidding and award	23.175	39
Unrealistic enforced contract duration	42.346	14
Lack of experience of owner (or owner representative) in construction projects	37.893	22
Delay by owner in handing over process or approval of completed work	39.462	20
Delays related to Consultants		
lack of experience of consultants	37.792	23
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	47.664	9
Mistakes or discrepancies in documents or specifications issued by consultants	38.412	21
Poor communication and coordination with other parties	47.387	11
Delay in inspection	32.032	31
Delays related to Contractor		
Difficulties in financing the project by contractor	41.912	15
Poor site management and supervision	49.913	6
Deficiency in planning and scheduling of project	46.200	12
Rework due to errors during construction	36.798	25
Delays related to sub-contractors work	51.172	4
Lack of experience of contractor (Poor qualification of contractors' staff)	41.055	17
Inappropriate construction methods	29.366	34
Poor communication and coordination with other parties	41.902	16
Unsafe practice at site (Poor safety conditions on site)	34.743	27
Delays related to Material		
Shortage of construction materials	49.706	7
Delays due to material delivery	48.448	8
Changes in material types and specifications during construction	40.744	18
Inflation and escalation of material prices	33.454	28
Delays related to Labor		
Shortage of labors	46.138	13
Unqualified workforce	50.139	5
Low productivity of labor	57.886	1
Delays related to Construction site		
Shortage of equipment and/or equipment failure	37.260	24
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	34.866	26
Restriction at job site (Poor site access, traffic congestion)	32.386	30
Lack of site utilities or services such as (water, electricity, etc.)	24.803	37
Accident during construction	25.493	36
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	23.639	38
Delays related to External		
Weather effect (heat, rain, etc.)	33.178	29
Changes in government regulations and laws	23.113	41
Delay in performing final inspection and certification by a third party	30.404	33
Global financial crisis	23.141	40
Force Majeure (earthquake, etc.)	20.874	42

4.3.4 RII vs FAII Ranking

Spearman's rank correlation factor (r) was used in this paper to assess the association degree between the rankings of RII and FAII based on data collected from all respondents, as well as for various to show the degree of association between rankings resulted from other categories. With the help of correlation factor, better understanding of how close the results of the two tools ranking are.

The correlation coefficient value varies between +1 and −1. Where +1 implies a perfect positive relationship or agreement, but 0 implies no correlation, and a value of −1 implies a perfect negative relationship or disagreement.

It can be seen from Table 9 that value of correlation factor found to be equal 0.86 which indicates an agreement relationship between the RII and FAII. As FAII considers both the frequency and importance of the delay factors on construction projects, it will be used as the main ranking tool for various groups of respondents in the coming sections of the chapter [36].

Table 9 - Spearman's rank correlation factor for RII vs FAII rankings for all respondents

code	Delays related to owner or owner representative	RI	RI rank	FI%	FII	FII rank	d	d^2
O1	Delay in decision making	0.850	1	66.145	56.242	2	1	1
O2	Suspension of work	0.743	11	42.682	31.713	32	21	441
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	0.709	20	67.151	47.643	10	-10	100
O4	Delay in delivering construction site to contractor	0.645	29	45.028	29.029	35	6	36
O5	Delay of financing and payments by owner	0.742	12	54.190	40.203	19	7	49
O6	Changes to the project by owner	0.784	4	67.263	52.758	3	-1	1
O7	Type of project bidding and award	0.532	42	43.575	23.175	39	-3	9
O8	Unrealistic enforced contract duration	0.715	18	59.218	42.346	14	-4	16
O9	Lack of experience of owner (or owner representative) in construction projects	0.695	23	54.525	37.893	22	-1	1
O10	Delay by owner in handing over process or approval of completed work	0.648	28	60.894	39.462	20	-8	64
	Delays related to Consultants							
CS1	lack of experience of consultants	0.715	18	52.849	37.792	23	5	25
CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	0.750	9	63.575	47.664	9	0	0
CS3	Mistakes or discrepancies in documents or specifications issued by consultants	0.664	26	57.877	38.412	21	-5	25
CS4	Poor communication and coordination with other parties	0.736	13	64.358	47.387	11	-2	4
CS5	Delay in inspection	0.625	32	51.285	32.032	31	-1	1
	Delays related to Contractor						0	0
C1	Difficulties in financing the project by contractor	0.734	15	57.095	41.912	15	0	0
C2	Poor site management and supervision	0.808	2	61.788	49.913	6	4	16
C3	Deficiency in planning and scheduling of project	0.746	10	61.899	46.200	12	2	4
C4	Rework due to errors during construction	0.655	27	56.201	36.798	25	-2	4
C5	Delays related to sub-contractors work	0.736	13	69.497	51.172	4	-9	81
C6	Lack of experience of contractor (Poor qualification of contractors' staff)	0.704	22	58.324	41.055	17	-5	25
C7	Inappropriate construction methods	0.593	38	49.497	29.366	34	-4	16
C8	Poor communication and coordination with other parties	0.689	24	60.782	41.902	16	-8	64
C9	Unsafe practice at site (Poor safety conditions on site)	0.615	34	56.536	34.743	27	-7	49
	Delays related to Material							
M1	Shortage of construction materials	0.804	3	61.788	49.706	7	4	16
M2	Delays due to material delivery	0.774	6	62.570	48.448	8	2	4

M3	Changes in material types and specifications during construction	0.721	17	56.536	40.744	18	1	1
M4	Inflation and escalation of material prices	0.612	35	54.637	33.454	28	-7	49
	Delays related to Labor							
L1	Shortage of labors	0.778	5	59.330	46.138	13	8	64
L2	Unqualified workforce	0.754	8	66.480	50.139	5	-3	9
L3	Low productivity of labor	0.771	7	75.084	57.886	1	-6	36
	Delays related to Construction site							
S1	Shortage of equipment and/or equipment failure	0.705	21	52.849	37.260	24	3	9
S2	Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	0.724	16	48.156	34.866	26	10	100
S3	Restriction at job site (Poor site access, traffic congestion)	0.609	36	53.184	32.386	30	-6	36
S4	Lack of site utilities or services such as (water, electricity, etc.)	0.589	39	42.123	24.803	37	-2	4
S5	Accident during construction	0.639	31	39.888	25.493	36	5	25
S6	Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)	0.555	41	42.570	23.639	38	-3	9
	Delays related to External							
E1	Weather effect (heat, rain, etc.)	0.641	30	51.732	33.178	29	-1	1
E2	Changes in government regulations and laws	0.584	40	39.553	23.113	41	1	1
E3	Delay in performing final inspection and certification by a third party	0.616	33	49.385	30.404	33	0	0
E4	Global financial crisis	0.606	37	38.212	23.141	40	3	9
E5	Force Majeure (earthquake, etc.)	0.689	24	30.279	20.874	42	18	324
							sum	1729
							Spearman's Rank Correlation	0.8599

4.4 Ranking Comparison amongst Respondents

Further to earlier conducted ranking of delay attributes based on all responses data collected, ranking was implemented based on the views of experts from other categories. It was performed to various perceptions within the construction field, such as location, organization type, industry type, total construction experience, and the size of the company. Comparisons were conducted between all categories, but 9 significant comparisons listed here are as follows: Qatar vs world, owner vs contractor, owner vs consultant, contractor vs consultant, superstructure vs infrastructures, superstructure vs oil & gas, infrastructures vs oil & gas, experts with more than 15 years experience in construction vs experts with less than 5 years experience in construction, and large company size vs others was conducted in the research.

4.4.1 Qatar vs World

The first Spearman's rank correlation factor comparison conducted FAII rankings of delay attributes between respondents from Qatar and other parts of the world. The computed value of 0.9080 for Spearman's correlation factor from Table 10 indicates that a positive correlation and there is an agreement between the rankings from the two respondent groups.

Table 10 - Spearman's rank correlation factor between rankings for Qatar vs World

code	Delays related to owner or owner representative	Qatar FAI rank	Rest of world FAI rank	d	d^2
O1	Delay in decision making	2	1	-1	1
O2	Suspension of work	32	30	-2	4
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	10	13	3	9
O4	Delay in delivering construction site to contractor	35	28	-7	49
O5	Delay of financing and payments by owner	18	24	6	36
O6	Changes to the project by owner	3	6	3	9
O7	Type of project bidding and award	40	37	-3	9
O8	Unrealistic enforced contract duration	14	18	4	16
O9	Lack of experience of owner in construction projects	24	17	-7	49
O10	Delay by owner in handing over process	16	33	17	289
	Delays related to Consultants				
CS1	lack of experience of consultants	22	26	4	16
CS2	Delay in approval of submittals, design drawings, etc.	9	16	7	49
CS3	Mistakes or discrepancies in documents or specifications	21	31	10	100
CS4	Poor communication and coordination with other parties	11	12	1	1
CS5	Delay in inspection	31	27	-4	16
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	15	14	-1	1
C2	Poor site management and supervision	7	3	-4	16
C3	Deficiency in planning and scheduling of project	13	5	-8	64
C4	Rework due to errors during construction	25	20	-5	25
C5	Delays related to sub-contractors work	4	4	0	0
C6	Lack of experience of contractor	20	11	-9	81
C7	Inappropriate construction methods	34	34	0	0
C8	Poor communication and coordination with other parties	17	9	-8	64
C9	Unsafe practice at site (Poor safety conditions on site)	28	22	-6	36
	Delays related to Material				
M1	Shortage of construction materials	6	8	2	4
M2	Delays due to material delivery	8	9	1	1
M3	Changes in material types and specifications during construction	19	19	0	0
M4	Inflation and escalation of material prices	26	35	9	81
	Delays related to Labor			0	
L1	Shortage of labors	12	15	3	9
L2	Unqualified workforce	5	7	2	4
L3	Low productivity of labor	1	2	1	1
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	23	21	-2	4
S2	Unforeseen site conditions	27	23	-4	16
S3	Restriction at job site (Poor site access, traffic congestion)	30	29	-1	1
S4	Lack of site utilities or services such as (water, electricity, etc.)	37	39	2	4
S5	Accident during construction	36	38	2	4
S6	Problem with nearby structure or facilities	38	42	4	16
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	29	25	-4	16
E2	Changes in government regulations and laws	39	41	2	4
E3	Delay in performing final inspection and certification by a third party	33	32	-1	1
E4	Global financial crisis	41	36	-5	25
E5	Force Majeure (earthquake, etc.)	42	40	-2	4
				sum	1135
				Spearman's Rank Correlation	0.9080

4.4.2 Owner vs contractor

The computed value of 0.8929 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 11 - Spearman's rank correlation factor between rankings for Owner vs contractor

code	Delays related to owner or owner representative	Owner FAI rank	Contractor FAI rank	d	d^2
O1	Delay in decision making	1	2	1	1
O2	Suspension of work	32	29	-3	9
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	13	7	-6	36
O4	Delay in delivering construction site to contractor	37	34	-3	9
O5	Delay of financing and payments by owner	24	15	-9	81
O6	Changes to the project by owner	6	5	-1	1
O7	Type of project bidding and award	40	37	-3	9
O8	Unrealistic enforced contract duration	17	16	-1	1
O9	Lack of experience of owner in construction projects	34	17	-17	289
O10	Delay by owner in handing over process	26	20	-6	36
	Delays related to Consultants				
CS1	lack of experience of consultants	16	21	5	25
CS2	Delay in approval of submittals, design drawings, etc.	9	4	-5	25
CS3	Mistakes or discrepancies in documents or specifications	25	14	-11	121
CS4	Poor communication and coordination with other parties	7	9	2	4
CS5	Delay in inspection	27	30	3	9
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	12	22	10	100
C2	Poor site management and supervision	2	11	9	81
C3	Deficiency in planning and scheduling of project	5	13	8	64
C4	Rework due to errors during construction	18	26	8	64
C5	Delays related to sub-contractors work	8	3	-5	25
C6	Lack of experience of contractor	10	23	13	169
C7	Inappropriate construction methods	36	35	-1	1
C8	Poor communication and coordination with other parties	19	18	-1	1
C9	Unsafe practice at site (Poor safety conditions on site)	20	31	11	121
	Delays related to Material				
M1	Shortage of construction materials	15	6	-9	81
M2	Delays due to material delivery	11	10	-1	1
M3	Changes in material types and specifications during construction	21	19	-2	4
M4	Inflation and escalation of material prices	31	28	-3	9
	Delays related to Labor			0	
L1	Shortage of labors	14	12	-2	4
L2	Unqualified workforce	3	8	5	25
L3	Low productivity of labor	4	1	-3	9
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	22	24	2	4
S2	Unforeseen site conditions	23	27	4	16
S3	Restriction at job site (Poor site access, traffic congestion)	28	32	4	16
S4	Lack of site utilities or services such as (water, electricity, etc.)	35	38	3	9
S5	Accident during construction	30	42	12	144
S6	Problem with nearby structure or facilities	38	40	2	4
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	29	25	-4	16
E2	Changes in government regulations and laws	39	39	0	0
E3	Delay in performing final inspection and certification by a third party	33	33	0	0
E4	Global financial crisis	41	36	-5	25
E5	Force Majeure (earthquake, etc.)	42	41	-1	1
				sum	1650
				Spearman's Rank Correlation	0.8663

4.4.3 Owner vs consultant

The computed value of 0.825 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 12 - Spearman's rank correlation factor between rankings for Owner vs consultant

code	Delays related to owner or owner representative	Owner FAI rank	consultant FAI rank	d	d^2
O1	Delay in decision making	1	3	2	4
O2	Suspension of work	32	27	-5	25
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	13	19	6	36
O4	Delay in delivering construction site to contractor	37	34	-3	9
O5	Delay of financing and payments by owner	24	15	-9	81
O6	Changes to the project by owner	6	2	-4	16
O7	Type of project bidding and award	40	40	0	0
O8	Unrealistic enforced contract duration	17	9	-8	64
O9	Lack of experience of owner in construction projects	34	17	-17	289
O10	Delay by owner in handing over process	26	12	-14	196
	Delays related to Consultants				
CS1	lack of experience of consultants	16	33	17	289
CS2	Delay in approval of submittals, design drawings, etc.	9	16	7	49
CS3	Mistakes or discrepancies in documents or specifications	25	30	5	25
CS4	Poor communication and coordination with other parties	7	13	6	36
CS5	Delay in inspection	27	35	8	64
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	12	21	9	81
C2	Poor site management and supervision	2	6	4	16
C3	Deficiency in planning and scheduling of project	5	14	9	81
C4	Rework due to errors during construction	18	25	7	49
C5	Delays related to sub-contractors work	8	4	-4	16
C6	Lack of experience of contractor	10	20	10	100
C7	Inappropriate construction methods	36	28	-8	64
C8	Poor communication and coordination with other parties	19	8	-11	121
C9	Unsafe practice at site (Poor safety conditions on site)	20	29	9	81
	Delays related to Material				
M1	Shortage of construction materials	15	7	-8	64
M2	Delays due to material delivery	11	11	0	0
M3	Changes in material types and specifications during construction	21	18	-3	9
M4	Inflation and escalation of material prices	31	23	-8	64
	Delays related to Labor			0	
L1	Shortage of labors	14	5	-9	81
L2	Unqualified workforce	3	10	7	49
L3	Low productivity of labor	4	1	-3	9
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	22	22	0	0
S2	Unforeseen site conditions	23	24	1	1
S3	Restriction at job site (Poor site access, traffic congestion)	28	26	-2	4
S4	Lack of site utilities or services such as (water, electricity, etc.)	35	39	4	16
S5	Accident during construction	30	37	7	49
S6	Problem with nearby structure or facilities	38	36	-2	4
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	29	32	3	9
E2	Changes in government regulations and laws	39	38	-1	1
E3	Delay in performing final inspection and certification by a third party	33	31	-2	4
E4	Global financial crisis	41	42	1	1
E5	Force Majeure (earthquake, etc.)	42	41	-1	1
				sum	2158
				Spearman's Rank Correlation	0.8251

4.4.4 Contractor vs consultant

The computed value of 0.893 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 13 - Spearman's rank correlation factor between rankings for contractor vs consultant

code	Delays related to owner or owner representative	Contractor FAI rank	consultant FAI rank	d	d^2
O1	Delay in decision making	2	3	1	1
O2	Suspension of work	29	27	-2	4
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	7	19	12	144
O4	Delay in delivering construction site to contractor	34	34	0	0
O5	Delay of financing and payments by owner	15	15	0	0
O6	Changes to the project by owner	5	2	-3	9
O7	Type of project bidding and award	37	40	3	9
O8	Unrealistic enforced contract duration	16	9	-7	49
O9	Lack of experience of owner in construction projects	17	17	0	0
O10	Delay by owner in handing over process	20	12	-8	64
	Delays related to Consultants				
CS1	lack of experience of consultants	21	33	12	144
CS2	Delay in approval of submittals, design drawings, etc.	4	16	12	144
CS3	Mistakes or discrepancies in documents or specifications	14	30	16	256
CS4	Poor communication and coordination with other parties	9	13	4	16
CS5	Delay in inspection	30	35	5	25
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	22	21	-1	1
C2	Poor site management and supervision	11	6	-5	25
C3	Deficiency in planning and scheduling of project	13	14	1	1
C4	Rework due to errors during construction	26	25	-1	1
C5	Delays related to sub-contractors work	3	4	1	1
C6	Lack of experience of contractor	23	20	-3	9
C7	Inappropriate construction methods	35	28	-7	49
C8	Poor communication and coordination with other parties	18	8	-10	100
C9	Unsafe practice at site (Poor safety conditions on site)	31	29	-2	4
	Delays related to Material				
M1	Shortage of construction materials	6	7	1	1
M2	Delays due to material delivery	10	11	1	1
M3	Changes in material types and specifications during construction	19	18	-1	1
M4	Inflation and escalation of material prices	28	23	-5	25
	Delays related to Labor			0	
L1	Shortage of labors	12	5	-7	49
L2	Unqualified workforce	8	10	2	4
L3	Low productivity of labor	1	1	0	0
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	24	22	-2	4
S2	Unforeseen site conditions	27	24	-3	9
S3	Restriction at job site (Poor site access, traffic congestion)	32	26	-6	36
S4	Lack of site utilities or services such as (water, electricity, etc.)	38	39	1	1
S5	Accident during construction	42	37	-5	25
S6	Problem with nearby structure or facilities	40	36	-4	16
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	25	32	7	49
E2	Changes in government regulations and laws	39	38	-1	1
E3	Delay in performing final inspection and certification by a third party	33	31	-2	4
E4	Global financial crisis	36	42	6	36
E5	Force Majeure (earthquake, etc.)	41	41	0	0
				sum	1318
				Spearman's Rank Correlation	0.8932

4.4.5 Superstructure vs Infrastructures

The computed value of 0.944 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 14 - Spearman's rank correlation factor between rankings for Superstructure vs Infrastructures

code	Delays related to owner or owner representative	Superstructure FAI rank	Infra FAI rank	d	d^2
O1	Delay in decision making	1	1	0	0
O2	Suspension of work	34	32	-2	4
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	12	12	0	0
O4	Delay in delivering construction site to contractor	36	33	-3	9
O5	Delay of financing and payments by owner	15	21	6	36
O6	Changes to the project by owner	3	3	0	0
O7	Type of project bidding and award	40	39	-1	1
O8	Unrealistic enforced contract duration	11	16	5	25
O9	Lack of experience of owner in construction projects	19	22	3	9
O10	Delay by owner in handing over process	21	19	-2	4
	Delays related to Consultants				
CS1	lack of experience of consultants	24	18	-6	36
CS2	Delay in approval of submittals, design drawings, etc.	10	10	0	0
CS3	Mistakes or discrepancies in documents or specifications	18	24	6	36
CS4	Poor communication and coordination with other parties	13	7	-6	36
CS5	Delay in inspection	31	30	-1	1
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	14	17	3	9
C2	Poor site management and supervision	6	5	-1	1
C3	Deficiency in planning and scheduling of project	16	8	-8	64
C4	Rework due to errors during construction	25	26	1	1
C5	Delays related to sub-contractors work	4	6	2	4
C6	Lack of experience of contractor	23	14	-9	81
C7	Inappropriate construction methods	35	34	-1	1
C8	Poor communication and coordination with other parties	20	15	-5	25
C9	Unsafe practice at site (Poor safety conditions on site)	30	25	-5	25
	Delays related to Material				
M1	Shortage of construction materials	5	9	4	16
M2	Delays due to material delivery	7	11	4	16
M3	Changes in material types and specifications during construction	17	20	3	9
M4	Inflation and escalation of material prices	28	29	1	1
	Delays related to Labor			0	
L1	Shortage of labors	9	13	4	16
L2	Unqualified workforce	8	4	-4	16
L3	Low productivity of labor	2	2	0	0
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	22	23	1	1
S2	Unforeseen site conditions	26	27	1	1
S3	Restriction at job site (Poor site access, traffic congestion)	32	28	-4	16
S4	Lack of site utilities or services such as (water, electricity, etc.)	38	38	0	0
S5	Accident during construction	39	37	-2	4
S6	Problem with nearby structure or facilities	42	36	-6	36
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	29	35	6	36
E2	Changes in government regulations and laws	33	42	9	81
E3	Delay in performing final inspection and certification by a third party	27	31	4	16
E4	Global financial crisis	37	41	4	16
E5	Force Majeure (earthquake, etc.)	41	40	-1	1
				sum	690
				Spearman's Rank Correlation	0.9441

4.4.6 Superstructure vs Oil & Gas

The computed value of 0.794 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 15 - Spearman's rank correlation factor between rankings for Superstructure vs Oil & Gas

code	Delays related to owner or owner representative	Superstructure FAI rank	Oil & Gas FAI rank	d	d^2
O1	Delay in decision making	1	8	7	49
O2	Suspension of work	34	9	-25	625
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	12	5	-7	49
O4	Delay in delivering construction site to contractor	36	31	-5	25
O5	Delay of financing and payments by owner	15	29	14	196
O6	Changes to the project by owner	3	21	18	324
O7	Type of project bidding and award	40	35	-5	25
O8	Unrealistic enforced contract duration	11	27	16	256
O9	Lack of experience of owner in construction projects	19	30	11	121
O10	Delay by owner in handing over process	21	20	-1	1
	Delays related to Consultants				
CS1	lack of experience of consultants	24	32	8	64
CS2	Delay in approval of submittals, design drawings, etc.	10	13	3	9
CS3	Mistakes or discrepancies in documents or specifications	18	25	7	49
CS4	Poor communication and coordination with other parties	13	10	-3	9
CS5	Delay in inspection	31	33	2	4
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	14	19	5	25
C2	Poor site management and supervision	6	6	0	0
C3	Deficiency in planning and scheduling of project	16	11	-5	25
C4	Rework due to errors during construction	25	17	-8	64
C5	Delays related to sub-contractors work	4	2	-2	4
C6	Lack of experience of contractor	23	15	-8	64
C7	Inappropriate construction methods	35	34	-1	1
C8	Poor communication and coordination with other parties	20	12	-8	64
C9	Unsafe practice at site (Poor safety conditions on site)	30	24	-6	36
	Delays related to Material				
M1	Shortage of construction materials	5	3	-2	4
M2	Delays due to material delivery	7	4	-3	9
M3	Changes in material types and specifications during construction	17	16	-1	1
M4	Inflation and escalation of material prices	28	23	-5	25
	Delays related to Labor			0	
L1	Shortage of labors	9	14	5	25
L2	Unqualified workforce	8	7	-1	1
L3	Low productivity of labor	2	1	-1	1
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	22	25	3	9
S2	Unforeseen site conditions	26	22	-4	16
S3	Restriction at job site (Poor site access, traffic congestion)	32	28	-4	16
S4	Lack of site utilities or services such as (water, electricity, etc.)	38	37	-1	1
S5	Accident during construction	39	36	-3	9
S6	Problem with nearby structure or facilities	42	40	-2	4
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	29	18	-11	121
E2	Changes in government regulations and laws	33	42	9	81
E3	Delay in performing final inspection and certification by a third party	27	38	11	121
E4	Global financial crisis	37	39	2	4
E5	Force Majeure (earthquake, etc.)	41	41	0	0
				sum	2537
				Spearman's Rank Correlation	0.7944

4.4.7 Infrastructures vs Oil & Gas

The computed value of 0.829 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 16 - Spearman's rank correlation factor between rankings for Infrastructure vs Oil & Gas

code	Delays related to owner or owner representative	Infra FAI rank	Oil & Gas FAI rank	d	d^2
O1	Delay in decision making	1	8	7	49
O2	Suspension of work	32	9	-23	529
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	12	5	-7	49
O4	Delay in delivering construction site to contractor	33	31	-2	4
O5	Delay of financing and payments by owner	21	29	8	64
O6	Changes to the project by owner	3	21	18	324
O7	Type of project bidding and award	39	35	-4	16
O8	Unrealistic enforced contract duration	16	27	11	121
O9	Lack of experience of owner in construction projects	22	30	8	64
O10	Delay by owner in handing over process	19	20	1	1
	Delays related to Consultants				
CS1	lack of experience of consultants	18	32	14	196
CS2	Delay in approval of submittals, design drawings, etc.	10	13	3	9
CS3	Mistakes or discrepancies in documents or specifications	24	25	1	1
CS4	Poor communication and coordination with other parties	7	10	3	9
CS5	Delay in inspection	30	33	3	9
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	17	19	2	4
C2	Poor site management and supervision	5	6	1	1
C3	Deficiency in planning and scheduling of project	8	11	3	9
C4	Rework due to errors during construction	26	17	-9	81
C5	Delays related to sub-contractors work	6	2	-4	16
C6	Lack of experience of contractor	14	15	1	1
C7	Inappropriate construction methods	34	34	0	0
C8	Poor communication and coordination with other parties	15	12	-3	9
C9	Unsafe practice at site (Poor safety conditions on site)	25	24	-1	1
	Delays related to Material				
M1	Shortage of construction materials	9	3	-6	36
M2	Delays due to material delivery	11	4	-7	49
M3	Changes in material types and specifications during construction	20	16	-4	16
M4	Inflation and escalation of material prices	29	23	-6	36
	Delays related to Labor			0	
L1	Shortage of labors	13	14	1	1
L2	Unqualified workforce	4	7	3	9
L3	Low productivity of labor	2	1	-1	1
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	23	25	2	4
S2	Unforeseen site conditions	27	22	-5	25
S3	Restriction at job site (Poor site access, traffic congestion)	28	28	0	0
S4	Lack of site utilities or services such as (water, electricity, etc.)	38	37	-1	1
S5	Accident during construction	37	36	-1	1
S6	Problem with nearby structure or facilities	36	40	4	16
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	35	18	-17	289
E2	Changes in government regulations and laws	42	42	0	0
E3	Delay in performing final inspection and certification by a third party	31	38	7	49
E4	Global financial crisis	41	39	-2	4
E5	Force Majeure (earthquake, etc.)	40	41	1	1
				sum	2105
				Spearman's Rank Correlation	0.8294

4.4.8 Experts with more than 15 years experience in construction vs experts with less than 5 years experience in construction

The computed value of 0.8747 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from both respondents groups.

Table 17 - Spearman's rank correlation factor between rankings for Experts with more than 15 years experience in construction vs experts with less than 5 years experience in construction

code	Delays related to owner or owner representative	above 15 FAI rank	5-0 FAI rank	d	d^2
O1	Delay in decision making	1	6	5	25
O2	Suspension of work	36	23	-13	169
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	7	5	-2	4
O4	Delay in delivering construction site to contractor	34	34	0	0
O5	Delay of financing and payments by owner	9	27	18	324
O6	Changes to the project by owner	2	3	1	1
O7	Type of project bidding and award	39	37	-2	4
O8	Unrealistic enforced contract duration	11	15	4	16
O9	Lack of experience of owner in construction projects	20	31	11	121
O10	Delay by owner in handing over process	19	25	6	36
	Delays related to Consultants				
CS1	lack of experience of consultants	22	26	4	16
CS2	Delay in approval of submittals, design drawings, etc.	14	11	-3	9
CS3	Mistakes or discrepancies in documents or specifications	23	22	-1	1
CS4	Poor communication and coordination with other parties	13	12	-1	1
CS5	Delay in inspection	31	30	-1	1
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	16	16	0	0
C2	Poor site management and supervision	4	8	4	16
C3	Deficiency in planning and scheduling of project	10	9	-1	1
C4	Rework due to errors during construction	26	21	-5	25
C5	Delays related to sub-contractors work	8	2	-6	36
C6	Lack of experience of contractor	18	20	2	4
C7	Inappropriate construction methods	32	35	3	9
C8	Poor communication and coordination with other parties	17	14	-3	9
C9	Unsafe practice at site (Poor safety conditions on site)	27	29	2	4
	Delays related to Material				
M1	Shortage of construction materials	12	4	-8	64
M2	Delays due to material delivery	15	7	-8	64
M3	Changes in material types and specifications during construction	21	17	-4	16
M4	Inflation and escalation of material prices	24	33	9	81
	Delays related to Labor			0	
L1	Shortage of labors	5	13	8	64
L2	Unqualified workforce	6	10	4	16
L3	Low productivity of labor	3	1	-2	4
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	28	18	-10	100
S2	Unforeseen site conditions	25	28	3	9
S3	Restriction at job site (Poor site access, traffic congestion)	30	24	-6	36
S4	Lack of site utilities or services such as (water, electricity, etc.)	38	38	0	0
S5	Accident during construction	37	36	-1	1
S6	Problem with nearby structure or facilities	41	39	-2	4
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	33	19	-14	196
E2	Changes in government regulations and laws	35	42	7	49
E3	Delay in performing final inspection and certification by a third party	29	32	3	9
E4	Global financial crisis	40	40	0	0
E5	Force Majeure (earthquake, etc.)	42	41	-1	1
				sum	1546
				Spearman's Rank Correlation	0.8747

4.4.9 Large company size vs others

The computed value of 0.8929 for Spearman's correlation factor from below indicates that a positive agreement between the rankings from large company size respondent and other company sizes respondent.

Table 18 - Spearman's rank correlation factor between rankings for Large Company size vs others company sizes

code	Delays related to owner or owner representative	above 250 FAI rank	>250 FAI rank	d	d^2
O1	Delay in decision making	2	6	4	16
O2	Suspension of work	31	31	0	0
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	10	7	-3	9
O4	Delay in delivering construction site to contractor	35	33	-2	4
O5	Delay of financing and payments by owner	20	15	-5	25
O6	Changes to the project by owner	3	10	7	49
O7	Type of project bidding and award	39	38	-1	1
O8	Unrealistic enforced contract duration	13	29	16	256
O9	Lack of experience of owner in construction projects	21	26	5	25
O10	Delay by owner in handing over process	19	20	1	1
	Delays related to Consultants				
CS1	lack of experience of consultants	22	27	5	25
CS2	Delay in approval of submittals, design drawings, etc.	9	8	-1	1
CS3	Mistakes or discrepancies in documents or specifications	23	16	-7	49
CS4	Poor communication and coordination with other parties	11	11	0	0
CS5	Delay in inspection	32	25	-7	49
	Delays related to Contractor				
C1	Difficulties in financing the project by contractor	18	9	-9	81
C2	Poor site management and supervision	6	13	7	49
C3	Deficiency in planning and scheduling of project	12	14	2	4
C4	Rework due to errors during construction	25	24	-1	1
C5	Delays related to sub-contractors work	4	3	-1	1
C6	Lack of experience of contractor	16	18	2	4
C7	Inappropriate construction methods	33	37	4	16
C8	Poor communication and coordination with other parties	15	22	7	49
C9	Unsafe practice at site (Poor safety conditions on site)	28	21	-7	49
	Delays related to Material				
M1	Shortage of construction materials	7	4	-3	9
M2	Delays due to material delivery	8	5	-3	9
M3	Changes in material types and specifications during construction	17	17	0	0
M4	Inflation and escalation of material prices	30	19	-11	121
	Delays related to Labor			0	
L1	Shortage of labors	14	1	-13	169
L2	Unqualified workforce	5	12	7	49
L3	Low productivity of labor	1	2	1	1
	Delays related to Construction site				
S1	Shortage of equipment and/or equipment failure	24	23	-1	1
S2	Unforeseen site conditions	26	30	4	16
S3	Restriction at job site (Poor site access, traffic congestion)	29	32	3	9
S4	Lack of site utilities or services such as (water, electricity, etc.)	37	39	2	4
S5	Accident during construction	36	40	4	16
S6	Problem with nearby structure or facilities	38	42	4	16
	Delays related to External				
E1	Weather effect (heat, rain, etc.)	27	34	7	49
E2	Changes in government regulations and laws	41	35	-6	36
E3	Delay in performing final inspection and certification by a third party	34	28	-6	36
E4	Global financial crisis	40	36	-4	16
E5	Force Majeure (earthquake, etc.)	42	41	-1	1
				sum	1322
				Spearman's Rank Correlation	0.8929

4.4.10 Matrices for Spearman's correlation factor

Below are the rest of results found from applying Spearman's correlation factor to various categories:

Table 19 Spearman's correlation factor matrix based on location

	Location	
	Qatar	Rest of world
Qatar	1	0.908
Rest of world		1

Table 20 Spearman's correlation factor matrix based on Organization Type

	Organization type					
	Owner	contractor	Consultant	Designer/ Architect	Subcontractor	Supplier
Owner	1	0.866	0.825	0.886	0.749	0.774
contractor		1	0.893	0.852	0.767	0.875
Consultant			1	0.859	0.753	0.802
Designer/ Architect				1	0.709	0.785
Subcontractor					1	0.696
Supplier						1

Table 21 Spearman's correlation factor matrix based on Job Designation

	Job Designation				
	Owner	Resident Engineer	Project / Construction manager	Project Engineer	Site superintendent	Others
Owner	1	0.719	0.779	0.753	0.649	0.718
Resident Engineer		1	0.746	0.795	0.776	0.779
Project / Construction manager			1	0.864	0.774	0.835
Project Engineer				1	0.874	0.917
Site superintendent					1	0.812
Others						1

Table 22 Spearman's correlation factor matrix based on Industry Type

	Industry type				
	Superstructure	Infrastructure	Oil & Gas	Industrial	Others
Superstructure	1	0.944	0.794	0.845	0.805
Infrastructure		1	0.829	0.821	0.821
Oil & Gas			1	0.710	0.759
Industrial				1	0.719
Others					1

Table 23 Spearman's correlation factor matrix based on Total experience in construction in years

	Total experience in construction in years			
	0 to 5	6 to 10	11 to 15	> 15
0 to 5	1	0.908	0.867	0.875
6 to 10		1	0.859	0.918
11 to 15			1	0.914
> 15				1

Table 24 Spearman's correlation factor matrix based on Total experience in construction in years

	Size of your company	
	>250 employees	<250 employees
>250 employees	1	0.893
<250 employees		1

4.5 T-test Results

T-test is a tool which is used to statistically identify if there is a significant difference between two independent categories groups exists. T-test is utilized in this study to identify among the independent set of groups which delay attributes had significant level of disagreement. Probability (ρ) value less than 0.1 shows a significant disagreement.

Table 25 – T-test **results**shows the results of the T-test comparison among various groups based on location, organization type, industry type, total construction experience, and size of the company.

Table 25 – T-test results

code	Attribute	T-Test (ρ)
	Qatar vs World	
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	0.0308
O10	Delay by owner in handing over process or approval of completed work	0.0530
CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	0.0673
CS3	Mistakes or discrepancies in documents or specifications issued by consultant	0.0251
M4	Inflation and escalation of material prices	0.0001
S6	Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural)	0.0828
	Owner vs Contractor	
CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	0.0950
CS3	Mistakes or discrepancies in documents or specifications issued by consultant	0.0805
C5	Delays related to sub-contractors work	0.0037
C9	Unsafe practice at site (Poor safety conditions on site)	0.0666
M1	Shortage of construction materials	0.0634
S4	Lack of site utilities or services such as (water, electricity, etc.)	0.0995
	Owner vs Consultant	
O10	Delay by owner in handing over process or approval of completed work	0.0872
CS1	Lake of experience of consultants	0.0139
C5	Delays related to sub-contractors work	0.0732
C9	Unsafe practice at site (Poor safety conditions on site)	0.0229
	Contractor vs Consultant	
O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	0.0491
CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	0.0187
CS3	Mistakes or discrepancies in documents or specifications issued by consultant	0.0324
	Superstructure vs Infrastructures	
O4	Delay in delivering construction site to contractor	0.0439
CS4	Poor communication and coordination with other parties	0.0802
C6	Lack of experience of contractor (Poor qualification of contractors' staff)	0.0081
S1	Shortage of equipment and/or equipment failure	0.0902
S6	Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural)	0.0688
E2	Changes in government regulations and laws	0.0989
	Superstructure vs Oil & Gas	
O5	Delay of financing and payments by owner	0.0916
O6	Changes to the project by owner	0.0214
O8	Unrealistic enforced contract duration	0.0199
E1	Weather effect (heat, rain, etc.)	0.0667
E2	Changes in government regulations and laws	0.0557
E3	Delay in performing final inspection and certification by a third party	0.0969
	Infrastructures vs Oil & Gas	
O2	Suspension of work	0.0657
O6	Changes to the project by owner	0.0576
O8	Unrealistic enforced contract duration	0.0776
S6	Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural)	0.0271
	More than 10 years experience vs Less than 10 years experience	
O2	Suspension of work	0.0199
CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	0.0865
CS4	Poor communication and coordination with other parties	0.0761
C3	Deficiency in planning and scheduling of project	0.0931
E1	Weather effect (heat, rain, etc.)	0.0184
	Large company size vs Other company sizes	
O5	Delay of financing and payments by owner	0.0696
O7	Type of project bidding and award	0.0604
L1	Shortage of labors	0.0068
E2	Changes in government regulations and laws	0.0477
E3	Delay in performing final inspection and certification by a third party	0.0714
E4	Global financial crisis	0.0495

Where code (O) represents group of delays related to owner or owner representative, code (CS) represents group of delays related to consultants, code (C) represents group of delays related to contractor, code (M) represents group of delays related to material, code (L) represents group of delays related to labor, code (OS) represents group of delays related to construction site, and code (E) represents group Of delays related to external.

4.6 Risk mapping matrix:

Risk mapping matrix, is a tool used to help in identifying in which risk zone each delay factor falls by visual representation of each attribute average value of impact and frequency level for data collected for all responses as shown in Table 26.

Table 26 – mean value results for data collected from all responses

Delay factor code	Impact MEAN	Frequency MEAN
O1	4.251	3.307
O2	3.715	2.134
O3	3.547	3.358
O4	3.223	2.251
O5	3.709	2.709
O6	3.922	3.363
O7	2.659	2.179
O8	3.575	2.961
O9	3.475	2.726
O10	3.240	3.045
CS1	3.575	2.642
CS2	3.749	3.179
CS3	3.318	2.894
CS4	3.682	3.218
CS5	3.123	2.564
C1	3.670	2.855
C2	4.039	3.089
C3	3.732	3.095
C4	3.274	2.810
C5	3.682	3.475
C6	3.520	2.916
C7	2.966	2.475
C8	3.447	3.039
C9	3.073	2.827
M1	4.022	3.089
M2	3.872	3.128
M3	3.603	2.827
M4	3.061	2.732
L1	3.888	2.966
L2	3.771	3.324
L3	3.855	3.754
S1	3.525	2.642
S2	3.620	2.408
S3	3.045	2.659
S4	2.944	2.106
S5	3.196	1.994
S6	2.777	2.128
E1	3.207	2.587
E2	2.922	1.978
E3	3.078	2.469
E4	3.028	1.911
E5	3.447	1.514

Next step, will be presenting each group of delay factors risk matrix using mean values as earlier discussed. Due to size restrictions legend of each scatter plot chart will be presented below each chart describing each delay attribute and the symbol point used to represent each factor in each chart.

4.6.1 All responses risk matrix: For Delays related to owner or owner representative

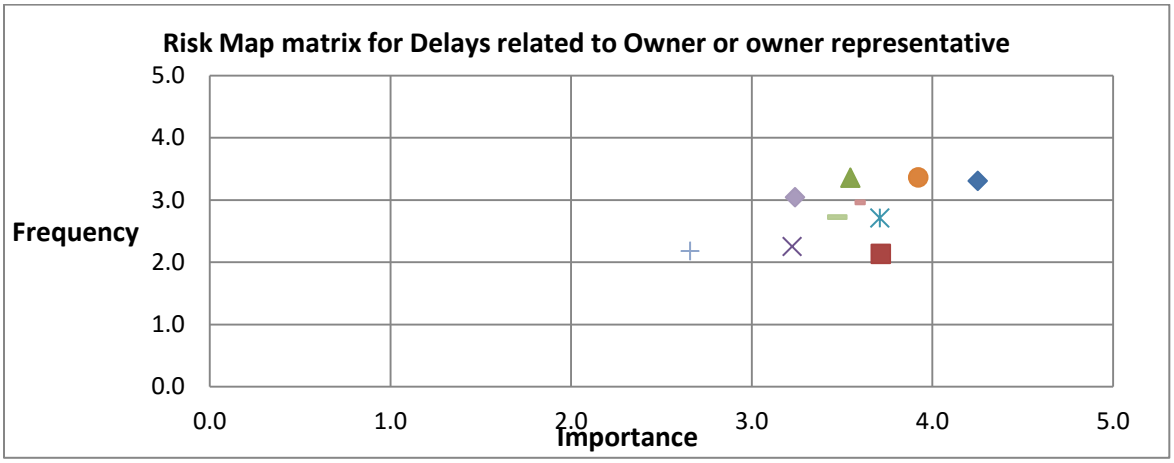

Figure 9 - risk matrix chart for delays related to owner or owner representative

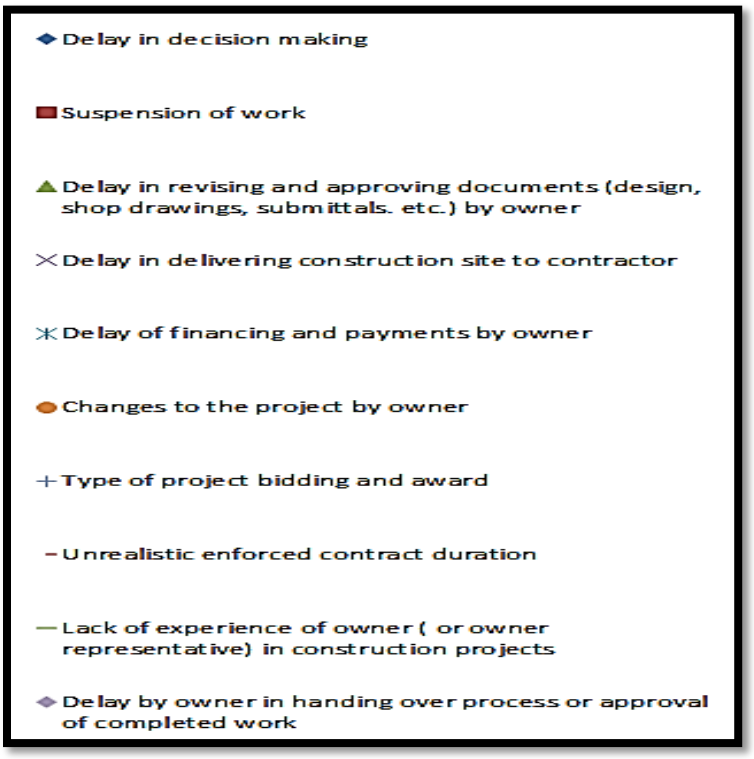

Figure 10 - Legend for delays related to owner or owner representative risk matrix

4.6.2 All responses risk matrix: For Delays related to Consultants

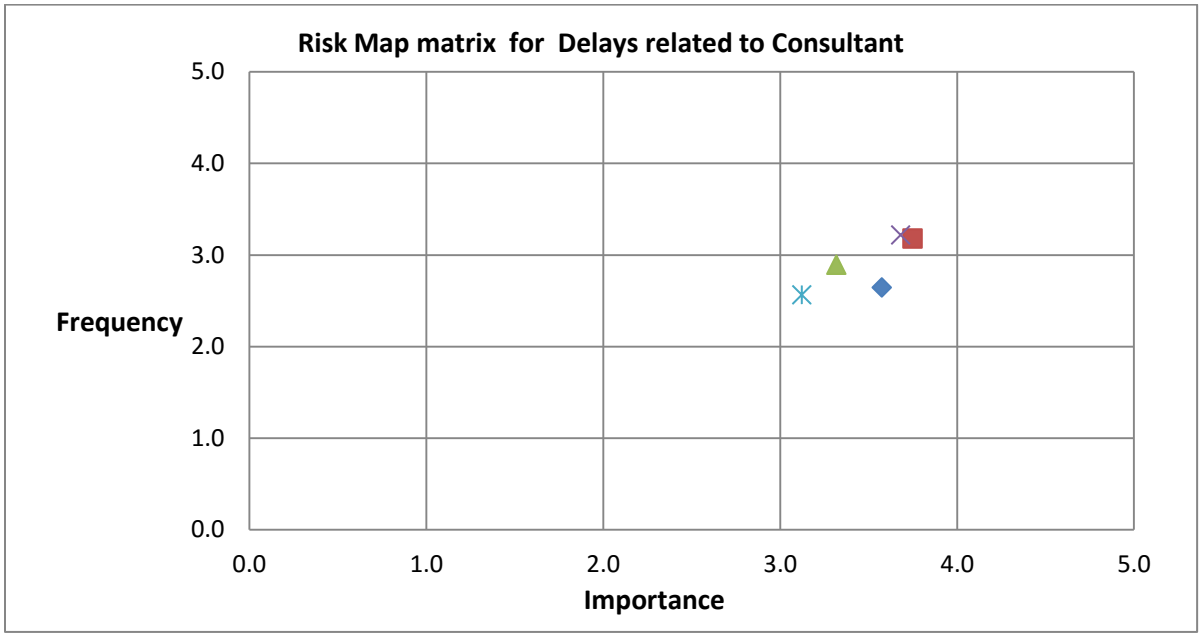

Figure 11 - risk matrix chart for delays related to Consultant

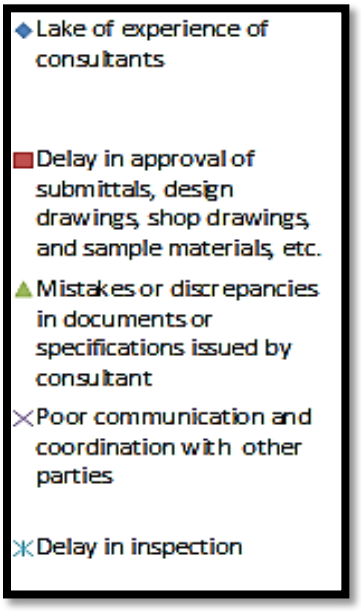

Figure 12 - Legend for delays related to Consultant risk matrix

4.6.3 All responses risk matrix: for Delays related to Contractor

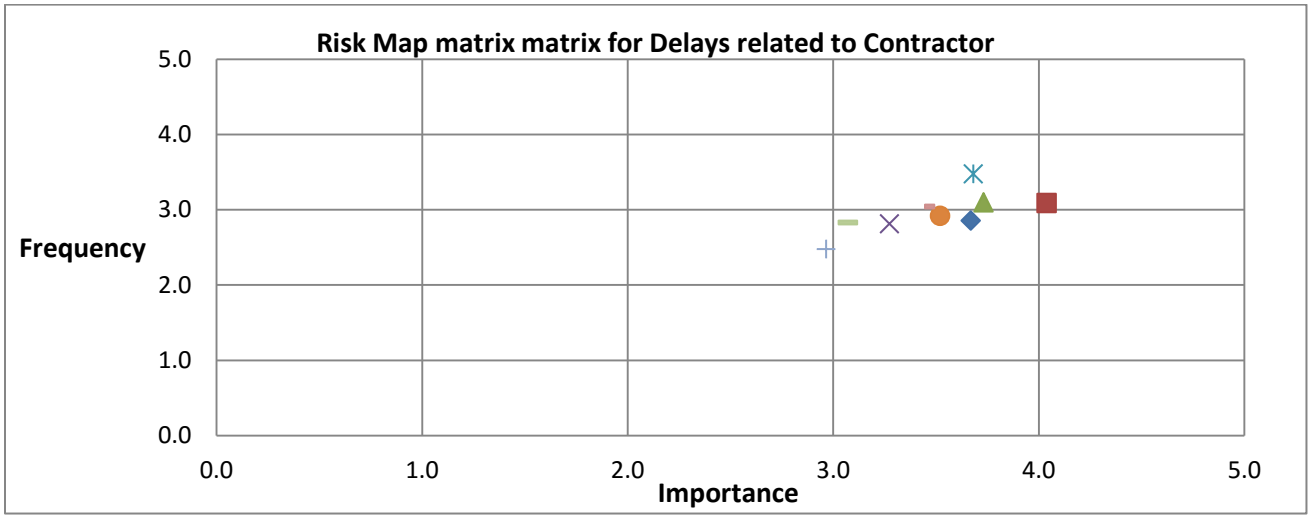

Figure 13 - risk matrix chart for delays related to contractor

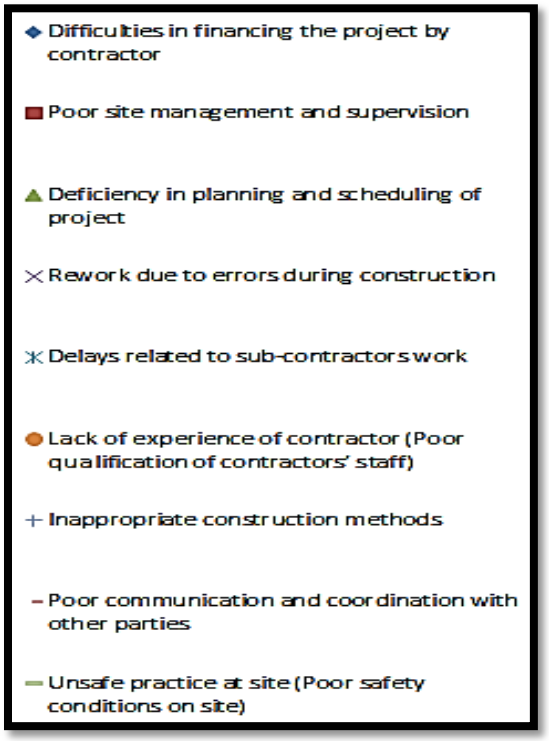

Figure 14 - Legend for delays related to contractor risk matrix

4.6.4 All responses risk matrix: for Delays related to Material

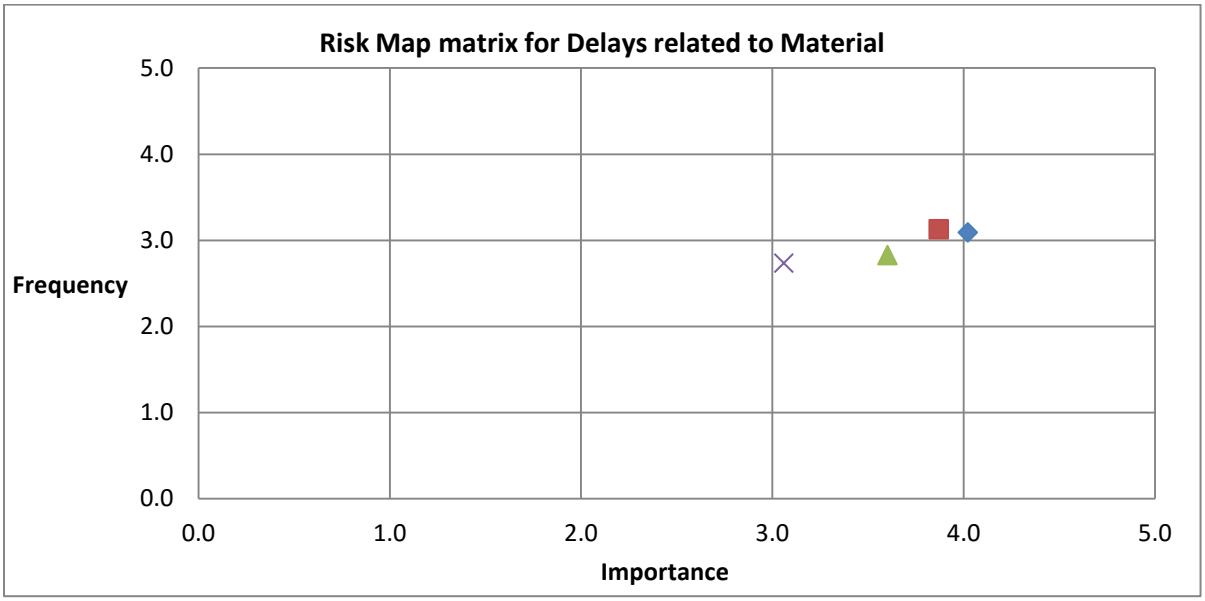

Figure 15 - risk matrix chart for delays related to material

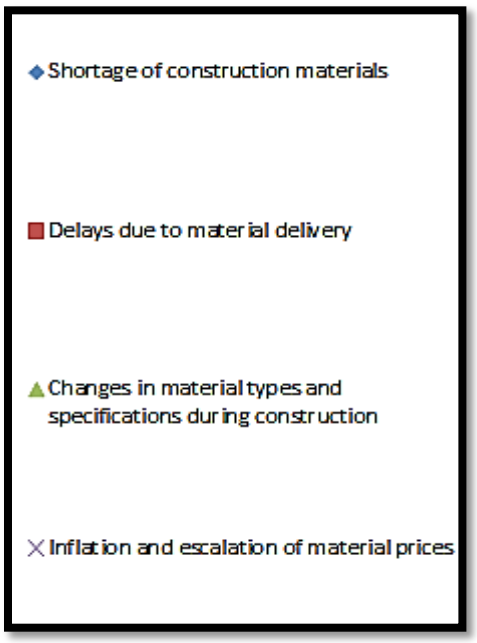

Figure 16 - Legend for delays related to material risk matrix

4.6.5 All responses risk matrix: for Delays related to Labor

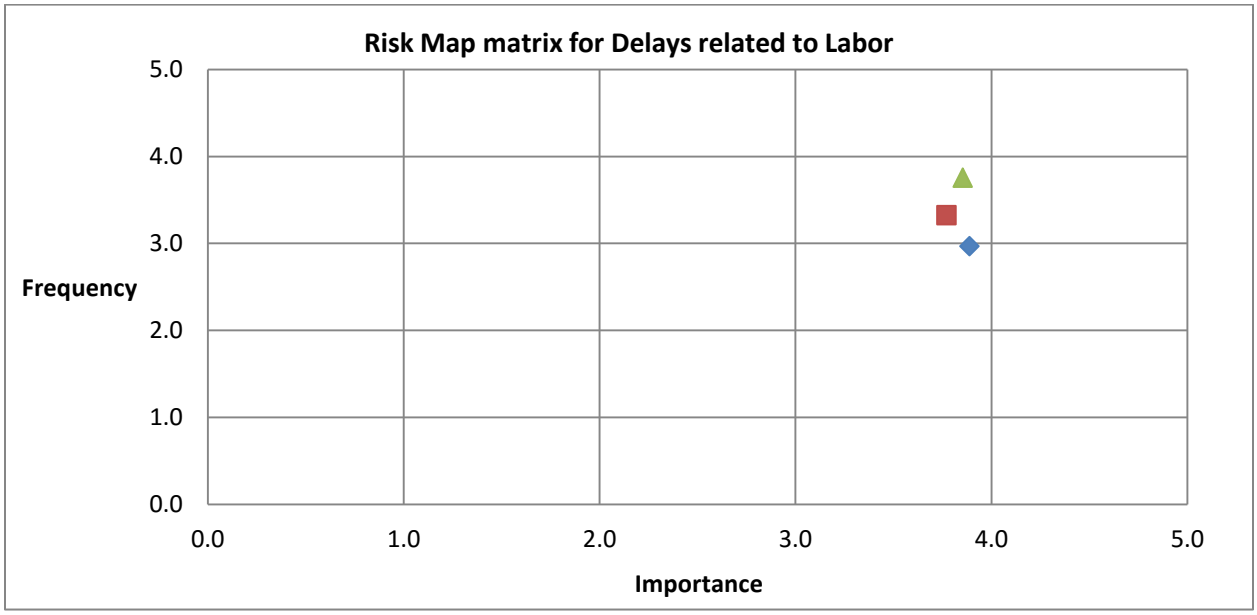

Figure 17 - risk matrix chart for delays related to Labour

Figure 18 - Legend for delays related to Labour risk matrix

4.6.6 All responses risk matrix: for Delays related to Construction site

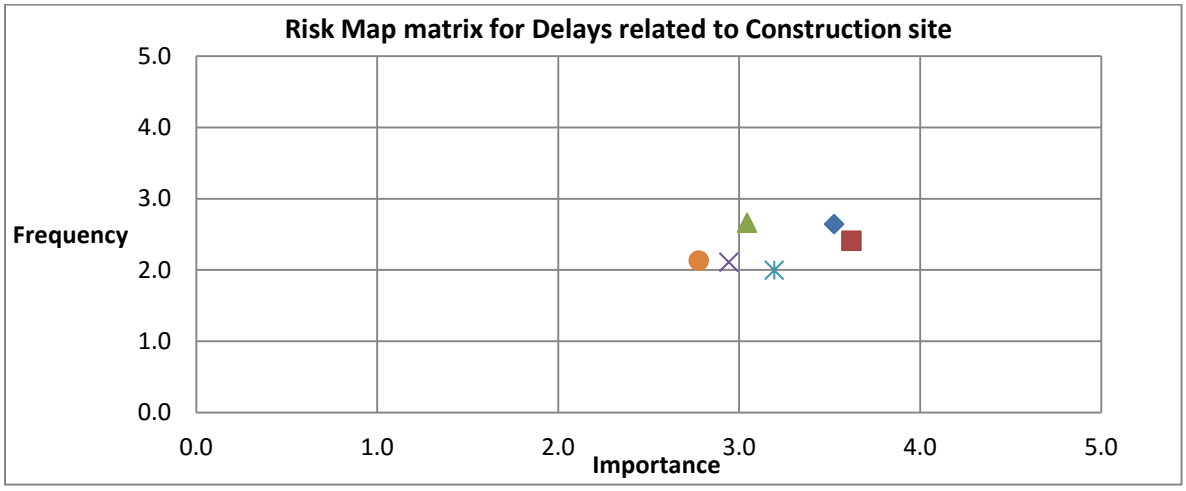

Figure 19 - risk matrix chart for delays related to construction site

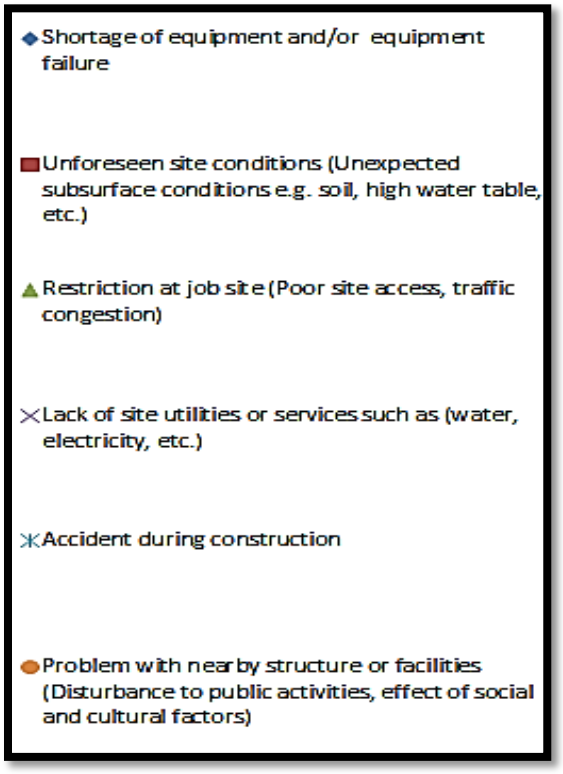

Figure 20 - Legend for delays related to construction site risk matrix

4.6.7 All responses risk matrix: for Delays related to External

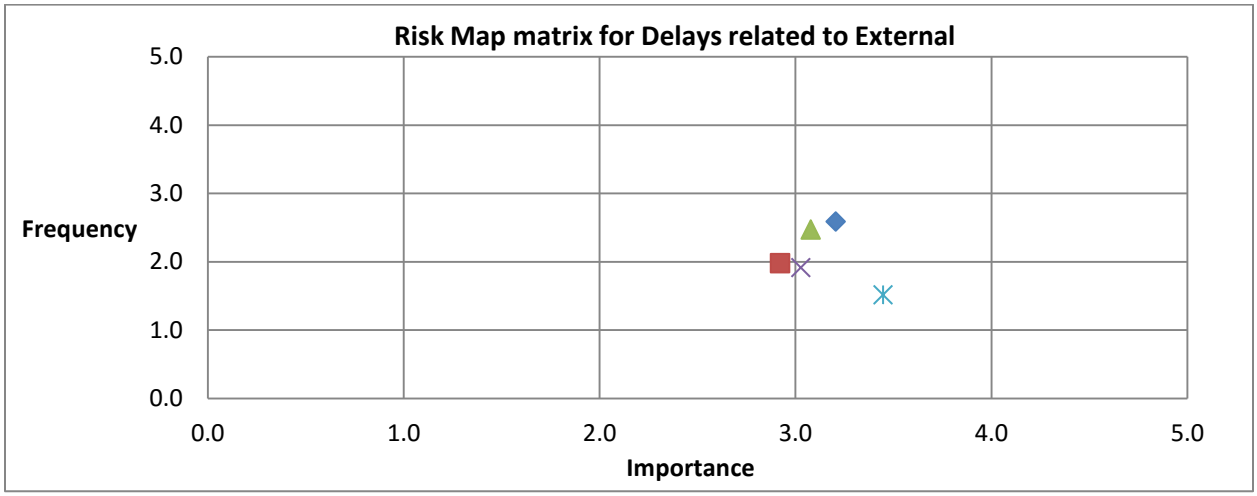

Figure 21 - risk matrix chart for delays related to External

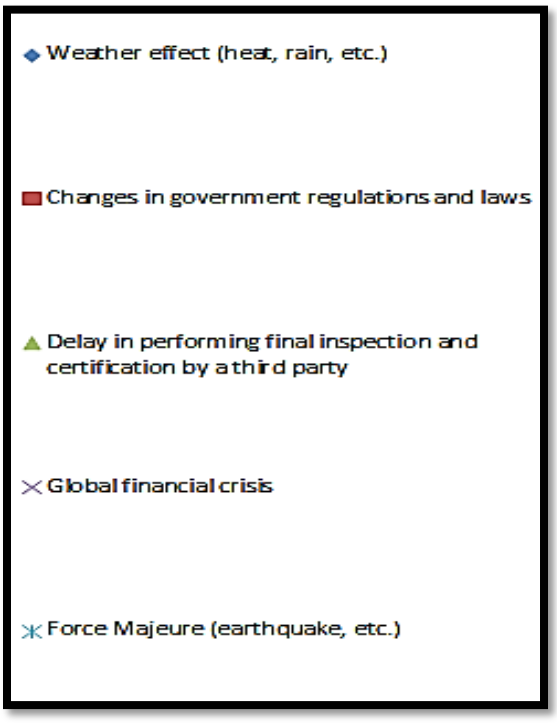

Figure 22 - Legend for delays related to External risk matrix

4.6.8 All responses risk matrix: Groups top delay factor

The most benefit from risk mapping matrix is to visually determine the top delay factors based on impact and frequency mean values, and in which risk zone each factor is falling,

Table 27 below summarized each delay factor group top factor impact and frequency mean value and risk zone. Figure 23 shows risk mapping matrix zones used to present delay factor.

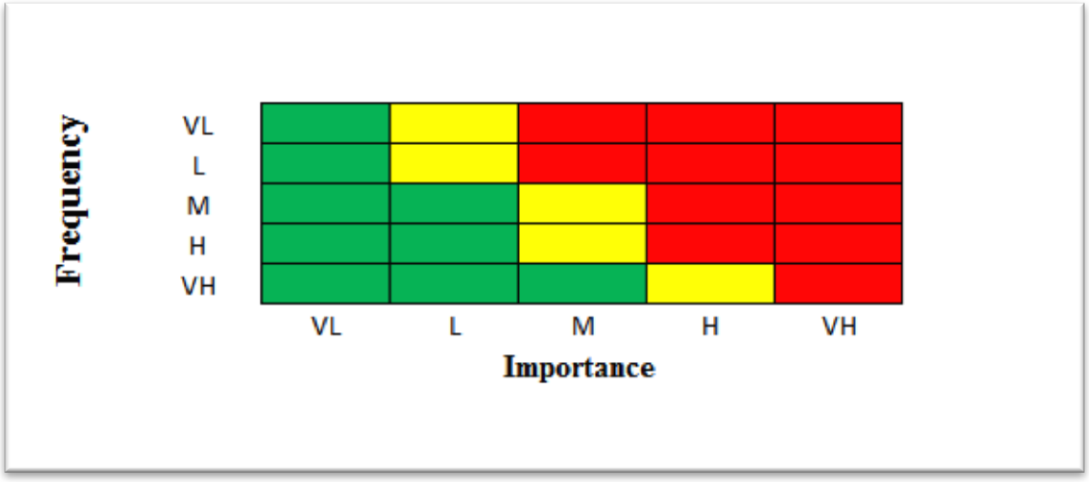

Figure 23 Scale used to present factor's risk related to importance and frequency of occurrence

Table 27 - Delay factor group risk matrix top factors

code	Delay factor group	Factor	Impact value	Frequency value	Matrix zone
O1	Delays related to owner or owner representative	Delay in decision making	4.3	3.3	Red
CS2	Delays related to Consultants	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	3.75	3.2	Red
C2	Delays related to Contractor	Poor site management and supervision	4.04	3.1	Red
M1	Delays related to Material	Shortage of construction materials	4.02	3.09	Red
L3	Delays related to Labor	Low productivity of labor	3.9	3.8	Red
S2	Delays related to Construction site	Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)	3.6	2.4	Red
E1	Delays related to External	Weather effect (heat, rain, etc.)	3.207	2.587	Red

4.6.9 Different response categories risk matrix comparisons

In this part of study, conducted a comparison between different response categories risk matrix that will be based on earlier developed T-test results, using the values of probability (ρ), comparison selection criteria was to compare categorize based on selecting the lowest delay factor probability, or to find a common delay factors group between various categories . For example it was found that by developing T-test comparison between responses from Qatar and rest of the world responses, delays related to inflation and escalation of material prices, which is grouped under delays related to Material, represents the lowest probability (ρ) value equal to 0.0001 that governs high level of disagreement, so risk matrix comparison will be conducted between Qatar and rest of world for group of delays related to material. While delays related to owner or owner representative are common between superstructure, infrastructures, and oil & gas categorize[1].

[1] Refer to earlier parts from the study for legends and characteristics of each delay factors group risk matrix.

- **Risk matrix comparison between Qatar and rest of the world responses:**

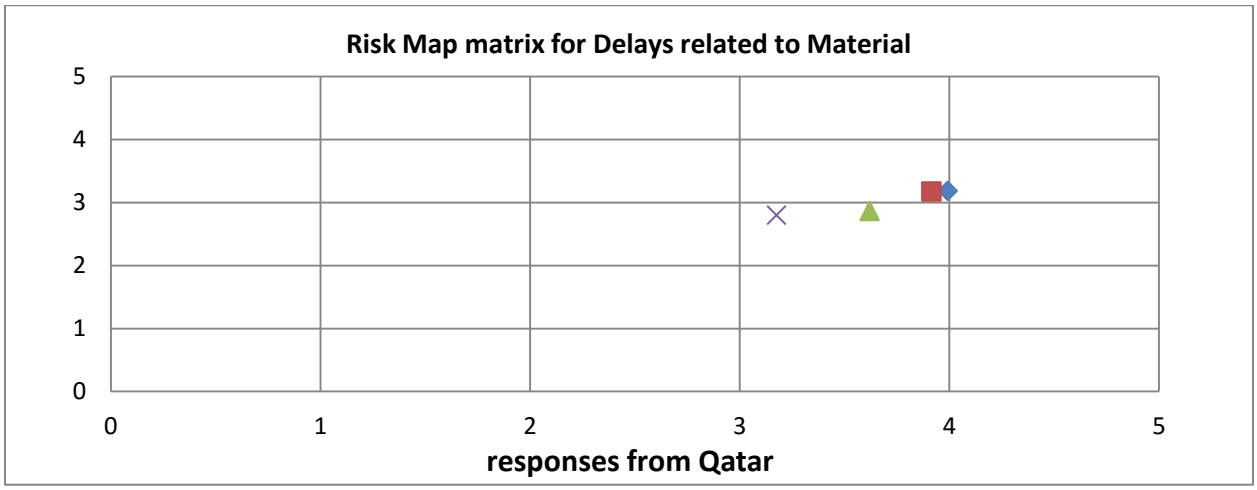

Figure 24 - risk matrix chart for delays related to material responses from Qatar category

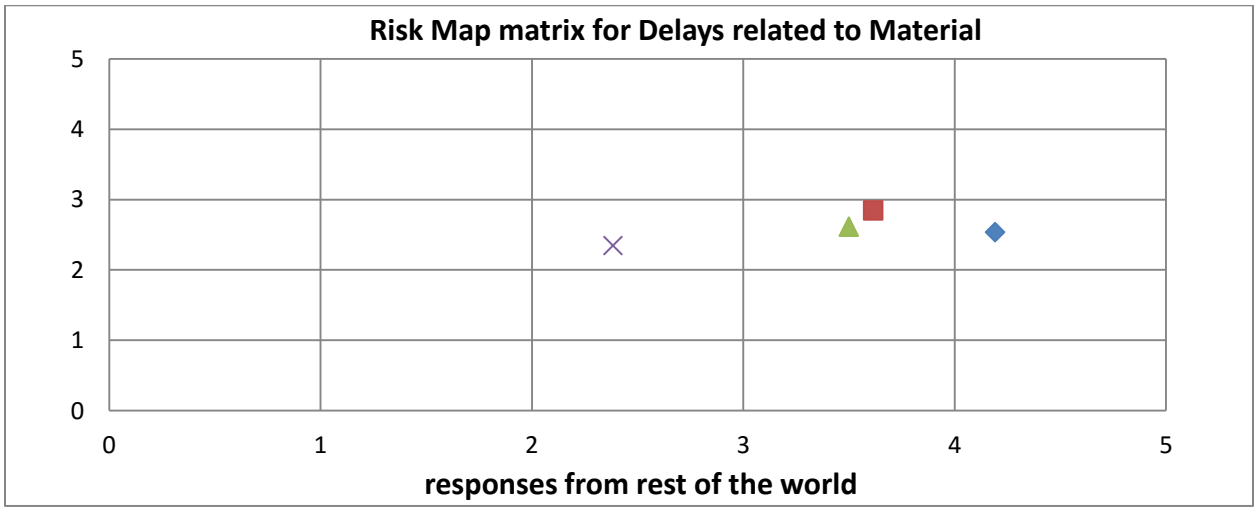

Figure 25 - risk matrix chart for delays related to material responses from rest of the world category

- **Risk matrix comparison between owner and contractor responses:**

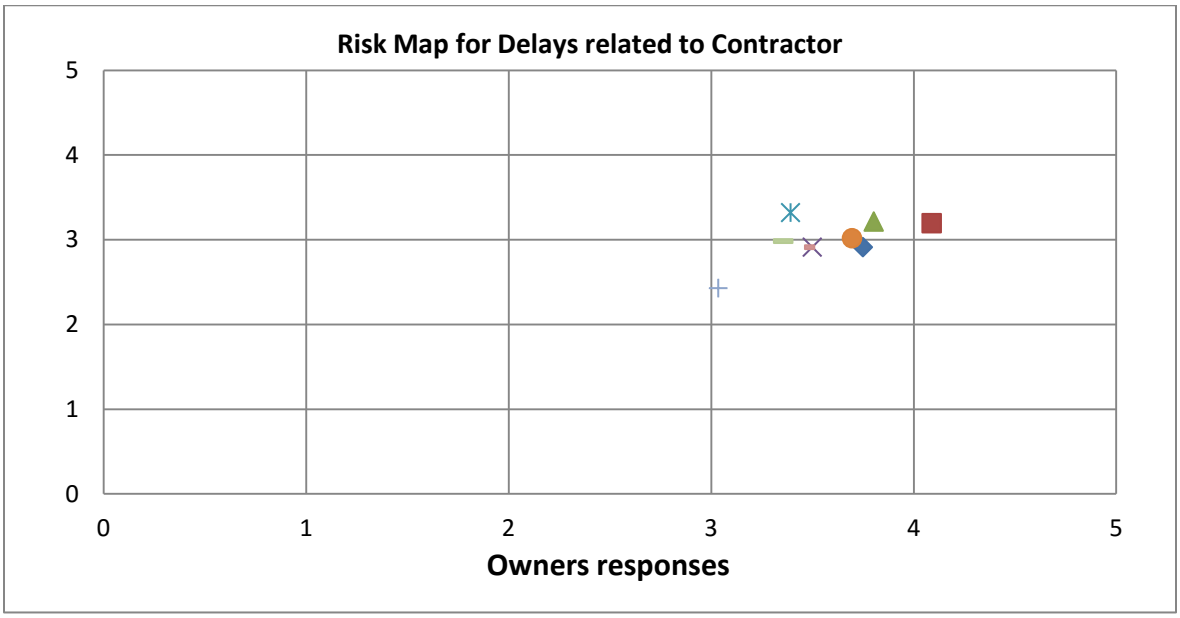

Figure 26 - risk matrix chart for delays related to contractor responses from owner category

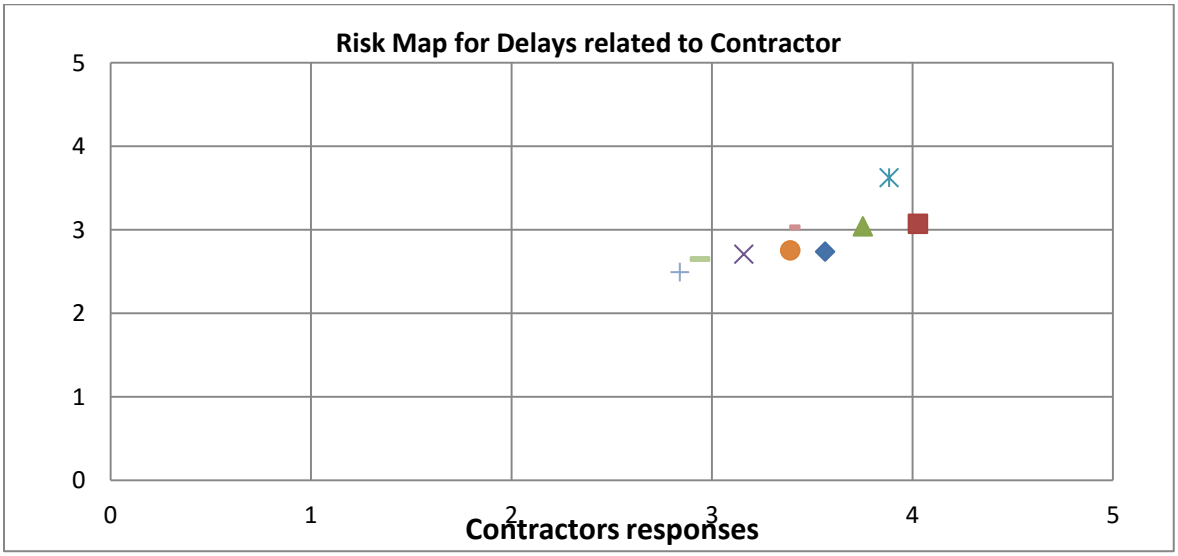

Figure 27 - risk matrix chart for delays related to contractor responses from contractor category

- **Risk matrix comparison between owner and consultant responses:**

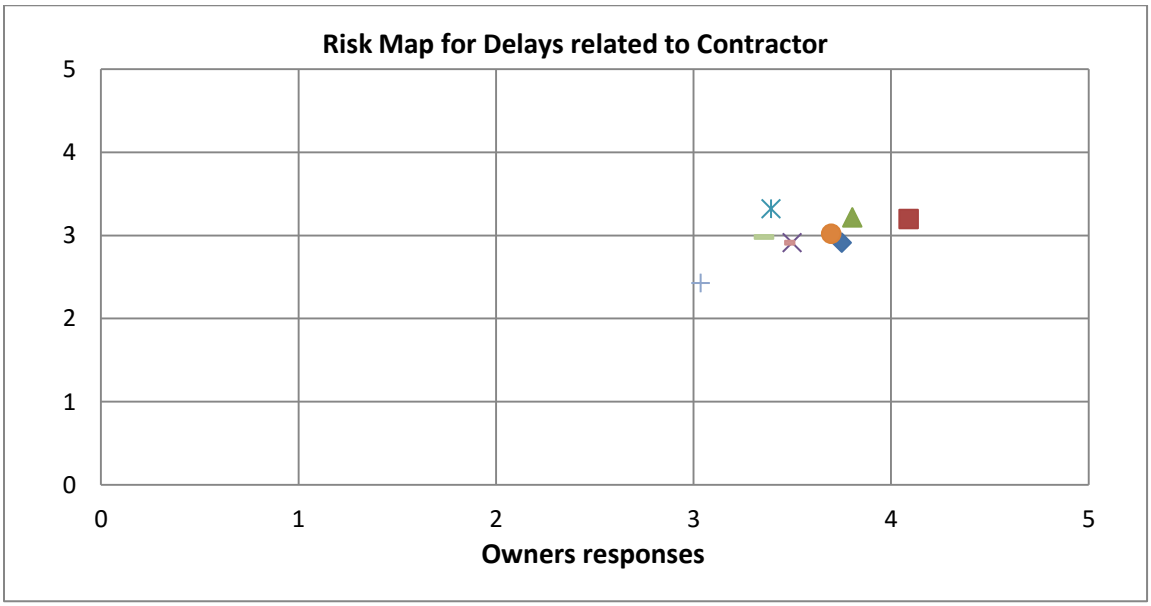

Figure 28 - risk matrix chart for delays related to contractor responses from owner category

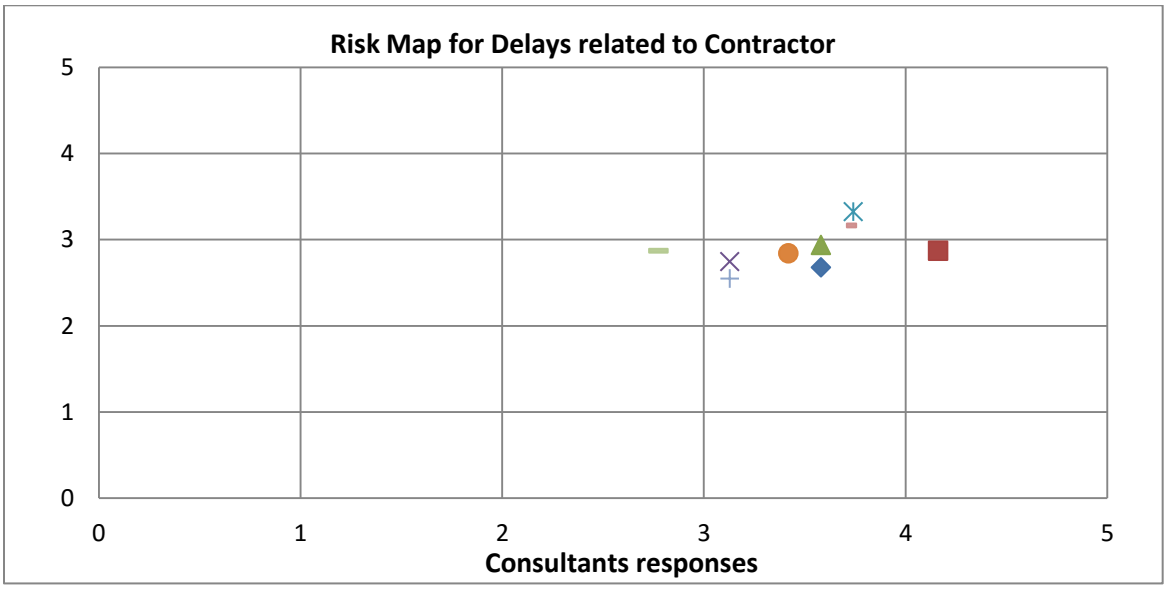

Figure 29 - risk matrix chart for delays related to contractor responses from consultant category

- **Risk matrix comparison between contractor and consultant responses:**

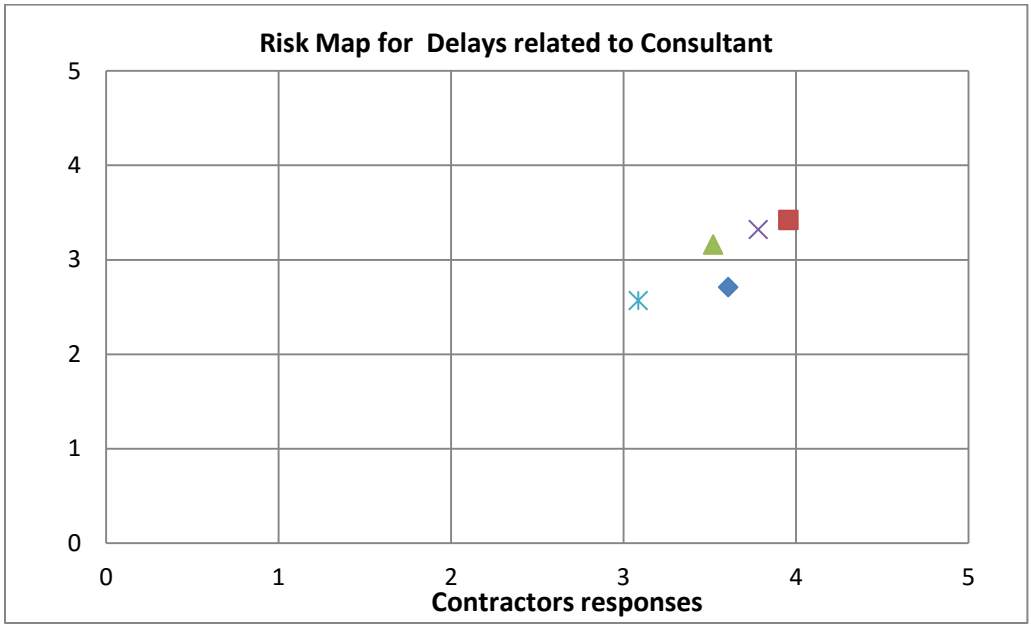

Figure 30 - risk matrix chart for delays related to consultant responses from contractor category

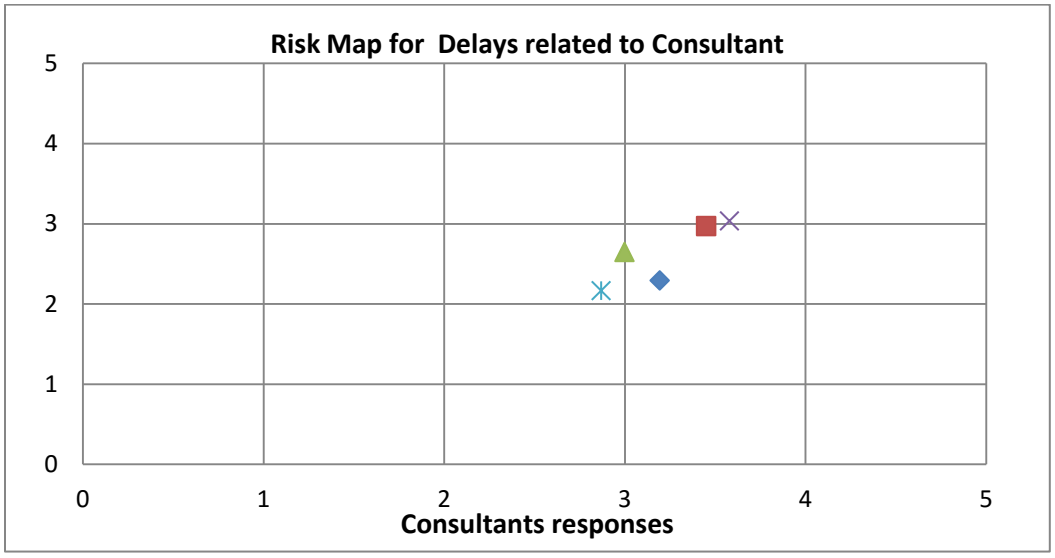

Figure 31 - risk matrix chart for delays related to consultant responses from consultant category

- **Risk matrix comparison between superstructure and infrastructures responses:**

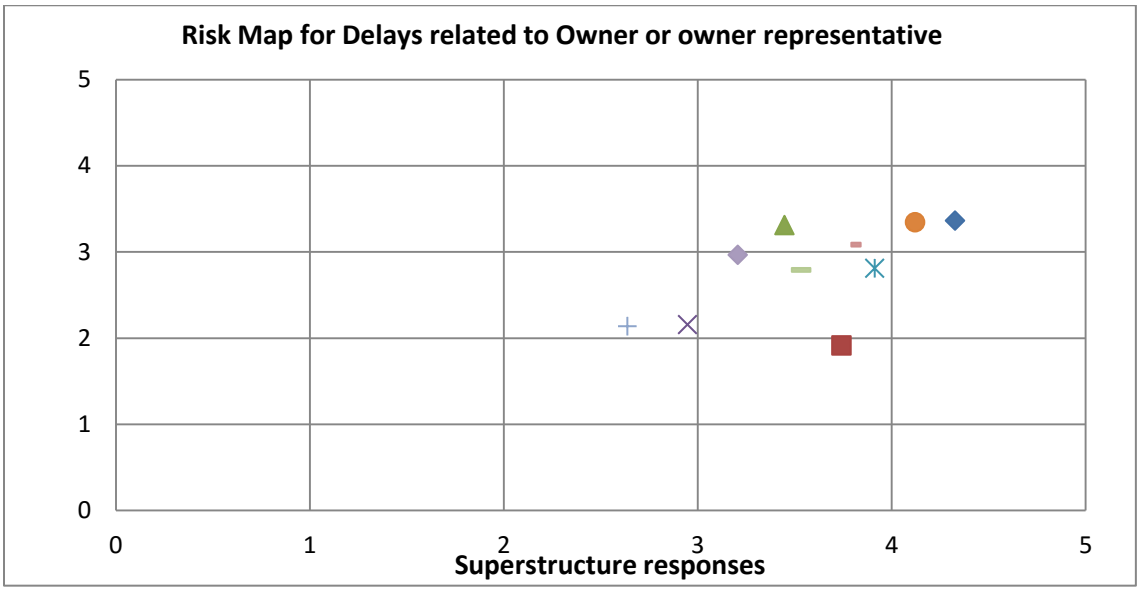

Figure 32 - risk matrix chart for delays related to owner responses from superstructure category

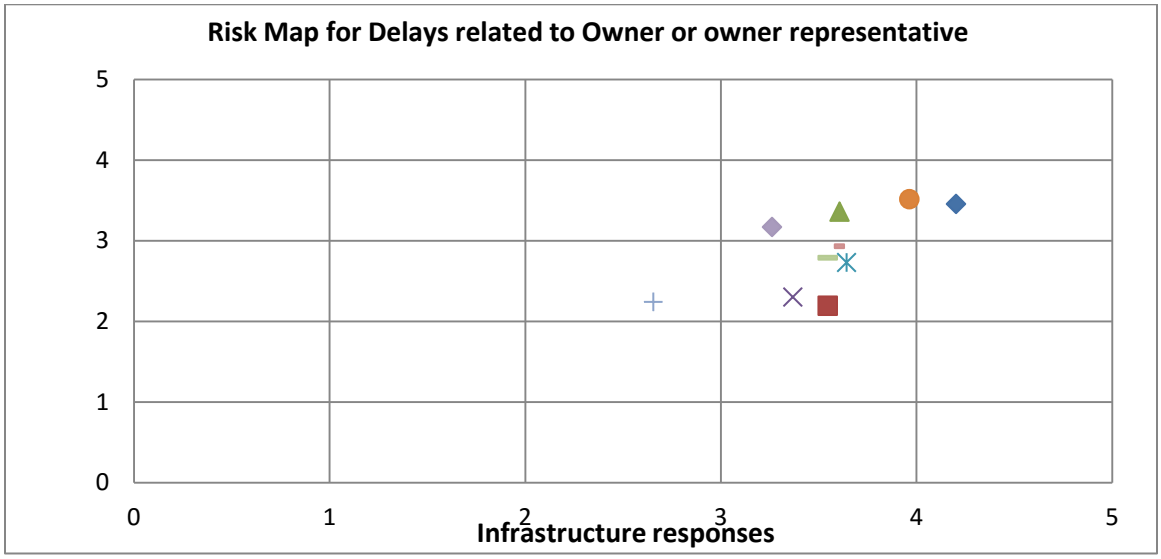

Figure 33 - risk matrix chart for delays related to owner responses from infrastructure category

- **Risk matrix comparison between superstructure and oil & gas responses:**

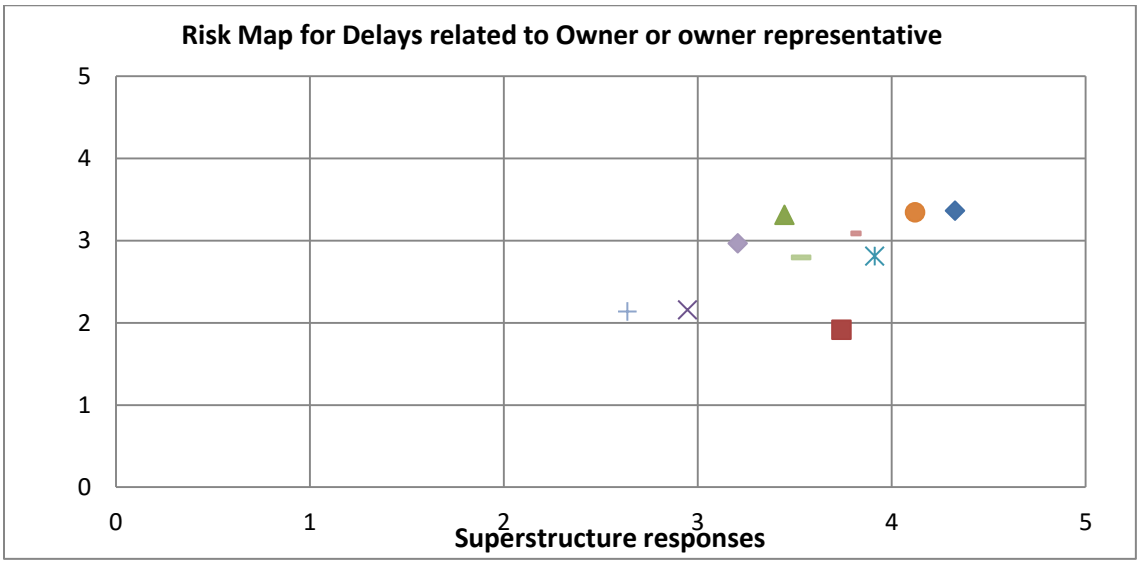

Figure 34 - risk matrix chart for delays related to owner responses from superstructure category

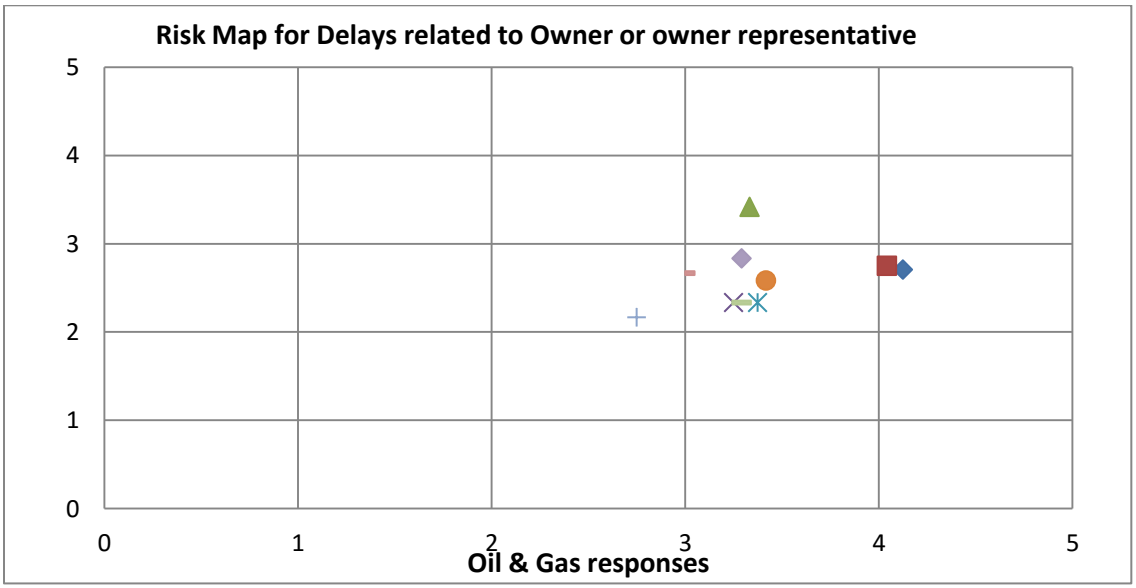

Figure 35 - risk matrix chart for delays related to owner responses from oil & gas category

- **Risk matrix comparison between infrastructures and oil & gas responses:**

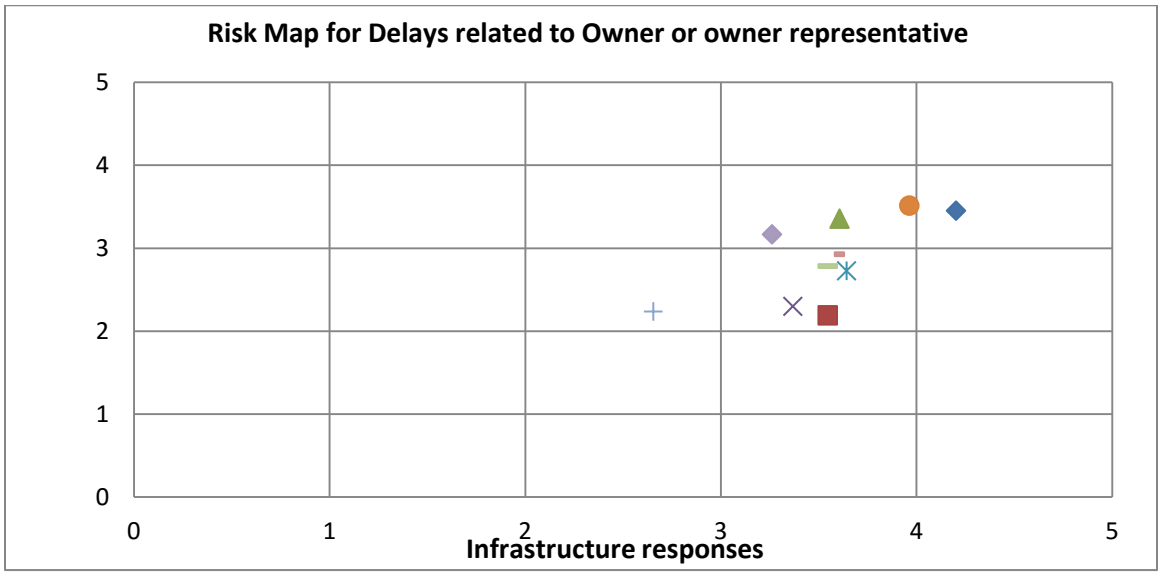

Figure 36 - risk matrix chart for delays related to owner responses from infrastructure category

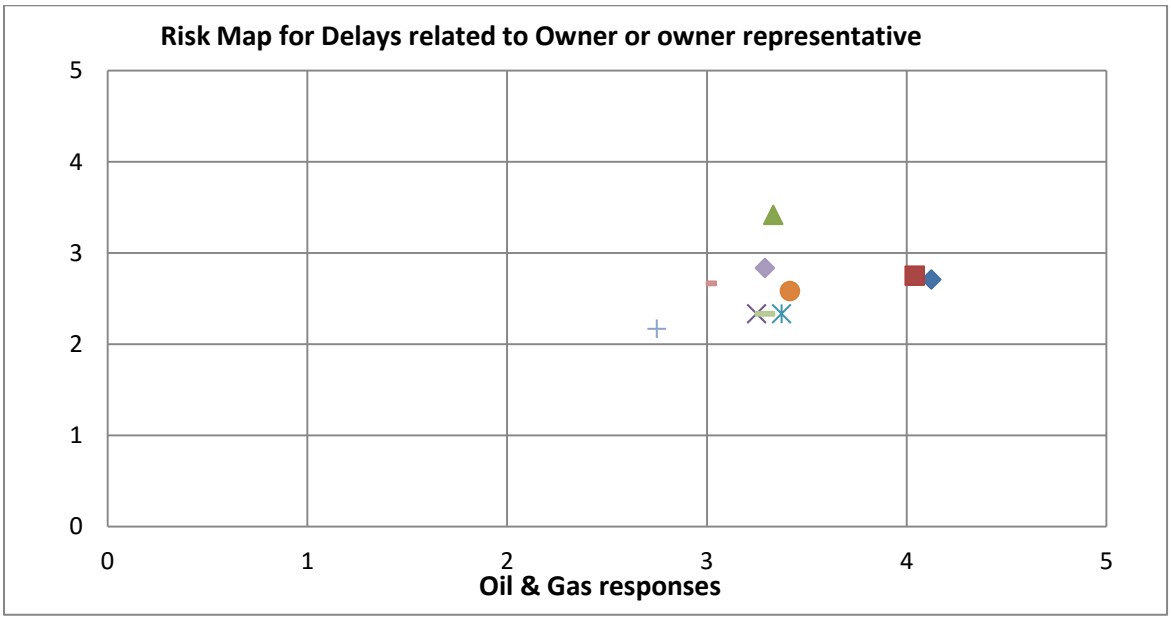

Figure 37 - risk matrix chart for delays related to owner from responses from oil & gas category

- **Risk matrix comparison between more than 10 years experience and less than 10 years experience responses:**

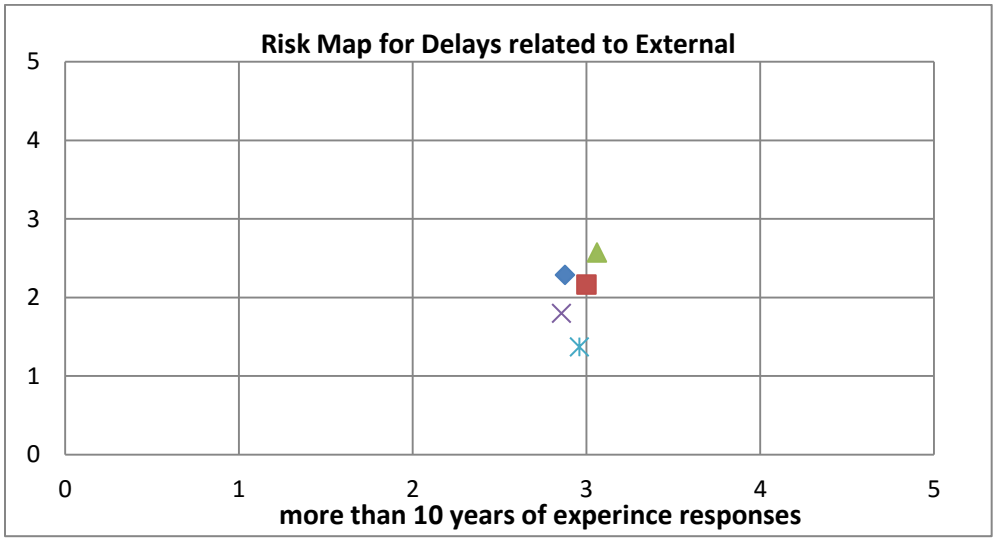

Figure 38 - risk matrix chart for delays related to external for responses from more than 10 years experience category

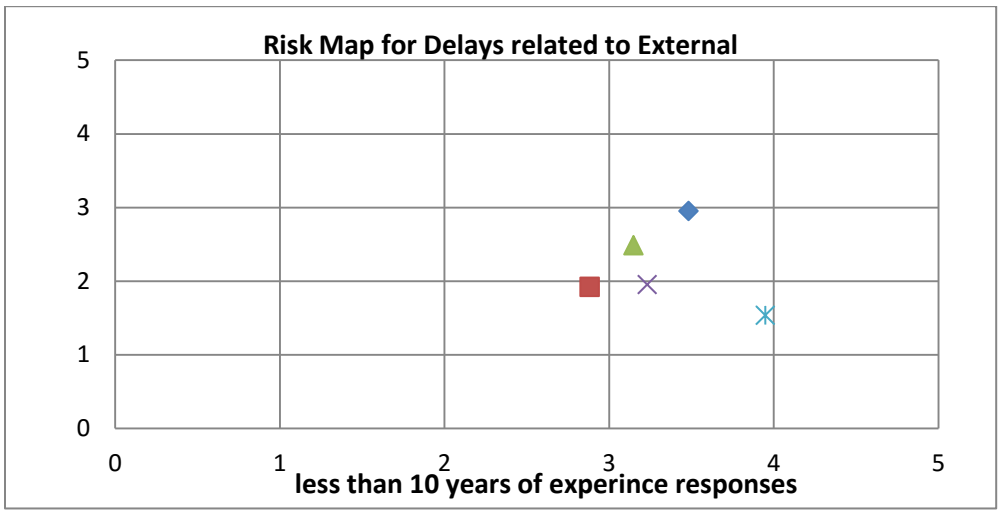

Figure 39 - risk matrix chart for delays related to external responses from less than 10 years experience category

- **Risk matrix comparison between more than 10 years experience and less than 10 years experience responses:**

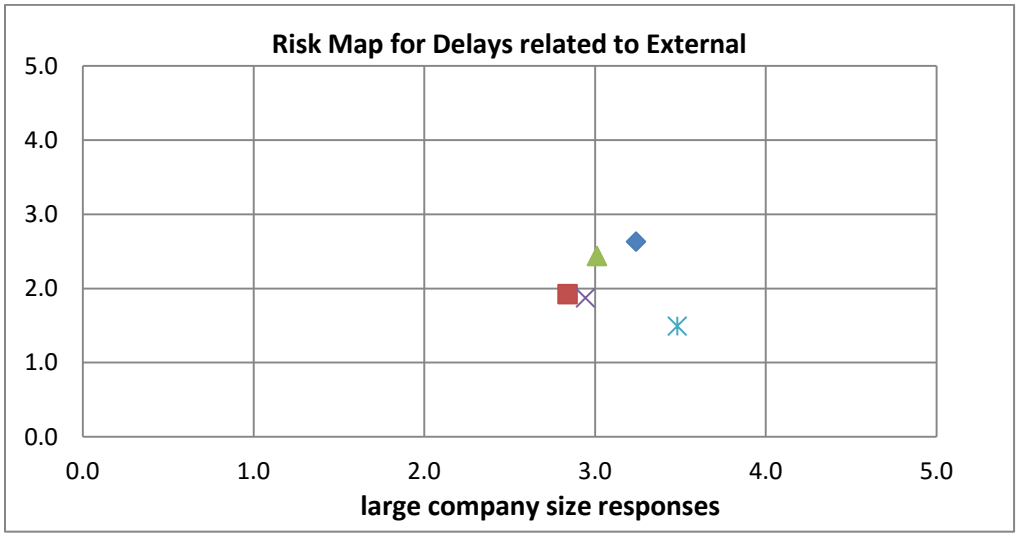

Figure 40 - risk matrix chart for delays related to external responses from large company size category

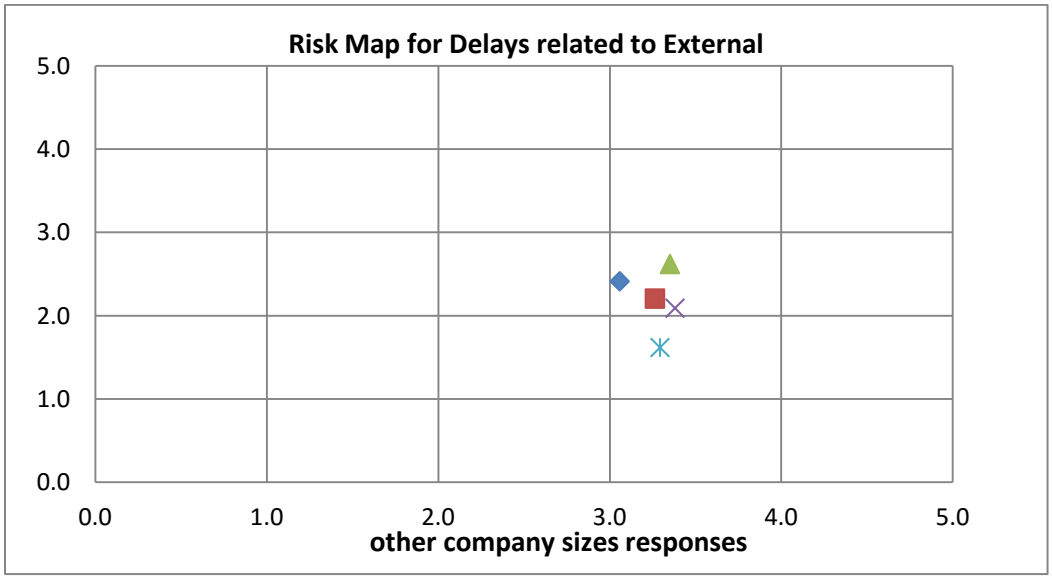

Figure 41 - risk matrix chart for delays related to external responses from other company sizes categories

4.7 Factor Analysis

As part of the objective, factor analysis was adopted as a data reduction method in this research to extract factors to represent relationships between the delay attributes. The aim was to explain the large set of 42 delay attributes in terms of lesser fundamental factors. It assisted to define groups of related variables and reducing large number of variables into understandable small numbers.

To conduct the factor analysis SPSS v.20 was employed. The validation of factor analysis was performed by interpreting the values of Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity. The KMO measure for the data is 0.861 and the Bartlett's sphericity (3445.300) is significant as shown in Table 28. As the KMO value is obtained from Table 28, the inter section of straight lines that had deferent slopes shown in Figure 42. This indicates that data obtained from the respondents are suitable to perform factor analysis [37]. The value of Bartlett's test of sphericity suggested that the population correlation matrix was not an identity matrix. For factor extraction, Principal Component Analysis method was chosen. Varimax was selected for rotation of the factors.

Table 28 KMO and Bartlett's Test results

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.861
Bartlett's Test of Sphericity	3445.300

The next step is to decide on the required number of factors to be retained by following the guidelines of “The Kaiser criterion” and “Scree plot”. The Kaiser criterion proposes to retain factors with Eigen value greater than 1, which resulted in 11 Factors that is more than groups identified in this study. “Eigenvalue is the amount of information explained by a factor or the number of variables represented by the factor” based on definition by Kaiser [37]. Some experts suggest that it is also possible to retain factor values before the point inflexion of lines by observing the scree plot of the Eigen values, shown in Figure 42 below, and to eliminate factors where the graph smoothens. That had resulted in 2 factors leading with eliminating most of the rest of the factors. Experts also suggest conducting trial and error process as well. Based on these guidelines, the final decision was made after many trials and found to be meaningful by selecting 3 Factors as shown in Figure 42.

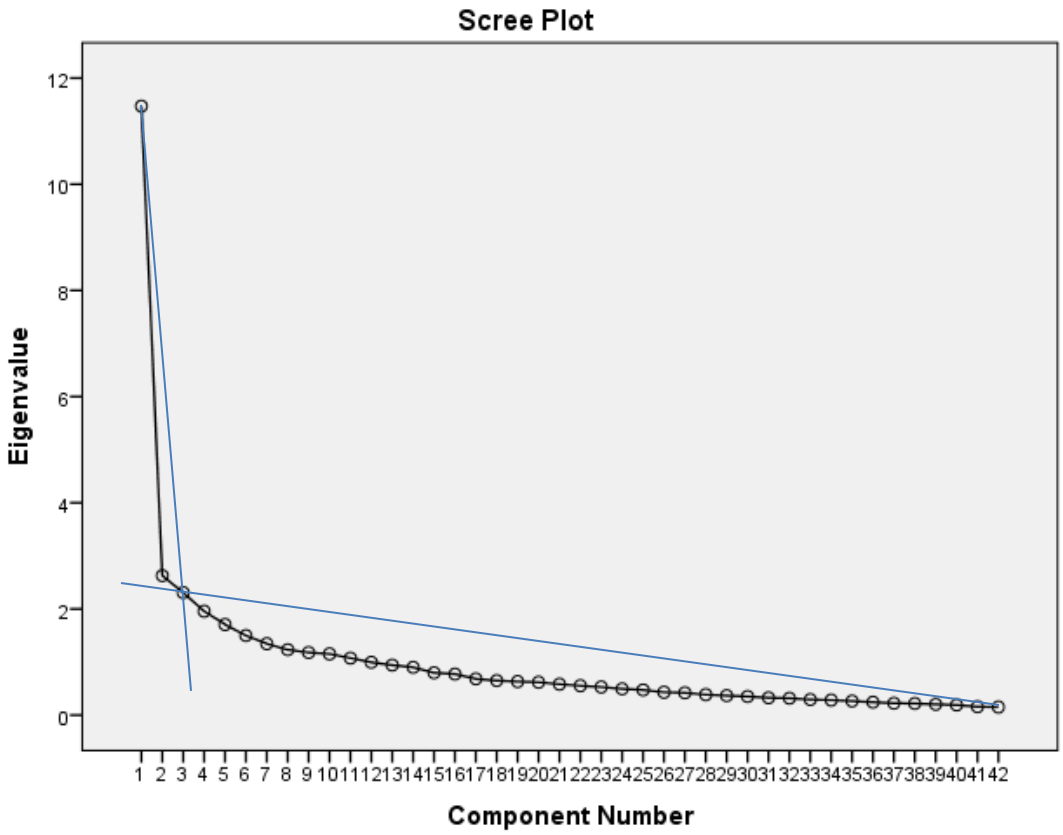

Figure 42 - scree plot of the Eigen values

Table 29 below shows each factor loadings, as well as weights and correlations between each variable and the factor. A Factor loading of 0.4 and above were selected to group the delay attributes under each factor. 3 factors were extracted which accounted for 55.72% of the total variance. Table 29 below presents the factor analysis results.

Table 29 results of factor analysis

	Delay attributes	Interpreted Factor	Factor loadings	% of variance	Eigen value
1	Force Majeure (earthquake, etc.)	Specific construction project characteristics	0.756	27.313	11.471
2	Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)		0.662		
3	Shortage of construction materials		0.627		
4	Accident during construction		0.579		
5	Changes in material types and specifications during construction		0.562		
6	Weather effect (heat, rain, etc.)		0.555		
7	Inflation and escalation of material prices		0.527		
8	Delays due to material delivery		0.508		
9	Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)		0.49		
10	Changes in government regulations and laws		0.432		
11	Global financial crisis		0.408		
12	Mistakes or discrepancies in documents or specifications issued by consultants	lack of owner and consultant commitments	0.745	16.01	2.628
13	Delay by owner in handing over process or approval of completed work		0.683		
14	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner		0.674		
15	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.		0.595		
16	Lack of experience of owner (or owner representative) in construction projects		0.5		
17	Poor communication and coordination with other parties		0.481		
18	Delay in performing final inspection and certification by a third party		0.467		
19	Unrealistic enforced contract duration		0.438		
20	lack of experience of consultants		0.425		
21	Delay in inspection		0.423		
22	Lack of experience of contractor (Poor qualification of contractors' staff)	lack of contractor commitments	0.808	12.405	2.307
23	Unsafe practice at site (Poor safety conditions on site)		0.656		
24	Inappropriate construction methods		0.634		
25	Rework due to errors during construction		0.618		
26	Poor site management and supervision		0.583		
27	Poor communication and coordination with other parties		0.563		
28	Difficulties in financing the project by contractor		0.498		
29	Deficiency in planning and scheduling of project		0.488		
30	Lack of site utilities or services such as (water, electricity, etc.)		0.456		

4.7.1 Factor 1

The first interpreted factor “Project specific characteristics” has the highest percentage of the total variance (27.313%) and consists of 11 attributes as shown in Table 29. Construction projects are unique accomplishments due to many characteristics related to projects scope, projects location, investment, involved stakeholders, methods of construction and many more. Adequate measures should be undertaken to protect and to recover projects activities during unexpected weather and environment conditions. As temperatures during summer or unexpected raining during winter, exposes outdoor activities to unexpected delays or damages. On the other hand these weather conditions expose workers to high temperature, high humidity, cold and illness. These fluctuating environmental factors must be addressed by the management experts to adopt proper planning or recovery practices during construction, or to scheduled construction activities during day and night working overtime and during different set times of the day, during expected suitable working days. Work overtimes need to be regulated to avoid fatigue, reduced productivity, stress and accidents. Site layout needs to be carefully planned and conditions of project sites are to be continuously monitored and improved to reduce construction accident rates. Hence, safety and accident prevention program needs to be carefully evaluated and implemented for each individual project.

4.7.2 Factor 2

The second factor “lack of owner and consultant commitments” consists of 10 delay attributes and constitutes 16.01% of the total variance. The attributes under this group represent the various ways owners and consultants can influence construction projects performance. Besides technical and financial evaluation of bids, owners or consultants can evaluate previous projects records. With the help of many procedures and tools, they can anticipate where and when delays may

occur, further they can encourage contractors to achieve better performance by applying steps or procedures generated or planned in advance. Moreover, increasing owner's and consultants efforts in management during project execution phase by attending meetings, job site visits, mandating reporting of required reports, applying modern techniques in inspection and in maintaining records, and encouraging incentive programs will significantly reduce delays on site. Both owners and consultants can perform more efficiently with more coordination to resolve issues on site rather than overloading the construction process with minor issues causing delays to accumulate.

4.7.3 Factor 3

The final factor refers to "lack of contractor commitments" and consists of 9 delay attributes. It represents 12.405% of the total variance. Contractors play a vital role in providing specialized trades in the construction industry. Construction projects performance relies on the performance of the contractors. To achieve an overall acceptable construction performance in the project, it is essential to control behaviors of all parties as well as subcontractors. This can be typically agreed upon in the contract during the bidding process. Skilled staff may guarantee to an extent continuity of construction works without delays. Adequate trainings need to be provided by the contractor to its workers to establish a positive attitude. This will also enable the workers to carry out job activities effectively. All related information such as proper usage of tools, safe behavior needs to be communicated to the workers through toolbox talks and meetings. Continuous support from the management by rewarding performance among workers will motivate the workers even further to engage in desiring to commence more achievements.

By the collective efforts of establishing a well-organized and reliable staff to supervise site activities, providing adequate trainings, proper emergency & risk mitigation techniques,

communication efforts through toolbox talks & safety meetings, mandating use of technology, and through frequent job site inspections; the contractor will be able to ensure high project performance. Proper planning is a well-known requirement for project success.

5 Chapter 5 Discussion, Conclusions & Recommendations

5.1 Discussion

The objective of this project is to identify the most influential delay attributes affecting the construction industry. After a review of past literature, a list of 42 delay attributes was produced and presented in a questionnaire survey. The survey was distributed to various experts in the field of construction industry. 179 respondents evaluated the 42 delay attributes based on importance (the delay impact on construction project) and frequency (How often the attribute is implemented or considered). The gathered data of 179 complete responses were then analyzed by Importance Index, Spearman's Rank Correlation, T-Test, risk mapping, and factor analysis.

From Table 8, it can be concluded that the factor which is considered most significant is the low productivity of labor (57.886%), while it is the responsibility of the worker to ensure his own capabilities and high work performance, it is also equally important that the employer should employ skilled staff, as well as to provide required work environment on site. Work environment requires a variety of items such as healthy and safe work environment, trainings, work incentives, required work tools, etc. Each serves an important purpose.

Delay in decision making (56.242%) and changes to the project by owner (52.758%) were seen as the second and third most important factors. These factors are also of high importance as in any field, owner decisions or changes to the projects are vital in order to accomplish construction projects work on time. Many extensions of time and variation orders claims are raised by both consultants and contractors based on owner decisions. Thus owners need to provide confident decisions when it is needed with complete valid information, in order to facilitate the flow of work performance, and to avoid unnecessary decisions that may lead to future delays in work.

Delays related to sub-contractors work (51.172%) were ranked at number four most important factor. Unreliable subcontractor due to improper experience or capabilities will always lead the main contractors to face high risk of project delays. The main contractors are held responsible to all subcontractors' works. Main contractors sometimes maintain excessive supervision on subcontractors, and in many cases main contractors may rework activities were held by subcontractors. Main contractors should hire subcontractors with required experience and capabilities to accomplish work on time.

The fifth significant attribute (50.139%) is encouraging contractors to set high criteria in choosing workforce. It is important to select workforce with a proven record for successful completion of the project. Research has proven that selecting a competent workforce whose strives to achieve project specific goals has a better level of overall performance [2].

Comparing the ranking by the two tools, RII and FAII, from Table 9 it can be seen that both delay in decision making and changes to the project by owner are within the top four important delays in construction projects. However delays related either to contractor, or material or labors, such as poor site management and supervision, delays related to sub-contractors work, shortage of construction materials, shortage of construction materials, unqualified workforce, low productivity of labor, were considered important but are implemented less frequently amongst the top five. Also looking at the value of Spearman's rank correlation factor, it can be inferred that there is a positive correlation between the RII and FAII.

On comparing ranking of the attributes by experts in Qatar and other parts of the world, it was established that:

- Qatar prioritizes low productivity of labor, delay in decision making, changes to the project by owner, delays related to sub-contractors work, and unqualified workforce. This could be ascertained to the fact that there are numerous infrastructure construction projects ongoing currently for development of the country. These attributes will serve as the main line of defense against reasons of falling behind planned dates in the face of budget and time constraints.
- While experts from the rest of the world confirm that delay in decision making, low productivity of labor, poor site management and supervision, delays related to sub-contractors work, and deficiency in planning and scheduling of project plays a major role in achieving a set of construction goals.
- (removed 2 points as instructed)

Table 30 below summarizes the top 5 ranked delay attributes based on the views of various compared groups.

Table 30 - summary the top 5 ranked delay attributes by various views

	Qatar Ranking		FAI %		Rest of the world Ranking		FAI %
L3	Low productivity of labor	1	59.373	O1	Delay in decision making	1	52.243
O1	Delay in decision making	2	56.931	L3	Low productivity of labor	2	49.503
O6	Changes to the project by owner	3	54.364	C2	Poor site management and supervision	3	48.604
C5	Delays related to sub-contractors work	4	51.646	C5	Delays related to sub-contractors work	4	48.426
L2	Unqualified workforce	5	51.358	C3	Deficiency in planning and scheduling of project	5	46.615
	Owner Ranking		FAI %		Contractor Ranking		FAI %
O1	Delay in decision making	1	52.673	L3	Low productivity of labor	1	62.155
C2	Poor site management and supervision	2	52.284	O1	Delay in decision making	2	58.979
L2	Unqualified workforce	3	51.316	C5	Delays related to sub-contractors work	3	56.291
L3	Low productivity of labor	4	50.939	CS2	Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.	4	54.130
C3	Deficiency in planning and scheduling of project	5	48.903	O6	Changes to the project by owner	5	54.083
	Consultant Ranking		FAI %		Project-Construction manager Ranking		FAI %
L3	Low productivity of labor	1	58.422	O1	Delay in decision making	1	60.065
O6	Changes to the project by owner	2	55.804	L3	Low productivity of labor	2	56.660
O1	Delay in decision making	3	54.231	O6	Changes to the project by owner	3	54.216
C5	Delays related to sub-contractors work	4	49.732	L1	Shortage of labors	4	50.941
L1	Shortage of labors	5	48.774	L2	Unqualified workforce	5	50.916
	Project engineer Ranking		FAI %		Superstructure Ranking		FAI %
L3	Low productivity of labor	1	60.062	O1	Delay in decision making	1	58.199
O1	Delay in decision making	2	55.389	L3	Low productivity of labor	2	57.812
M1	Shortage of construction materials	3	55.111	O6	Changes to the project by owner	3	55.132
C5	Delays related to sub-contractors work	4	53.922	C5	Delays related to sub-contractors work	4	54.185
O6	Changes to the project by owner	5	52.750	M1	Shortage of construction materials	5	52.637
	Infrastructure Ranking		FAI %		Oil & Gas Ranking		FAI %
O1	Delay in decision making	1	58.033	L3	Low productivity of labor	1	52.535
L3	Low productivity of labor	2	57.981	C5	Delays related to sub-contractors work	2	50.722
O6	Changes to the project by owner	3	55.689	M1	Shortage of construction materials	3	49.681
L2	Unqualified workforce	4	52.735	M2	Delays due to material delivery	4	48.958
C2	Poor site management and supervision	5	50.602	O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	5	45.556
	More than 15 years experience Ranking		FAI %		Less than 5 years experience Ranking		FAI %
O1	Delay in decision making	1	59.425	L3	Low productivity of labor	1	61.093
O6	Changes to the project by owner	2	53.843	C5	Delays related to sub-contractors work	2	53.280
L3	Low productivity of labor	3	51.242	O6	Changes to the project by owner	3	53.153
C2	Poor site management and supervision	4	50.159	M1	Shortage of construction materials	4	52.568
L1	Shortage of labors	5	47.480	O3	Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner	5	52.033
	Large company size Ranking		FAI %		Other company sizes Ranking		FAI %
L3	Low productivity of labor	1	57.947	L1	Shortage of labors	1	59.204
O1	Delay in decision making	2	57.145	L3	Low productivity of labor	2	57.567
O6	Changes to the project by owner	3	53.195	C5	Delays related to sub-contractors work	3	54.066
C5	Delays related to sub-contractors work	4	50.492	M1	Shortage of construction materials	4	53.481
L2	Unqualified workforce	5	50.264	M2	Delays due to material delivery	5	52.394

Another ranking tool was risk mapping matrix. It can be concluded that the most ranked factor of each delay category based on mean values are delay in decision making, delay in approval of submittals, design drawings, shop drawings, and sample materials, etc., poor site management and supervision, shortage of construction materials, low productivity of labor, unforeseen site conditions (unexpected subsurface conditions e.g. soil, high water table, etc.), weather effect (heat, rain, etc.). It can be seen that the majority of factors are due to human error that can be reduced and controlled by enhancing the skills of the construction parties.

5.2 Recommendations

Recommendations below are to selected categories from Table 30.

5.2.1 Qatar

In Qatar, the top 5 ranked influential delay attributes by experts were: (1) low productivity of labor, (2) delay in decision making, (3) changes to the project by owner, (4) delays related to sub-contractors work, (5) and unqualified workforce as shown in Table 30. It is strongly recommended to all construction project participants in Qatar to strictly adhere to contractual rules and procedures of the project. It is also recommended to conduct continuous training programs to all participants. Training should be provided periodically by contractors to all new and old employees in all projects to increase the level of awareness. Informal meetings by means of toolbox talks are to be held frequently to workers to remind them of required objective and targets, as well as to conduct routine assessments at worksites.

5.2.2 Owner

Owners and their representatives in Qatar play a significant role in influencing the ongoing and future construction projects. It is evident from their perspectives on delay attributes ranking, that they have a crucial role to improve construction industry performance (ranked 2nd and 3rd as seen in Table 8). Owner expectations are high on the contractors to perform the construction work. It is important that owners study the previous experience of the contractor, contractors' management systems, organization, list of subcontractors, etc. prior to awarding the contract.

5.2.3 Contractor

Majority of the projects undertaken for the next decade in majority of developing countries falls under the category of infrastructures. Horizontal type of construction such as highways, underground utilities and internal roads of entire town requires advance planning as well as urban planning, before implementation. Table 30 shows high agreement between ranking of top 3 factors of delay between responses of infrastructures and superstructures, on the other hand significant disagreement was noticed in the ranking between infrastructure responses and oil & gas top 5 delay factors. From the experts' point of view, it can be seen that contractors have a crucial role on influencing construction projects performance. Their influence will encourage the labors to perform and adopt acceptable level of productivity to avoid any delays on daily site activities by providing necessary training to enhance skills and awareness of workforce, tool box talks and regular job site inspections. Main contractor objectives should be considered top priority to subcontractors to ensure successful project delivery. Recommendations are made to contractors to be aware of delays associated with misuse of new technology, material handling and transportation deployed to accelerate project. The contractors are encouraged to develop a positive partnership with owners and client representatives. As well as contractors should to

keep attention to sub-contractors list and a close eye on sub-contractors work. Contractors should invest more in work forces training, awareness, insurance, taking appropriate measures to ensure high work force performance.

5.3 Conclusions

Various researches were conducted to understand delay factors that affect the construction projects. However, no study was conducted to identify the influential delay factors affecting construction industry in comparison with the Qatari construction industry.

This study focused on identifying the influential delay attributes affecting construction industry including the Qatari construction industry. 42 delay attributes were collected based on literature review. Survey questionnaire was distributed among various professionals with various backgrounds, expertise, and locations, involved in remarkable numerous projects within the construction field.

Analysis of construction industry significant attributes, which were ranked by various experts involved in the construction industry, by various statistical ranking tools such as relative importance index, frequency importance index, frequency adjusted importance index, Spearman's rank correlation, T-Test, and risk mapping, comparisons to results were discussed and recommendations were made.

Factor Analysis was done with the Principle Component Analysis using Varimax Rotation from which three factors were extracted, namely: Project specific characteristics, lack of owner and consultant commitments, lack of contractor commitments. The delay attributes were loaded into these three groups of factors.

5.4 Future Works

The work presented in this project can be improved further by:

- Conducting more interviews or face-to-face interviews with more respondents.
- Expanding the data set by distributing the survey to more professionals with various backgrounds and different industry experiences from Qatar, GCC, and rest of the world.
- Conducting comparison study of most influential delay attributes affecting the construction industry between developing countries and developed countries.
- Increase the number of delay attributes.
- By conducting case studies on real construction projects.
- Developing a framework for assessing the delays in current projects in Qatar.

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Appendix A – Questionnaire Survey

Causes of Delay in Construction Projects

1. Introduction

University of Qatar
College of Engineering
Engineering Management Master Program

Causes of Delay in Construction Projects (Questionnaire)

Dear Sir/Madam,

My name is Mohanad Abu Hassan, a graduate student of Qatar University. I am conducting a research about “Causes of Delay in Construction Projects”, which I had chosen as a topic to conduct research on it for my master's project.

The aim of the research is to study the various delay factors with regards to the construction environment. We kindly invite you to be a part of this research and request you to assist us in completing the brief questionnaire. We would kindly request your anticipate, and cooperation of your construction personnel and project managers in providing the required information in the questionnaire, as well as to thank you for your valuable time and efforts.

The information provided will only be used for research on an academic platform.

Yours Sincerely,
Mohanad Abu Hassan
Graduate Student,
Qatar University
Email: 200600152@student.qu.edu.qa
Advisor: Professor Murat Gunduz

Causes of Delay in Construction Projects

2. General Information

Please check which most accurately describes:

All information, including all results and personal information from participating individuals will be kept strictly confidential and be used only for research purposes by Qatar University ONLY.

1. Location

- ◯ Qatar
- ◯ GCC (Saudi Arabia, Kuwait, Bahrain, Oman, UAE)

Other (please specify)

2. Organization type

- ◯ Owner
- ◯ Contractor
- ◯ Consultant
- ◯ Designer/ Architect
- ◯ Subcontractor
- ◯ Supplier

Other (please specify)

3. Job Designation

- ◯ Owner
- ◯ Resident Engineer
- ◯ Project / Construction manager
- ◯ Project Engineer
- ◯ Site superintendent

Other (please specify)

4. Industry type

- ◯ Superstructure
- ◯ Infrastructure
- ◯ Oil & Gas
- ◯ Industrial

Other (please specify)

5. Total experience in construction in years

- ◯ 0 - 5
- ◯ 6 - 10
- ◯ 11 - 15
- ◯ 16 +

Other (please specify)

6. Size of your company

- ◯ Large (>250 employees)
- ◯ Medium (50 < employees < 250)
- ◯ Small (10 < employees < 50)
- ◯ Micro (< 10 employees)

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Causes of Delay in Construction Projects

3. Ranking Causes of Delay

Please Evaluate the following attributes based on:

Importance (the delay impact on construction project) and; Frequency (How often the attribute is implemented or considered) on a rating scale of 1 - 5 as shown below:

Rating scale	Very low	Low	Moderate	high	Very High
	1	2	3	4	5

For an example, for the first Cause of Delay factors" Delay in decision making", the respondent was asked to evaluate the:

- Importance: What is the impact of "Delay in decision making" on construction projects?

- Frequency: How often is "Delay in decision making "considered or does it occurs in construction projects?

* 7. Delays related to owner or owner representative

	Impact	Frequency
Delay in decision making		
Suspension of work		
Delay in revising and approving documents (design, shop drawings, submittals. etc.) by owner		
Delay in delivering construction site to contractor		
Delay of financing and payments by owner		
Changes to the project by owner		
Type of project bidding and award		
Unrealistic enforced contract duration		
Lack of experience of owner (or owner representative) in construction projects		
Delay by owner in handing over process or approval of completed work		

* 8. Delays related to Consultants

	Impact	Frequency
Lake of experience of consultants		
Delay in approval of submittals, design drawings, shop drawings, and sample materials, etc.		
Mistakes or discrepancies in documents or specifications issued by consultants		
Poor communication and coordination with other parties		
Delay in inspection		

* 9. Delays related to Contractor

	Impact	Frequency
Difficulties in financing the project by contractor		
Poor site management and supervision		
Deficiency in planning and scheduling of project		
Rework due to errors during construction		
Delays related to sub-contractors work		
Lack of experience of contractor (Poor qualification of contractors' staff)		
Inappropriate construction methods		
Poor communication and coordination with other parties		
Unsafe practice at site (Poor safety conditions on site)		

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Causes of Delay in Construction Projects

4. Ranking Causes of Delay

* 10. Delays related to Material

	Impact	Frequency
Shortage of construction materials		
Delays due to material delivery		
Changes in material types and specifications during construction		
Inflation and escalation of material prices		

* 11. Delays related to Labor

	Impact	Frequency
Shortage of labors		
Unqualified workforce		
Low productivity of labor		

* 12. Delays related to Construction site

	Impact	Frequency
Shortage of equipment and/or equipment failure		
Unforeseen site conditions (Unexpected subsurface conditions e.g. soil, high water table, etc.)		
Restriction at job site (Poor site access, traffic congestion)		
Lack of site utilities or services such as (water, electricity, etc.)		
Accident during construction		
Problem with nearby structure or facilities (Disturbance to public activities, effect of social and cultural factors)		

* 13. Delays related to External

	Impact	Frequency
Weather effect (heat, rain, etc.)		
Changes in government regulations and laws		
Delay in performing final inspection and certification by a third party		
Global financial crisis		
Force Majeure (earthquake, etc.)		

Thank you for your valuable time and efforts