QATAR UNIVERSITY

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Causes of Cost-Overrun in Construction Projects

BY

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COMMITTEE PAGE

COMMITTEE PAGE

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Abstract

Cost overrun in construction projects is a common issue affecting project performance. After a review of the literature, a list of 39 cost overrun attributes were gathered and presented in a survey questionnaire. The survey was distributed through face to face meetings with construction engineers and managers in different construction projects, in addition to publishing it online and sending it to various experts in the construction industry around the world. 101 complete responses were received and analyzed by importance index, frequency index, cost index, frequency adjusted cost index, Spearman's rank correlation, student's t-test, risk mapping and factor analysis. The results of the survey revealed that the main causes of cost overrun in construction industry include inaccurate cost estimations, improper planning and scheduling, unrealistic contract duration and requirements, frequent changes to the scope of work, frequent design changes, inadequate labor/skill availability, inflation of costs of machinery, labor, raw material and transportation prices.

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1. Introduction

1.1 Overview

Cost has its proven significance as the key factor for any project success. A completed project may not be considered as a successful endeavor unless it falls within the cost limitations applied to it. Despite its proven importance, it is very common to have a construction project that fails to achieve its specified cost goals. A lot of research has been performed to identify cost overrun attributes to improve the overall the construction industry performance. This study was conducted to identify the most important cost overrun factors affecting the construction industry.

1.2 Statement of the Problem

In Qatar, construction sector is a very crucial sector. It is of prime interest to the Qatari's government because the success in this sector, especially in this period of time, is critical for Qatar's success in hosting the FIFA world cup 2022 and achieving its national vision for 2030. In addition, it is one of the largest sectors that generate employment within the country as well as a key indicator of the economy of Qatar. As many other countries, Qatar is facing cost overrun in big number of construction projects. There are many factors that are responsible for these cost overruns. This paper attempts to identify, rank and compare the major factors of cost overrun in construction sector of Qatar and other countries, which can serve as the way forward for future work in reducing these overruns.

1.3 Objectives

The main objective of this project is to identify major cost overrun attributes affecting construction projects. Data were collected using face to face meetings and an online survey to measure the differences and importance of the attributes according to industry experts. The conclusions of this project can be used by different organization types and stakeholders to reduce the impact of cost overruns in their construction projects.

1.4 Methodology

The steps followed for the entire project are summarized below:

1. Review of 65 related literature to come up with a summarized list of cost overrun attributes affecting construction projects.
2. Data collected using a 5-point Likert Scale survey questionnaire based on importance, frequency and impact on cost.
3. Analysis of data was executed based on various statistical analysis methods such as: Importance Index, Frequency Index, Cost Index, Frequency Adjusted Cost Index, Spearman's rank correlation, T-Test and risk mapping matrices.
4. Ranking the factors as perceived by various groups of industry professionals.
5. 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

Cost variance is one of the most important indicators of project success [20]. It is not just a measure of the company's profitability but also the productivity of that organization at any time during the construction. Despite its proven importance, it is rare to see a project completed within the estimated cost [6].

In a study on 8000 projects conducted by the Standish Group, Frame J. D. [64] found that only 16% of the projects satisfied the three fundamental criteria of project success: Completing project on time, meeting the budgeted cost, and meeting quality standard.

On the other hand, a global study on cost overrun covered 258 infrastructure projects in 20 nations, Flyvbjerg [29] concluded that 9 out 10 projects faced cost overrun. A research by Azhar [6] studied some construction projects in Pakistan discovered that the minimum cost overrun recorded was 10% of the estimated/budgeted cost. Furthermore, the authors stated that this percentage is sometimes much bigger in developing countries where total actual cost sometimes exceeds double the amount of the budgeted cost of the project.

For example, in Nigeria, Omoregie [10] reported that the minimum average percentage of cost overrun was 14%, while in Portugal, Moura [10] stated that construction projects faced a minimum of 12% of cost overrun. Furthermore, Apolot [65] stated that there was cost overrun of more than double the contract price in Uganda's Northern-by-pass projects.

Previous researches has attempted discover causes of the variance between the tender price and the final actual cost of the projects. This section reviews the literature's most common factors that influence cost overruns.

Four factors were identified from the existing research findings [26, 30] These are: frequent design changes, improper planning and scheduling, unpredictable weather conditions; and fluctuations in the cost of materials.

To broaden the investigation, it was decided to complement the above list of factors with other factors gleaned from the final account reports. These were compared with the factors from the existing research findings, and a final list of 18 factors was prepared. They were then divided into two groups of nine critical factors and nine other factors which are usually ignored, but perceived to be of equal significance [26].

The prime variables of cost overruns have been commonly identified as: unpredictable weather, inflationary material cost, inaccurate materials estimates, complexity of project, contractor's lack of geographical experience, contractor's lack of project type experience, and non-familiarity with local regulations [42].

Morris S [63] studied the factors affecting cost overruns in public sector projects, he found that escalation in project cost belongs partially to the fact that the original estimates were prepared using only the current prices with no contingency, and partially to delays which enhance the effect of inflation, and to direct escalation in costs arising out of change in scope, errors etc. Based on certain assumptions with regard to the pace of expenditure on projects, S.Morris [63] has roughly computed that for the 133 projects

which were studied only about 25 to 30% of the cost increase can be attributed to inflation. The remaining 70 to 75% has to be explained in terms of delays, inefficiencies, scope changes, changes in statutory levies, variations in exchange rates and to the combined effect of these factors with inflation.

Morris [63] mentioned ten factors that influencing cost overruns of construction projects. These factors are:

1- Inadequate project preparation, planning and implementation
2- Delay in construction, supply of raw materials and equipment by contractors.
3- Change in the scope of the project.
4- Resources constraint: funds, foreign exchange, power; associated auxiliaries not ready.
5- The delays in decisions making by government, failure of specific coordinating bodies.
6- Wrong /inappropriate choice of site.
7- Technical incompetence and poor organizational structure.
8- Labor unrest.
9- Natural calamities.
10- Lack of experience of technical consultants, inadequacy of foreign collaboration agreements, monopoly of technology.

Kaming [42] investigated the factors influencing construction cost and time overruns in high-rise projects in Indonesia. He found that cost overruns occur more frequently than time overruns and therefore they are a more severe problem on high-rise construction in Indonesia. The predominant factors influencing cost overruns cost increases due to inflation, inaccurate materials estimating and degree of project complexity.

Ameh [8] investigated 42 causes of cost overrun and found that the lack of experience of contractors, cost of material, fluctuation in the prices of materials, frequent design changes, economic stability, high interest rates charged by banks on loans and mode of

financing, bonds and payments as well as fraudulent practices and kickbacks are the main factors causing cost overrun in Nigeria.

Chimwaso [26] studied ten projects to evaluate the performance of their cost. The results have shown that seven out of ten projects had reported cost overruns. The factors that influence cost overruns have been identified and ranked in order of significance. These factors have further been classified under categories according to the formal of final account reports. By classifying them into categories, helps to deal with them effectively. The four categories arrived at are: variations, measurement of provisional works, contractual claims and fluctuations in the cost of labour and materials, with variations being the most significant.

Frimpongs [20] studied 26 factors that cause cost overruns in ground water construction projects in Ghana. He sent 55 questionnaires to owners, 40 to contractors and 30 to consultants. According to the contractors and consultants, monthly payments difficulties from agencies was the most important cost overruns factor, while owners ranked poor contractor management as the most important factor. Despite some difference in viewpoint held by the three groups surveyed, there was a high degree of agreement among them with respect to their ranking of the factors. The overall ranking results indicated that the three groups felt that the major factors that can cause excessive groundwater project overruns in developing countries, according to their degree of influence, are: poor contractor management, monthly payment difficulties from agencies, material procurement, poor technical performances and escalation of material prices.

Adnan Enshassi [15] mentioned 10 major factors out of 42 investigated ones causing cost overrun in Gaza construction projects, they were:

1- Increase of materials prices due to continuous border closures.
2- Delay in construction, supply of raw materials and equipment by contractors.
3- Fluctuations in the cost of building materials.
4- Unsettlement of the local currency in relation to dollar value.
5- Project materials monopoly by some suppliers
6- Resources constraint: funds and associated auxiliaries not ready.
7- Lack of cost planning/monitoring during pre-and post-contract stages.
8- Improvements to standard drawings during construction stage.
9- Design changes
10- Inaccurate quantity take-off.

A study for Le-Hoai [57] found that poor site management and supervision, poor project management assistance, financial difficulties of owner, financial difficulties of contractor & design changes were the most significant causes of cost overrun in Vietnam construction industry.

In Kuwait, P. A. KOUSHKI [41] investigated delays and cost increases in the construction of private residential projects and found that cost-increases was greater when the total cost of a residential project was higher. A major factor contributing to both time and cost overruns was the inadequacy of money and time allocated to the design phase. The three main causes of cost overruns on the other hand were, in order:

1- Contractor related problems
2- Material-related problems
3- Owners' financial constraints.

Peter F. Kaming [42] indicated four major factors that cause cost overruns in high-rise projects in Indonesia, and they were: design changes, inadequate planning, unpredictable weather conditions; and fluctuations in the cost of building materials.

In Malaysia, Memon, A [23] found 15 causative factors responsible for cost overrun in MARA large construction projects. The results showed that cash flow and financial difficulties faced by contractors, contractor's poor site management and supervision, inadequate contractor experience, shortage of site workers and incorrect planning and scheduling by contractors were more significant factors affecting construction cost. Also, from correlation analysis it was perceived that "incorrect planning and scheduling by contractors with contractor's poor site management and supervision", "contractor's poor site management and supervision with inadequate contractor experience", "incorrect planning and scheduling by contractors with inadequate contractor experience" and "frequent design changes with change in the scope of the project" have a strong positive relationship with each other.

Extensive review of related literature worldwide has revealed 39 common attributes of cost overrun, categorized into seven groups, namely construction phase factors (CPH), design factors (D), financial management related factors (F), communication related factors (C), human resource (Labor) related factors (L), materials and equipment related

factors (M&E), project management related factors (PM). The causes and their groups are as presented in the following table:

Table 1 - List of 39 cost overrun attributes and their corresponding literature references

1- Construction Phase Factors	
Insufficient site management and inspection	[3], [5], [6], [23], [36], [38], [39], [43], [44], [48], [49], [57]
Schedule delay	[3], [10], [37]
Improper planning and scheduling	[2], [3], [4], [5], [6], [8], [15], [20], [23]
Improper monitoring and control	[3], [4], [5], [6], [20], [39], [45], [48]
Lack of experience in handling construction projects	[8], [15], [23], [36], [38], [39], [40], [42], [44]
Delay in inspection and approval of completed work	[34], [57], [36], [39], [43], [44], [45], [48], [49], [50], [51], [55]
Errors during construction	[34], [57], [35], [36], [44], [45], [49], [58], [54]
Accidents on site	[40], [43], [49], [50]
Effect of weather	[3], [34], [36], [20], [39], [40], [41], [42], [43], [44], [46]
Unforeseen ground conditions	[36], [57], [38], [39], [40], [44], [45]
2- Design Factors	
Frequent Design changes	[2], [3], [6], [8], [10], [15], [20], [23]
Design errors and mistakes	[4], [22], [34], [49], [50], [51], [57]
Incomplete design at time of tender	[4], [6], [15]
Deficient design and delays in design process	[43], [59]
Delay in approval of drawings	[10], [36], [43], [44], [48], [50], [53]
3- Financial Factors	
Delay in progress payment by owner for work completed	[2], [4], [6], [20], [34], [43], [44], [45], [48], [50], [51]
Financial difficulties of owner	[6], [20], [30], [57], [20], [39], [41], [42], [51], [52]
Cash flow difficulties faced by contractor	[4], [6], [20], [30], [34], [39], [57], [45], [49], [50], [51]
Poor financial control on site	[6], [8], [35], [46]
Delay payment to supplier /subcontractor	[10], [30], [51]
4- Communication Factors	
Weak communication between project parties	[8], [2], [5], [6], [15], [23], [22], [34], [36], [38], [39]
Weak coordination between project parties	[34], [40], [46], [48], [50], [51], [58], [55]
Weak collaboration between management and labour	[39], [46], [50]
Disputes on site	[34], [36], [43], [44], [46], [48]
5- Labour Factors	
Low labour productivity	[3], [30], [36], [38], [43], [44], [54], [56]
Lack and shortage of skilled labours	[3], [4], [6], [8], [20], [22], [23], [30], [34], [38], [40]
Inflation in the cost of labours	[4], [6], [8]
6- Material and equipment Factors	
Fluctuation in raw material prices	[4], [6], [8], [10], [15], [20], [22], [23]
Late delivery of materials and equipment	[2], [3], [4], [6], [10], [20], [22], [30], [34], [43], [45], [49]
Insufficient number of equipment	[3], [34], [43], [48], [50], [51], [52], [53]

Changes in material specs and types	[3], [34], [43], [48], [50], [51]
7- Project Management Factors	
Poor project management	[2], [6], [22], [57], [39], [49]
Frequent changes to the scope of work	[3,] [4], [6], [15], [20], [23], [30], [40], [43]
Delays in decisions making	[15], [20], [23], [34], [36], [38], [39], [43], [44]
Poor contract management	[36], [39], [44], [45], [46], [57]
Errors in contract documents	[36], [40], [43], [44], [48], [49]
Unrealistic contract duration and requirements imposed	[36], [38], [39], [40], [43], [44], [46], [48]
Owner interference	[35], [36], [39], [43], [51], [56]
Inaccurate time and cost estimates of project	[3],[4], [5], [10], [20], [57], [37], [39], [45], [56]

3. Chapter 3: Research Methodology

3.1 Introduction

This chapter presents the methodology used in this project. This study used both qualitative and quantitative research techniques. A draft list of cost overrun causes was established using a qualitative literature review, and then the list was compiled to 39 attributes after taking into account the recommendations of the construction industry experts. A questionnaire survey was prepared and distributed to achieve the objective of this research: identifying and ranking the significant cost overrun attributes affecting the construction industry. Quantitative analysis of the survey data was performed using the statistical methods discussed in the paragraphs below.

3.2 Survey Design

A questionnaire survey approach was adopted in order to gather the necessary data required to conduct data analysis. This research aimed to investigate the perceptions of the participants on the influencing cost overrun attributes prevalent in the construction industry. Using the results of the survey, the attributes were ranked, and ranking comparisons were applied between the various respondents groups: Locations, organization type, industry type, size of the company and years of experience in construction industry.

The questionnaire was published through an online website for a convenient and fast method of distribution and data collection.

It contains two sections:

1) Respondents information: To categorize the respondents into different groups for the purpose of comparisons.

2) Cost overrun attributes evaluation: Composed of the 39 common cost overrun attributes affecting construction projects. The respondents were requested to evaluate the "importance" (The impact of this factor on cost overrun in construction project), "frequency" (How often the attribute is implemented or considered) and "Impact on Cost Overrun" (What is the direct impact of this factor on the cost overrun) on a 5 point Likert Scale (1=Very Low, 2=Low, 3=Moderate, 4= high, 5=Very High). For an example, for the first cause of Cost Overrun factors" insufficient site management and inspection", the respondent was asked to evaluate the:

- Importance: What is the impact of this factor in decision making in construction projects?

- Frequency: How often is this factor considered or does it occur in construction projects?

- Impact on Cost Overrun: What is the impact of this factor on the cost overrun?

The survey was sent to numerous contacts that play key roles in the construction industry. A total of 101 completed surveys were received out of 145 attempted responses, indicating a response rate of 69%.

3.3 KJ-Method

The KJ Method is a qualitative tool that is used to sort data into categories based on their relationships. It is a very useful technique for classifying the data into organized categories. The KJ Method was adopted in this research to organize the 39 cost overrun causes attributes collected from literature and experts' suggestions. These groups are: Construction phase factors (CPH), design factors (D), financial management related factors (F), communication related factors (C), human resource (Labor) related factors (L), materials and equipment related factors (M&E), project management related factors (PM).

3.4 Hierarchal assessment of causes - Ranking of causes of cost overrun:

3.4.1 RII (Relative Importance Index)

Relative Importance Index is used to assess and rank the degree of importance for each factor. 5-point Likert Scale was applied to rate the importance of the attributes and the Relative Importance Index can be calculated as follows:

$$RII = \sum_{i=1}^{5} \frac{Wi*Xi}{A*N}$$

Where:
RII = Relative importance index
W = weighting given to each factor by respondents and it ranges from 1 to 5.
X = frequency of ith response given for each cause.
A = highest weight (i.e. 5 in this case)
N = total number of participants (i.e. 101 in this research)

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 Relative Frequency Index (FI) and Relative Cost-Impact Index (CII)

Similar to the above, the FI and CII can be calculated to assess and rank the degree of frequency and Cost Index for each factor.

3.4.3 Frequency-Cost Adjusted Importance Index (FCAII)

The Frequency-Cost Adjusted Importance Index (FCAII) is an inventive ranking approach adopted in this research to rank cost overrun attributes in construction industry.

This technique considers the importance, the frequency and the Cost Index in its formula resulted from responses scores using the 5 point Likert Scale. In order to find the FCAII, the Relative Importance Index, the Frequency Index (FI) and the Cost Impact Index (CII) are required to be measured and calculated referring to responses data collected in survey.

$$RII = \sum_{i=1}^{5} \frac{Wi*Xi}{A*N}$$

$$FI = \frac{\Sigma Wi*Xi}{A(N)}$$

$$CII = \frac{\Sigma Wi*Xi}{A(N)}$$

$$\mathbf{FCAII = RII \times FI \times CII}$$

3.5 Correlation Tests

3.5.1 Agreement Analysis (Spearman rank correlation factor):

The Spearman's rank correlation coefficient (ρ) was used to show the degree of agreement between the rankings of any two parties. RII, FI and CI

$$\rho = 1 - \frac{6\sum d^2}{N^3 - N}$$

Where,

ρ = Spearman rank correlation coefficient between two parties.

d = difference between ranks assigned to variables for each cause.

n = the number of attributes which is 39.

The Spearman's correlation is a non-parametric test and it assesses relationship between different groups regarding different factors strength. In this research, it has been used to check the correlation between the RII, FII and CII for all the collected responses. In addition, it is used in measuring accuracy in the relationship in comparing responses based on location, organization type, job designation etc. According to the definition of its formula, 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). Assumption of no multi-collinearity between attributes was made.

3.5.2 T Test:

The T-Test is a parametric test and it is used to evaluate how close or related are two different groups. It determines whether there is a significant difference between the means of two unrelated groups. In this project, T-test is used to identify the influential factors affecting construction cost overrun which have a significant level of agreement among the groups. If p-value is greater than 0.1 then this indicates agreement between two unpaired groups whereas a value less than 0.1 shows a significant disagreement.

$$t = \frac{\mathrm{x1} - \mathrm{x2}}{\sqrt{\frac{S1^2}{n1} + \frac{S2^2}{n2}}}$$

where,

$x1$= Mean of first set of values, $x2$= Mean of second set of values

$s1$= Standard deviation of first set of values, $s2$ = Standard deviation of second set of values

$n1$ = Total number of values in first set

$n2$ = Total number of values in second set

The independent group means the groups are not related, and any individual in one group cannot exist in the other group. The main value that is used to evaluate the groups is the significance value (p-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.

3.6 Ranking Percentage Agreement and Disagreement

Okpala and Aniekwu [61] proposed to evaluate the extent of agreement in ranking between different pairs of respondent groups, and called it the ranking agreement factor (RAF).

For any two groups, assuming the ranking of the i^{th} item in group 1 is $Ri1$, and in group 2 is $Ri2$, For any two groups, let the rank of the i^{th} item in group 1 be Ri1 and in group 2 be Ri2 . Then the absolute difference Di, between any ranking of the, between any ranking of the i^{th} item by the groups would be

$Di = |Ri1 - Ri2|$
Where i = 1, 2, . . . , N
And there are N items

$D\max = |Ri1 - Rj2|$
Where $j = N - i + 1$,

i.e., if i=1 and N=39, j=30−1+1=30

The percentage disagreement (PD) and the percentage agreement (PA) by the following equations:

$$PD = 100x \frac{\sum_{i=1}^{N} |Ri1 - Ri2|}{\sum_{x=1}^{N} |Rx1 - Rj2|}$$

PA = 100 – PD

According to the above formula of the PA, and PD of the FCAII of the various cost overrun causes and the effectiveness of the mitigation measures for different pairs of groups, respectively, were examined as per table 26, to see the extent of the difference among different groups of respondents.

Referring to the table 26, the values of PD for the Qatar vs GCC groups regarding the FCAII of cost overrun causes were the smallest compared with the other pairs of groups.

This indicates that there was a relatively strong consensus between these two groups (i.e. PA=74.47 % regarding the FCAII of cost overrun causes).

Greatest difference of viewpoint existed between the General Contractor group (GC) and the Owner group regarding the FCAII of cost overrun causes (PD=37.89%).

3.7 Risk Mapping

Risk mapping is used in order to improve the understanding of risks associated with each cost overrun 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 cost overrun factors: importance, frequency and impact on cost. Data will be plotted on scatter plot chart using mean values of data from respondents, X-axis represents the importance mean values, Y-axis represents the frequency means values, and the Z-axis represents the impact on cost mean values.

Characteristics of zones shown in table 2 are as follows:

- 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 happen during construction.

- Red Zone: Risks require an immediate and high level of control as their impact and occurrence are critical.

Table 2 - Scale used to present factor's risk related to Importance, Frequency and Impact on cost

Risk Matrix					
5 - Very High	5	10	15	20	25
4 - High	4	8	12	16	20
3 - Moderate	3	6	9	12	15
2 - Low	2	4	6	8	10
1 - Very Low	1	2	3	4	5
	1 - Very Low	2 - Low	3 - Moderate	4 - High	5 - Very High

4 Data Collection and Results

4.1 Introduction

This chapter presents the summarization of data collected from the survey and its analysis using different statistical methods. An online website has been used in developing the survey questionnaire, distributing it, and collecting the responses. The questionnaire link was sent out by emails and via face to face meetings with various construction experts. Only the complete responses were chosen to proceed with analysis, resulting with 101 completed questionnaires were chosen out of 145 in total.

4.2 Respondents Profile

Respondent profiles are presented based on location, organization type, job designation, type of industry, years of experience in construction industry, size of company, and percentage level of cost overrun in their projects.

4.2.1 Percentage of respondent based on location

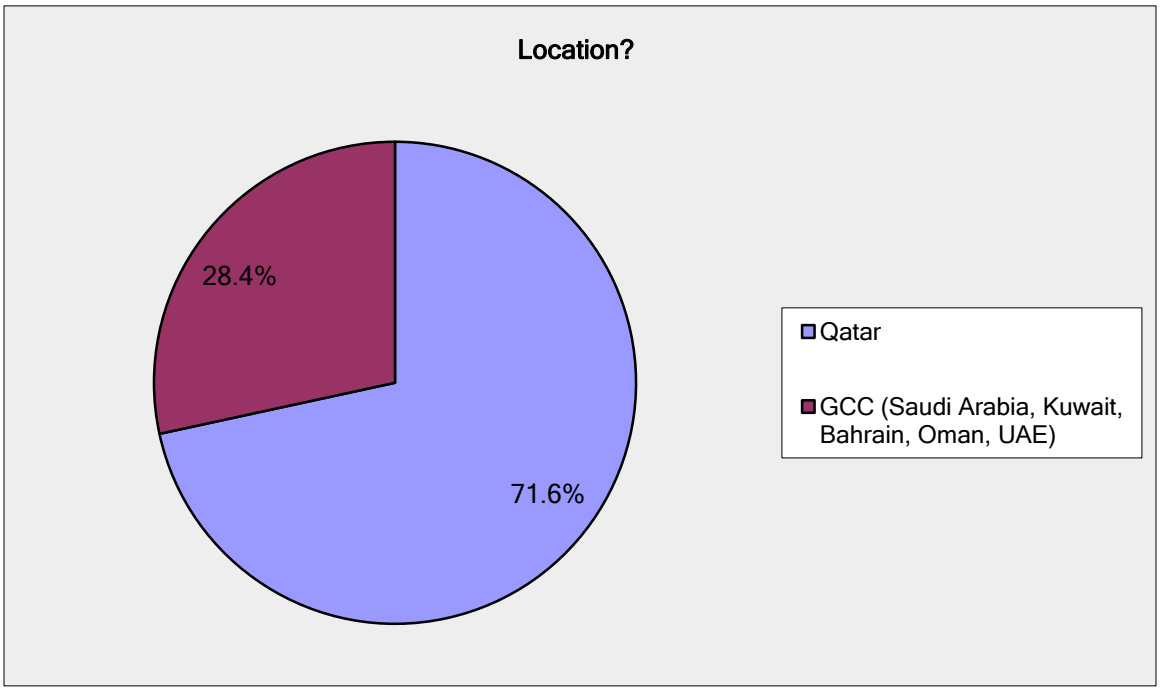

Figure 1 - Percentage of respondents based on location

The figure above shows location of the respondents. Participants from Qatar represents majority of the respondents constituting 71.6% of the total numbers. The rest of participants, which are 28.4% of total number of participants, are from the GCC. This variety in location is a good indicator that the final results and conclusions of this

research can be applied to develop the construction in Qatar and other GCC countries as well, which serves the purpose of this project.

4.2.2 Percentage of respondents based on organization type

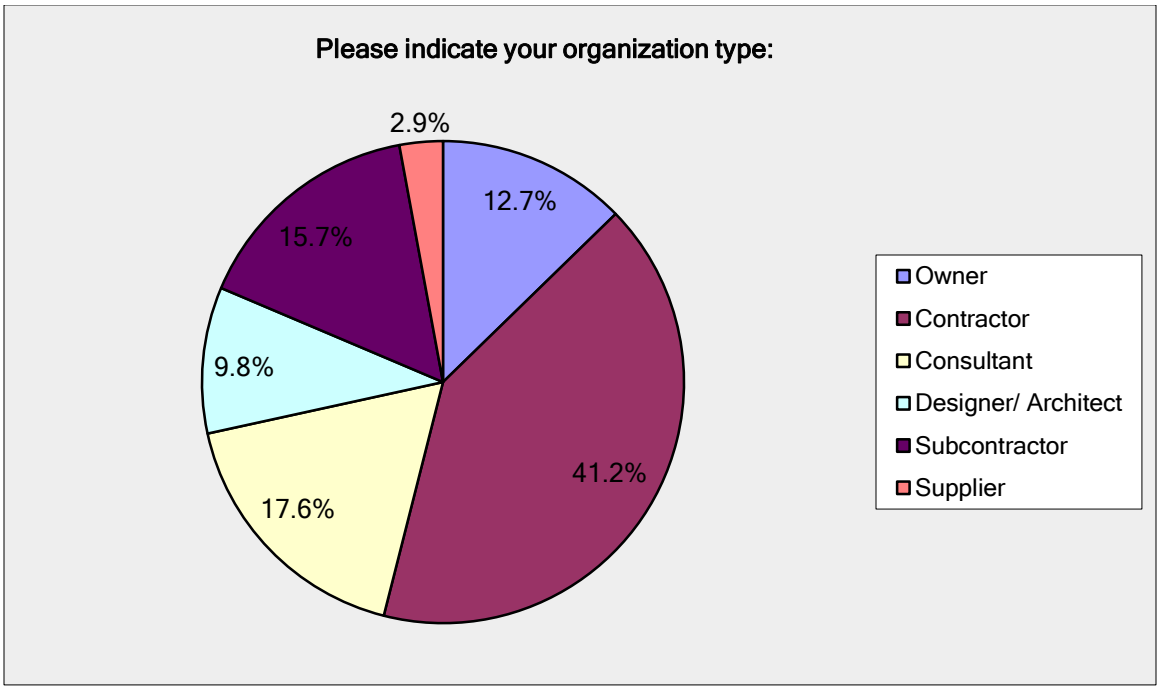

Figure 2 - Percentage of respondents based on Organization type

The participant from various organizations represents various fields that are related to construction, such as owners, contractors, consultants, designers, subcontractors and suppliers. In this research, contractors form the largest portion of respondents with 41.2% of responses. Consultants are the second largest contributors to the survey and form almost 18% of the total participants. The third largest number of contributions came from the subcontractors who form 16% of the responses.

4.2.3 Percentage of respondents based on job designation

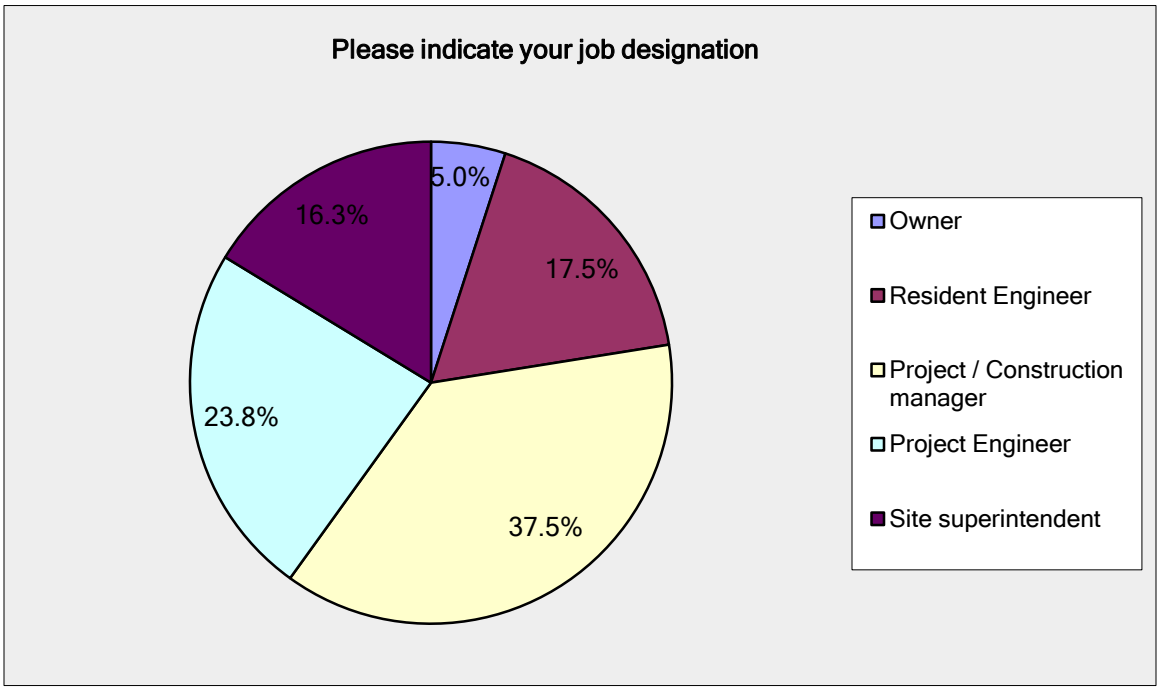

Figure 3 - Percentage of respondents based on Job Designation

The figure above represents the job designation of the respondents. Out of 101 respondents, 20 respondents chose (other) as their job designation and 81 respondents chose the available job designation options. 37.5% of the 81 respondents were project or construction managers, 23.8% of them were project engineers, 17.5% of them were resident engineers, 16.3% were site engineers, 5% were owners. The other 20 respondents who chose (other) belong to other groups, such as: (Planning Manager, Accountant, Director of Operations, General Managers, planner and Quantity surveyors, Senior Quantity Surveyors, Designing Manager, Plant manager, Chief Operating Officer, Senior Project Controls Manager, Academicians, and many others).

4.2.4 Percentage of respondents based on Industry type

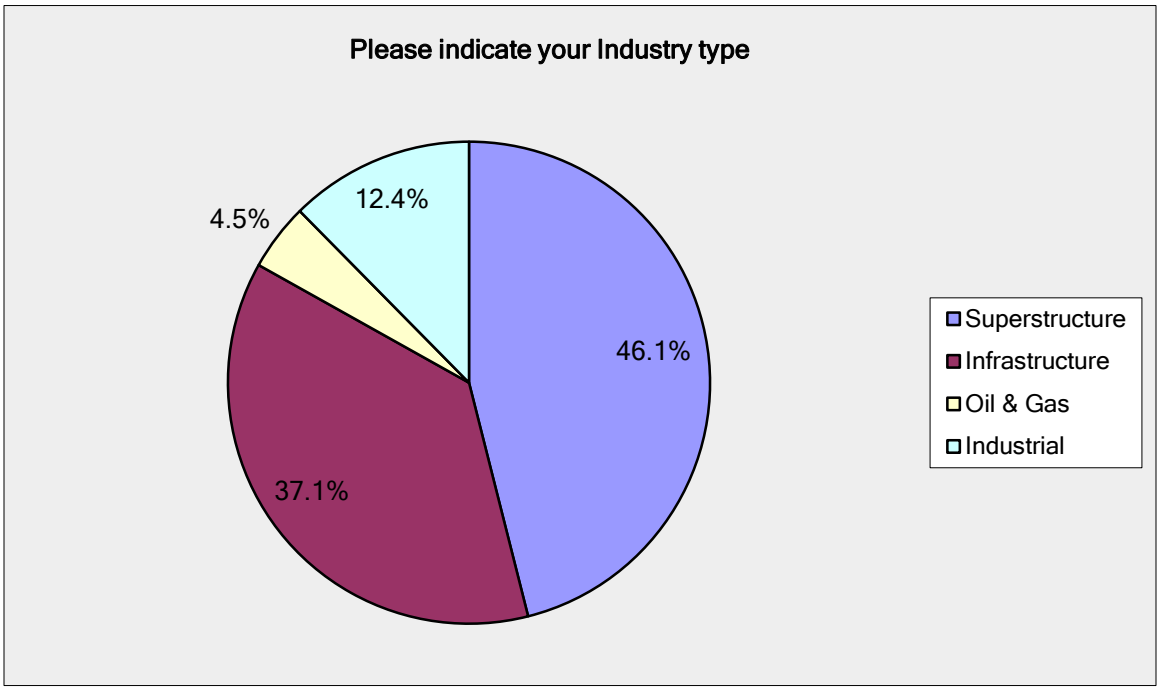

Figure 4 - Percentage of respondents based on type of industry

The figure above represents the percentage of participants involved in superstructure construction projects holds significant portion of participants with almost 46.1% of responses, followed by infrastructure construction projects with 37.1% of responses. The remainders are involved in oil & gas with 4.5%, 12.4% of respondents are from industrial industry.

4.2.5 Percentage of respondents based on size of company

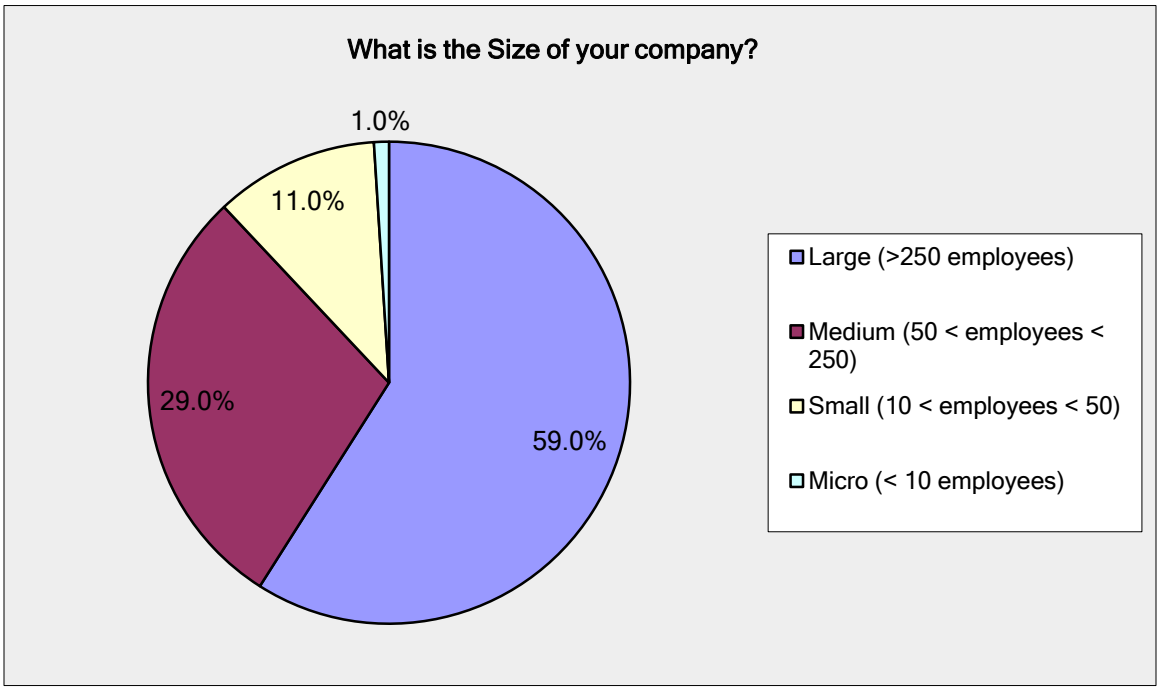

Figure 5 - Percentage of respondents based on company size

The figure 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 59%, followed by a medium size company which is 29% of the respondents. This is a good indicator of the survey responses quality, because usually the employees in large companies have a deep experience in the field and face many issues in the work that makes their point of views more realistic than others.

4.2.6 Percentage of respondents based on years of experience

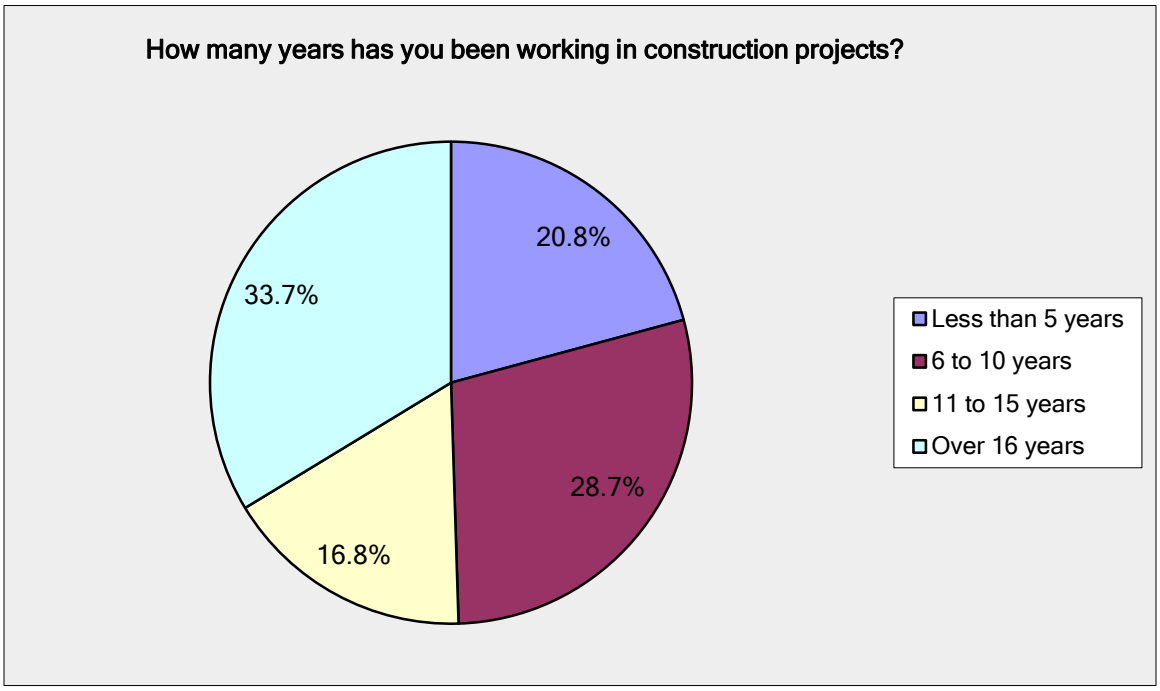

Figure 6 - Percentage of respondents based on Years of experience in construction

As shown in the above Figure, participants were categorized based on total years of work experiences in construction based on 4 groups, which are less than 5 years, 6 to 10 years, 11 to 15 years and more than 16 years. 33.7% of participants in the survey are professionals who have been practicing the construction for more than 16 years as seen in the Figure. On the other hand, a percentage of 28.7% of respondents fall into category of 6 to 10 years of experience. This means that 62.4% of respondents have 6 to more than 16 years of experience, which is a good indicator of the responses quality.

4.2.7 Number of respondents based on percentage level of cost overrun in their projects

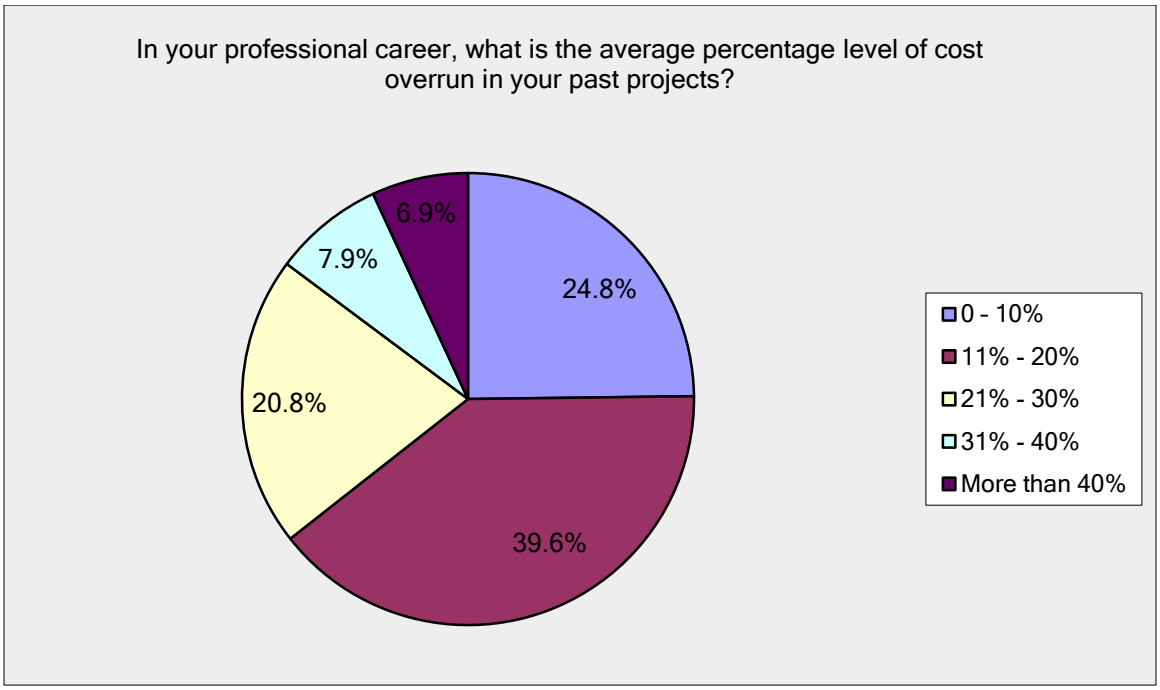

Figure 7 - Percentage of respondents based on percentage level of cost overrun in their projects

From the Figure above, it can be seen that the 39.6% of respondents faced average cost overruns of 11% to 20% of the original contract sum of their previous projects. On the other hand, only 6.9% of the respondents faced average cost overruns that exceeded 40% of the contracts price.

4.3 Evaluation of Cost Overrun Attributes

One of the objectives of this research is to identify the influencing cost overrun attributes based on point of views of the construction industry professionals in Qatar and the other parts of the world. Survey participants used a 5 - point Likert Scale to rate each individual cost overrun factor's importance, frequency and extent of Cost Index. The options of the scale are 1 (very low), 2 (low), 3 (moderate), 4 (high), and 5 (very high). The importance was rated to measure the impact of the factor on the cost of the construction project, while the frequency was used to determine how often the attribute occurs in construction projects, and the impact on cost was used to assess the extent of the direct effect of this attribute on the cost overrun of the project.

Table 3 below presents the raw data of the survey showing the importance, Table 2 shows the data of the survey frequency, Table 3 shows the cost index values provided by the respondents. Data collected was analyzed to develop the RII, FI, CII, and FCAII values of each attribute. The higher the value of the RII, FI, CII or FCAII, the higher importance level of the cost overrun attribute and vice versa. The cost overrun factor codes CPH (construction phase), D (Design factors), F (Finance factors), C (Communication factors), L (Labor factors), M&E (Material and Equipment factors), and PM (Project Management factors) represents cost overrun attributes related to construction phase, cost overrun attributes related to design phase, cost overrun attributes related to finance, cost overrun attributes related to communications, cost overrun attributes related to labor, cost overrun

attributes related to materials and equipment, cost overrun attributes related to project management, respectively.

Table 3 - Importance ratings of cost overrun factors by all respondents

Code	Answer Options	1	2	3	4	5	Response Count
CPH	Insufficient site management and inspection	3	8	20	52	18	101
CPH	Schedule delay	0	4	14	51	32	101
CPH	Improper planning and scheduling	1	1	15	31	53	101
CPH	Improper monitoring and control	0	9	21	48	23	101
CPH	Lack of experience in handling construction projects	4	10	22	46	19	101
CPH	Delay in inspection and approval of completed work	4	9	48	28	12	101
CPH	Errors during construction	3	10	40	26	22	101
CPH	Accidents on site	13	8	21	13	46	101
CPH	Effect of weather	12	46	29	10	4	101
CPH	Unforeseen ground conditions	16	20	35	19	11	101
D	Frequent Design changes	0	3	13	30	55	101
D	Design errors and mistakes	2	9	15	37	38	101
D	Incomplete design at time of tender	3	11	16	25	46	101
D	Deficient design and delays in design process	3	6	22	46	24	101
D	Delay in approval of drawings	2	16	17	48	18	101
F	Delay in progress payment by owner for work completed	2	5	18	29	47	101
F	Financial difficulties of owner	2	9	15	28	47	101
F	Cash flow difficulties faced by contractor	2	7	12	51	29	101
F	Poor financial control on site	6	6	19	45	25	101
F	Delay payment to supplier /subcontractor	5	7	16	47	26	101
C	Weak communication between project parties	2	9	18	52	20	101
C	Weak coordination between project parties	2	3	23	53	20	101
C	Weak collaboration between management and labor	3	19	34	26	19	101
C	Disputes on site	9	14	43	24	11	101
L	Low labor productivity	2	6	25	28	40	101
L	Lack and shortage of skilled labors	2	8	20	24	47	101
L	Inflation in the cost of labors	9	16	13	22	41	101
M&E	Fluctuation in raw material prices	0	11	17	26	47	101
M&E	Late delivery of materials and equipment	0	4	23	51	23	101

M&E	Insufficient number of equipment	5	11	43	27	15	101
M&E	Changes in material specs and types	5	4	25	45	22	101
PM	Poor project management	2	1	14	26	58	101
PM	Frequent changes to the scope of work	1	2	23	23	52	101
PM	Delays in decisions making	3	4	22	24	48	101
PM	Poor contract management	3	9	15	51	23	101
PM	Errors in contract documents	3	7	20	24	47	101
PM	Unrealistic contract duration and requirements imposed	1	2	16	24	58	101
PM	Owner interference	5	14	30	19	33	101
PM	Inaccurate time and cost estimates of project	1	3	16	29	52	101

Table 4 - Frequency of occurrence ratings of cost overrun factors by all respondents

	Answer Options	1	2	3	4	5	Response Count
CPH	Insufficient site management and inspection	9	18	47	19	8	101
CPH	Schedule delay	7	9	30	40	15	101
CPH	Improper planning and scheduling	8	16	37	21	19	101
CPH	Improper monitoring and control	4	24	47	19	7	101
CPH	Lack of experience in handling construction projects	8	22	47	18	6	101
CPH	Delay in inspection and approval of completed work	10	19	25	39	8	101
CPH	Errors during construction	9	22	49	16	5	101
CPH	Accidents on site	45	21	20	11	4	101
CPH	Effect of weather	28	46	14	10	3	101
CPH	Unforeseen ground conditions	48	19	22	10	2	101
D	Frequent Design changes	16	21	23	26	15	101
D	Design errors and mistakes	20	26	37	14	4	101
D	Incomplete design at time of tender	16	33	23	18	11	101
D	Deficient design and delays in design process	14	37	27	17	6	101
D	Delay in approval of drawings	11	26	35	17	12	101
F	Delay in progress payment by owner for work completed	9	18	43	20	11	101
F	Financial difficulties of owner	14	46	24	14	3	101
F	Cash flow difficulties faced by contractor	8	27	39	19	8	101
F	Poor financial control on site	12	25	41	18	5	101
F	Delay payment to supplier /subcontractor	8	20	43	21	9	101
C	Weak communication between project parties	16	21	28	31	5	101
C	Weak coordination between project parties	10	24	40	21	6	101
C	Weak collaboration between management and labor	14	23	44	15	5	101
C	Disputes on site	25	16	44	10	6	101
L	Low labor productivity	11	25	34	24	7	101
L	Lack and shortage of skilled labors	8	23	22	39	9	101
L	Inflation in the cost of labors	15	44	20	17	5	101
M&E	Fluctuation in raw material prices	16	19	45	15	6	101
M&E	Late delivery of materials and equipment	6	20	52	16	7	101
M&E	Insufficient number of equipment	9	23	54	14	1	101
M&E	Changes in material specs and types	11	24	45	10	11	101
PM	Poor project management	13	13	50	17	8	101
PM	Frequent changes to the scope of work	16	6	46	24	9	101
PM	Delays in decisions making	11	18	42	19	11	101
PM	Poor contract management	12	16	45	22	6	101

PM	Errors in contract documents	24	18	37	13	9	101
PM	Unrealistic contract duration and requirements imposed	17	18	32	23	11	101
PM	Owner interference	15	22	37	19	8	101
PM	Inaccurate time and cost estimates of project	7	22	43	15	14	101

Table 5 - Cost Index Overrun ratings by all respondents

	Answer Options	1	2	3	4	5	Response Count
CPH	Insufficient site management and inspection	7	6	22	49	17	101
CPH	Schedule delay	3	4	12	41	41	101
CPH	Improper planning and scheduling	1	4	19	34	43	101
CPH	Improper monitoring and control	2	10	17	45	27	101
CPH	Lack of experience in handling construction projects	7	9	20	42	23	101
CPH	Delay in inspection and approval of completed work	12	11	22	45	11	101
CPH	Errors during construction	2	15	41	20	23	101
CPH	Accidents on site	18	16	15	20	32	101
CPH	Effect of weather	35	30	18	14	4	101
CPH	Unforeseen ground conditions	28	11	33	18	11	101
D	Frequent Design changes	2	7	11	28	53	101
D	Design errors and mistakes	8	6	14	39	34	101
D	Incomplete design at time of tender	7	8	14	26	46	101
D	Deficient design and delays in design process	5	13	22	39	22	101
D	Delay in approval of drawings	8	12	37	26	18	101
F	Delay in progress payment by owner for work completed	14	6	16	40	25	101
F	Financial difficulties of owner	10	8	19	26	38	101
F	Cash flow difficulties faced by contractor	9	8	19	45	20	101
F	Poor financial control on site	10	5	20	44	22	101
F	Delay payment to supplier /subcontractor	11	7	22	42	19	101
C	Weak communication between project parties	6	15	19	53	8	101
C	Weak coordination between project parties	7	12	40	26	16	101
C	Weak collaboration between management and labor	15	14	40	22	10	101
C	Disputes on site	16	16	38	22	9	101
L	Low labor productivity	5	16	23	34	23	101
L	Lack and shortage of skilled labors	8	16	14	44	19	101
L	Inflation in the cost of labors	13	17	12	24	35	101
M&E	Fluctuation in raw material prices	8	8	17	52	16	101
M&E	Late delivery of materials and equipment	4	14	33	37	13	101
M&E	Insufficient number of equipment	7	16	40	28	10	101
M&E	Changes in material specs and types	4	11	25	42	19	101
PM	Poor project management	4	8	17	26	46	101
PM	Frequent changes to the scope of work	1	9	11	30	50	101
PM	Delays in decisions making	4	12	21	38	26	101
PM	Poor contract management	8	7	20	45	21	101
PM	Errors in contract documents	6	6	23	28	38	101
PM	Unrealistic contract duration and requirements	1	7	19	23	51	101

	imposed						
PM	Owner interference	12	13	34	24	18	101
PM	Inaccurate time and cost estimates of project	5	5	15	32	44	101

4.3.1 Hierarchal assessment of causes - Ranking of causes of cost overrun: RII (Relative Importance Index)

Table 6 shows both RII values and ranking of cost overrun attributes developed based on importance scale values by responses from all the participants. The values were calculated using Relative Importance Index (RII) as per RII equation.

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

Category	Answer Options →	1	2	3	4	5	RII	Rank
D	Frequent Design changes	0	3	13	30	55	0.871	1
PM	Poor project management	2	1	14	26	58	0.871	2
PM	Unrealistic contract duration and requirements imposed	1	2	16	24	58	0.869	3
CPH	Improper planning and scheduling	1	1	15	31	53	0.865	4
PM	Inaccurate time and cost estimates of project	1	3	16	29	52	0.853	5
PM	Frequent changes to the scope of work	1	2	23	23	52	0.844	6
F	Delay in progress payment by owner for work completed	2	5	18	29	47	0.826	7
CPH	Schedule delay	0	4	14	51	32	0.820	8
PM	Delays in decisions making	3	4	22	24	48	0.818	9
F	Financial difficulties of owner	2	9	15	28	47	0.816	10
M&E	Fluctuation in raw material prices	0	11	17	26	47	0.816	11
L	Lack and shortage of skilled labors	2	8	20	24	47	0.810	12
PM	Errors in contract documents	3	7	20	24	47	0.808	13
D	Design errors and mistakes	2	9	15	37	38	0.798	14
D	Incomplete design at time of tender	3	11	16	25	46	0.798	15
F	Cash flow difficulties faced by contractor	2	7	12	51	29	0.794	16
L	Low labor productivity	2	6	25	28	40	0.794	17
M&E	Late delivery of materials and equipment	0	4	23	51	23	0.784	18
C	Weak coordination between project parties	2	3	23	53	20	0.770	19
CPH	Improper monitoring and control	0	9	21	48	23	0.768	20
D	Deficient design and delays in design process	3	6	22	46	24	0.762	21
F	Delay payment to supplier /subcontractor	5	7	16	47	26	0.762	22
PM	Poor contract management	3	9	15	51	23	0.762	23
C	Weak communication between project parties	2	9	18	52	20	0.756	24

F	Poor financial control on site	6	6	19	45	25	0.752	25
M&E	Changes in material specs and types	5	4	25	45	22	0.749	26
CPH	Insufficient site management and inspection	3	8	20	52	18	0.747	27
CPH	Accidents on site	13	8	21	13	46	0.741	28
L	Inflation in the cost of labors	9	16	13	22	41	0.739	29
CPH	Lack of experience in handling construction projects	4	10	22	46	19	0.731	30
D	Delay in approval of drawings	2	16	17	48	18	0.727	31
PM	Owner interference	5	14	30	19	33	0.721	32
CPH	Errors during construction	3	10	40	26	22	0.707	33
C	Weak collaboration between management and labor	3	19	34	26	19	0.677	34
M&E	Insufficient number of equipment	5	11	43	27	15	0.671	35
CPH	Delay in inspection and approval of completed work	4	9	48	28	12	0.669	36
C	Disputes on site	9	14	43	24	11	0.628	37
CPH	Unforeseen ground conditions	16	20	35	19	11	0.578	38
CPH	Effect of weather	12	46	29	10	4	0.497	39

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

1- Frequent design changes (Design related factors)

2- Poor project management (project management related factor)

3- Unrealistic contract duration and requirements imposed (project management related factor)

4- Improper planning and scheduling (Construction related factor)

5- Inaccurate time and cost estimates of project (Project management related factor)

4.3.2 Relative Frequency Index (FI) Ranking

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

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

Category	Answer Options	1	2	3	4	5	FI	Rank
CPH	Schedule delay	7	9	30	40	15	0.693	1
CPH	Improper planning and scheduling	8	16	37	21	19	0.653	2
L	Lack and shortage of skilled labors	8	23	22	39	9	0.636	3
CPH	Delay in inspection and approval of completed work	10	19	25	39	8	0.632	4
PM	Inaccurate time and cost estimates of project	7	22	43	15	14	0.614	5
F	Delay in progress payment by owner for work completed	9	18	43	20	11	0.612	6
PM	Frequent changes to the scope of work	16	6	46	24	9	0.608	7
D	Frequent Design changes	16	21	23	26	15	0.606	8
F	Delay payment to supplier /subcontractor	8	20	43	21	9	0.606	9
CPH	Improper monitoring and control	4	24	47	19	7	0.602	10
PM	Delays in decisions making	11	18	42	19	11	0.602	11
CPH	Insufficient site management and inspection	9	18	47	19	8	0.598	12
M&E	Late delivery of materials and equipment	6	20	52	16	7	0.596	13
PM	Poor project management	13	13	50	17	8	0.588	14
PM	Poor contract management	12	16	45	22	6	0.588	15
D	Delay in approval of drawings	11	26	35	17	12	0.586	16
PM	Unrealistic contract duration and requirements imposed	17	18	32	23	11	0.586	17
CPH	Lack of experience in handling construction projects	8	22	47	18	6	0.584	18
F	Cash flow difficulties faced by contractor	8	27	39	19	8	0.584	19
L	Low labor productivity	11	25	34	24	7	0.582	20
C	Weak coordination between project parties	10	24	40	21	6	0.578	21
C	Weak communication between project parties	16	21	28	31	5	0.576	22

CPH	Errors during construction	9	22	49	16	5	0.572	23
M&E	Changes in material specs and types	11	24	45	10	11	0.572	24
PM	Owner interference	15	22	37	19	8	0.566	25
F	Poor financial control on site	12	25	41	18	5	0.558	26
M&E	Fluctuation in raw material prices	16	19	45	15	6	0.552	27
D	Incomplete design at time of tender	16	33	23	18	11	0.550	28
M&E	Insufficient number of equipment	9	23	54	14	1	0.550	29
C	Weak collaboration between management and labor	14	23	44	15	5	0.549	30
PM	Errors in contract documents	24	18	37	13	9	0.531	31
D	Deficient design and delays in design process	14	37	27	17	6	0.529	32
D	Design errors and mistakes	20	26	37	14	4	0.513	33
C	Disputes on site	25	16	44	10	6	0.513	34
L	Inflation in the cost of labors	15	44	20	17	5	0.507	35
F	Financial difficulties of owner	14	46	24	14	3	0.493	36
CPH	Effect of weather	28	46	14	10	3	0.430	37
CPH	Accidents on site	45	21	20	11	4	0.418	38
CPH	Unforeseen ground conditions	48	19	22	10	2	0.400	39

From Table 7, it is concluded that the top 5 ranked factors based on FI rankings are:

1- Schedule delay (CPH)

2- Improper planning and scheduling (CPH)

3- Lack and shortage of skilled labors (L)

4- Delay in inspection and approval of completed work (CPH)

5- Inaccurate time and cost estimates of project (PM)

4.3.3 Relative Cost Impact Index (CII) Ranking

Cost Impact of cost overrun attributes in construction projects are represented in Table 8, as per the responses from all the participants. Cost Impact Index (CII) equation was used to come up with the CII values.

Table 8 - CII values and ranking of attributes by all respondents

Category	Cost Importance Index	1	2	3	4	5	CII	Rank
D	Frequent Design changes	2	7	11	28	53	0.844	1
PM	Frequent changes to the scope of work	1	9	11	30	50	0.836	2
PM	Unrealistic contract duration and requirements imposed	1	7	19	23	51	0.830	3
CPH	Improper planning and scheduling	1	4	19	34	43	0.826	4
CPH	Schedule delay	3	4	12	41	41	0.824	5
PM	Inaccurate time and cost estimates of project	5	5	15	32	44	0.808	6
PM	Poor project management	4	8	17	26	46	0.802	7
D	Incomplete design at time of tender	7	8	14	26	46	0.790	8
PM	Errors in contract documents	6	6	23	28	38	0.770	9
CPH	Improper monitoring and control	2	10	17	45	27	0.768	10
D	Design errors and mistakes	8	6	14	39	34	0.768	11
F	Financial difficulties of owner	10	8	19	26	38	0.747	12
PM	Delays in decisions making	4	12	21	38	26	0.739	13
CPH	Lack of experience in handling construction projects	7	9	20	42	23	0.729	14
PM	Poor contract management	8	7	20	45	21	0.727	15
CPH	Insufficient site management and inspection	7	6	22	49	17	0.725	16
F	Poor financial control on site	10	5	20	44	22	0.725	17
M&E	Changes in material specs and types	4	11	25	42	19	0.721	18
D	Deficient design and delays in design process	5	13	22	39	22	0.719	19
M&E	Fluctuation in raw material prices	8	8	17	52	16	0.719	20
F	Cash flow difficulties faced by contractor	9	8	19	45	20	0.717	21
F	Delay in progress payment by owner for work completed	14	6	16	40	25	0.711	22
L	Low labor productivity	5	16	23	34	23	0.707	23
F	Delay payment to supplier /subcontractor	11	7	22	42	19	0.701	24
L	Inflation in the cost of labors	13	17	12	24	35	0.701	25

L	Lack and shortage of skilled labors	8	16	14	44	19	0.699	26
CPH	Errors during construction	2	15	41	20	23	0.693	27
C	Weak communication between project parties	6	15	19	53	8	0.683	28
M&E	Late delivery of materials and equipment	4	14	33	37	13	0.681	29
D	Delay in approval of drawings	8	12	37	26	18	0.667	30
CPH	Delay in inspection and approval of completed work	12	11	22	45	11	0.663	31
CPH	Accidents on site	18	16	15	20	32	0.663	32
C	Weak coordination between project parties	7	12	40	26	16	0.663	33
PM	Owner interference	12	13	34	24	18	0.646	34
M&E	Insufficient number of equipment	7	16	40	28	10	0.636	35
C	Weak collaboration between management and labor	15	14	40	22	10	0.596	36
C	Disputes on site	16	16	38	22	9	0.584	37
CPH	Unforeseen ground conditions	28	11	33	18	11	0.547	38
CPH	Effect of weather	35	30	18	14	4	0.446	39

From Table 8, it is concluded that the top 5 ranked factors based on CII rankings are:

1- Frequent Design changes (D)

2- Frequent changes to the scope of work (PM)

3- Unrealistic contract duration and requirements imposed (PM)

4- Improper planning and scheduling (CPH)

5- Schedule delay (CPH)

4.3.4 Frequency-Cost Adjusted Importance Index (FCAII)

The significant impact of the cost overrun attributes on construction total cost has been evaluated by combining the RII, FI and the CII (importance, frequency and cost impact), by means of the Frequency-Cost Adjusted Importance Index (FCAII) equation as shown below:

$$\mathbf{FCAII = RII \times FI \times CII}$$

Table 9 - FCAII values and ranking of cost overrun attributes by all respondents

Category	Factor	RI	FI	CII	FCAII	Rank
CPH	Schedule delay	0.820	0.693	0.824	0.47	1
CPH	Improper planning and scheduling	0.865	0.653	0.826	0.47	2
D	Frequent Design changes	0.871	0.606	0.844	0.45	3
PM	Frequent changes to the scope of work	0.844	0.608	0.836	0.43	4
PM	Inaccurate time and cost estimates of project	0.853	0.614	0.808	0.42	5
PM	Unrealistic contract duration and requirements imposed	0.869	0.586	0.830	0.42	6
PM	Poor project management	0.871	0.588	0.802	0.41	7
PM	Delays in decisions making	0.818	0.602	0.739	0.36	8
L	Lack and shortage of skilled labors	0.810	0.636	0.699	0.36	9
F	Delay in progress payment by owner for work completed	0.826	0.612	0.711	0.36	10
CPH	Improper monitoring and control	0.768	0.602	0.768	0.36	11
D	Incomplete design at time of tender	0.798	0.550	0.790	0.35	12
F	Cash flow difficulties faced by contractor	0.794	0.584	0.717	0.33	13
PM	Errors in contract documents	0.808	0.531	0.770	0.33	14
L	Low labor productivity	0.794	0.582	0.707	0.33	15
PM	Poor contract management	0.762	0.588	0.727	0.33	16
M&E	Fluctuation in raw material prices	0.816	0.552	0.719	0.32	17
F	Delay payment to supplier /subcontractor	0.762	0.606	0.701	0.32	18
CPH	Insufficient site management and inspection	0.747	0.598	0.725	0.32	19
M&E	Late delivery of materials and equipment	0.784	0.596	0.681	0.32	20
D	Design errors and mistakes	0.798	0.513	0.768	0.31	21
CPH	Lack of experience in handling construction projects	0.731	0.584	0.729	0.31	22

M&E	Changes in material specs and types	0.749	0.572	0.721	0.31	23
F	Poor financial control on site	0.752	0.558	0.725	0.30	24
F	Financial difficulties of owner	0.816	0.493	0.747	0.30	25
C	Weak communication between project parties	0.756	0.576	0.683	0.30	26
C	Weak coordination between project parties	0.770	0.578	0.663	0.30	27
D	Deficient design and delays in design process	0.762	0.529	0.719	0.29	28
D	Delay in approval of drawings	0.727	0.586	0.667	0.28	29
CPH	Delay in inspection and approval of completed work	0.669	0.632	0.663	0.28	30
CPH	Errors during construction	0.707	0.572	0.693	0.28	31
PM	Owner interference	0.721	0.566	0.646	0.26	32
L	Inflation in the cost of labors	0.739	0.507	0.701	0.26	33
M&E	Insufficient number of equipment	0.671	0.550	0.636	0.23	34
C	Weak collaboration between management and labor	0.677	0.549	0.596	0.22	35
CPH	Accidents on site	0.741	0.418	0.663	0.21	36
C	Disputes on site	0.628	0.513	0.584	0.19	37
CPH	Unforeseen ground conditions	0.578	0.400	0.547	0.13	38
CPH	Effect of weather	0.497	0.430	0.446	0.10	39

From Table 9 - based on the FCAII values, the top 5 ranked cost overrun attributes by all respondents are:

1- Schedule delay (CPH)

2- Improper planning and scheduling (CPH)

3- Frequent Design changes (D)

4- Frequent changes to the scope of work (PM)

5- Inaccurate time and cost estimates of project (PM)

4.4 Correlation Test: Agreement Analysis (Spearman rank correlation factor):

The Spearman's rank correlation factor (r) was used in this project to show the degree of agreement between the rankings of RII, FI and CI based on data collected from all respondents.

The Spearman's correlation assesses the 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).

Table 10 - Spearman's rank correlation factor for RI vs FI rankings for all respondents

Category	Factors	RI	RI Rank	FI	FI rank	d	d^2
C1	Disputes on site	0.628	37	0.513	34	3	9
C2	Weak collaboration between management and labor	0.677	34	0.549	30	4	16
C3	Weak communication between project parties	0.756	24	0.576	22	2	4
C4	Weak coordination between project parties	0.770	19	0.578	21	2	4
CPH1	Accidents on site	0.741	28	0.418	38	10	100
CPH2	Delay in inspection and approval of completed work	0.669	36	0.632	4	32	1024
CPH3	Effect of weather	0.497	39	0.430	37	2	4
CPH4	Errors during construction	0.707	33	0.572	23	10	100
CPH5	Improper monitoring and control	0.768	20	0.602	10	10	100
CPH6	Improper planning and scheduling	0.865	4	0.653	2	2	4
CPH7	Insufficient site management and inspection	0.747	27	0.598	12	15	225
CPH8	Lack of experience in handling construction projects	0.731	30	0.584	18	12	144
CPH9	Schedule delay	0.820	8	0.693	1	7	49
CPH10	Unforeseen ground conditions	0.578	38	0.400	39	1	1
D1	Deficient design and delays in design process	0.762	21	0.529	32	11	121
D2	Delay in approval of drawings	0.727	31	0.586	16	15	225
D3	Design errors and mistakes	0.798	14	0.513	33	19	361
D4	Frequent Design changes	0.871	1	0.606	8	7	49
D5	Incomplete design at time of tender	0.798	15	0.550	28	13	169
F1	Cash flow difficulties faced by contractor	0.794	16	0.584	19	3	9
F2	Delay in progress payment by owner for work completed	0.826	7	0.612	6	1	1
F3	Delay payment to supplier /subcontractor	0.762	22	0.606	9	13	169
F4	Financial difficulties of owner	0.816	10	0.493	36	26	676
F5	Poor financial control on site	0.752	25	0.558	26	1	1
L1	Inflation in the cost of labors	0.739	29	0.507	35	6	36
L2	Lack and shortage of skilled labors	0.810	12	0.636	3	9	81
L3	Low labor productivity	0.794	17	0.582	20	3	9
M&E1	Changes in material specs and types	0.749	26	0.572	24	2	4
M&E2	Fluctuation in raw material prices	0.816	11	0.552	27	16	256
M&E3	Insufficient number of equipment	0.671	35	0.550	29	6	36
M&E4	Late delivery of materials and equipment	0.784	18	0.596	13	5	25
PM1	Delays in decisions making	0.818	9	0.602	11	2	4
PM2	Errors in contract documents	0.808	13	0.531	31	18	324
PM3	Frequent changes to the scope of work	0.844	6	0.608	7	1	1
PM4	Inaccurate time and cost estimates of project	0.853	5	0.614	5	0	0
PM5	Owner interference	0.721	32	0.566	25	7	49

PM6	Poor contract management	0.762	23	0.588	15	8	64
PM7	Poor project management	0.871	2	0.588	14	12	144
PM8	Unrealistic contract duration and requirements imposed	0.869	3	0.586	17	14	196
						Sum	**4794**
						Spearman's Rank Correlation	**0.515**

Table 11 - Spearman's rank correlation factor for RI vs CI rankings for all respondents

Category	Factors	RI	RI Rank	CI	CI rank	d	d^2
C1	Disputes on site	0.628	37	0.584	37	0	0
C2	Weak collaboration between management and labor	0.677	34	0.596	36	2	4
C3	Weak communication between project parties	0.756	24	0.683	28	4	16
C4	Weak coordination between project parties	0.770	19	0.663	33	14	196
CPH1	Accidents on site	0.741	28	0.663	32	4	16
CPH2	Delay in inspection and approval of completed work	0.669	36	0.547	38	2	4
CPH3	Effect of weather	0.497	39	0.663	31	8	64
CPH4	Errors during construction	0.707	33	0.446	39	6	36
CPH5	Improper monitoring and control	0.768	20	0.693	27	7	49
CPH6	Improper planning and scheduling	0.865	4	0.768	10	6	36
CPH7	Insufficient site management and inspection	0.747	27	0.826	4	23	529
CPH8	Lack of experience in handling construction projects	0.731	30	0.725	16	14	196
CPH9	Schedule delay	0.820	8	0.729	14	6	36
CPH10	Unforeseen ground conditions	0.578	38	0.824	5	33	1089
D1	Deficient design and delays in design process	0.762	21	0.719	19	2	4
D2	Delay in approval of drawings	0.727	31	0.667	30	1	1
D3	Design errors and mistakes	0.798	14	0.768	11	3	9
D4	Frequent Design changes	0.871	1	0.844	1	0	0
D5	Incomplete design at time of tender	0.798	15	0.790	8	7	49
F1	Cash flow difficulties faced by contractor	0.794	16	0.717	21	5	25
F2	Delay in progress payment by owner for work completed	0.826	7	0.711	22	15	225
F3	Delay payment to supplier /subcontractor	0.762	22	0.701	24	2	4
F4	Financial difficulties of owner	0.816	10	0.747	12	2	4
F5	Poor financial control on site	0.752	25	0.725	17	8	64
L1	Inflation in the cost of labors	0.739	29	0.701	25	4	16
L2	Lack and shortage of skilled labors	0.810	12	0.699	26	14	196
L3	Low labor productivity	0.794	17	0.707	23	6	36
M&E1	Changes in material specs and types	0.749	26	0.721	18	8	64
M&E2	Fluctuation in raw material prices	0.816	11	0.719	20	9	81
M&E3	Insufficient number of equipment	0.671	35	0.636	35	0	0
M&E4	Late delivery of materials and equipment	0.784	18	0.681	29	11	121
PM1	Delays in decisions making	0.818	9	0.739	13	4	16
PM2	Errors in contract documents	0.808	13	0.770	9	4	16
PM3	Frequent changes to the scope of work	0.844	6	0.836	2	4	16
PM4	Inaccurate time and cost estimates of project	0.853	5	0.808	6	1	1

PM5	Owner interference	0.721	32	0.646	34	2	4
PM6	Poor contract management	0.762	23	0.727	15	8	64
PM7	Poor project management	0.871	2	0.802	7	5	25
PM8	Unrealistic contract duration and requirements imposed	0.869	3	0.830	3	0	0
						SUM	**3312**
						Spearman's Rank Correlation	**0.665**

Table 12 - Spearman's rank correlation factor for FI vs CI rankings for all respondents

Category	Factors	FI	FI rank	CI	CI rank	d	d^2
C1	Disputes on site	0.513	34	0.584	37	3	9
C2	Weak collaboration between management and labor	0.549	30	0.596	36	6	36
C3	Weak communication between project parties	0.576	22	0.683	28	6	36
C4	Weak coordination between project parties	0.578	21	0.663	33	12	144
CPH1	Accidents on site	0.418	38	0.663	32	6	36
CPH2	Delay in inspection and approval of completed work	0.632	4	0.547	38	34	1156
CPH3	Effect of weather	0.430	37	0.663	31	6	36
CPH4	Errors during construction	0.572	23	0.446	39	16	256
CPH5	Improper monitoring and control	0.602	10	0.693	27	17	289
CPH6	Improper planning and scheduling	0.653	2	0.768	10	8	64
CPH7	Insufficient site management and inspection	0.598	12	0.826	4	8	64
CPH8	Lack of experience in handling construction projects	0.584	18	0.725	16	2	4
CPH9	Schedule delay	0.693	1	0.729	14	13	169
CPH10	Unforeseen ground conditions	0.400	39	0.824	5	34	1156
D1	Deficient design and delays in design process	0.529	32	0.719	19	13	169
D2	Delay in approval of drawings	0.586	16	0.667	30	14	196
D3	Design errors and mistakes	0.513	33	0.768	11	22	484
D4	Frequent Design changes	0.606	8	0.844	1	7	49
D5	Incomplete design at time of tender	0.550	28	0.790	8	20	400
F1	Cash flow difficulties faced by contractor	0.584	19	0.717	21	2	4
F2	Delay in progress payment by owner for work completed	0.612	6	0.711	22	16	256
F3	Delay payment to supplier /subcontractor	0.606	9	0.701	24	15	225
F4	Financial difficulties of owner	0.493	36	0.747	12	24	576
F5	Poor financial control on site	0.558	26	0.725	17	9	81
L1	Inflation in the cost of labors	0.507	35	0.701	25	10	100
L2	Lack and shortage of skilled labors	0.636	3	0.699	26	23	529
L3	Low labor productivity	0.582	20	0.707	23	3	9
M&E1	Changes in material specs and types	0.572	24	0.721	18	6	36
M&E2	Fluctuation in raw material prices	0.552	27	0.719	20	7	49
M&E3	Insufficient number of equipment	0.550	29	0.636	35	6	36
M&E4	Late delivery of materials and equipment	0.596	13	0.681	29	16	256
PM1	Delays in decisions making	0.602	11	0.739	13	2	4
PM2	Errors in contract documents	0.531	31	0.770	9	22	484
PM3	Frequent changes to the scope of work	0.608	7	0.836	2	5	25
PM4	Inaccurate time and cost estimates of project	0.614	5	0.808	6	1	1

PM5	Owner interference	0.566	25	0.646	34	9	81
PM6	Poor contract management	0.588	15	0.727	15	0	0
PM7	Poor project management	0.588	14	0.802	7	7	49
PM8	Unrealistic contract duration and requirements imposed	0.586	17	0.830	3	14	196
						SUM	**7750**
						Spearman's Rank Correlation	**0.216**

Table 13 - RI vs FI vs CI rankings for all respondents

Category	Factors	RI	RI Rank	FI	FI rank	CI	CI rank
C1	Disputes on site	0.628	37	0.513	34	0.584	37
C2	Weak collaboration between management and labour	0.677	34	0.549	30	0.596	36
C3	Weak communication between project parties	0.756	24	0.576	22	0.683	28
C4	Weak coordination between project parties	0.770	19	0.578	21	0.663	33
CPH1	Accidents on site	0.741	28	0.418	38	0.663	32
CPH2	Delay in inspection and approval of completed work	0.669	36	0.632	4	0.547	38
CPH3	Effect of weather	0.497	39	0.430	37	0.663	31
CPH4	Errors during construction	0.707	33	0.572	23	0.446	39
CPH5	Improper monitoring and control	0.768	20	0.602	10	0.693	27
CPH6	Improper planning and scheduling	0.865	4	0.653	2	0.768	10
CPH7	Insufficient site management and inspection	0.747	27	0.598	12	0.826	4
CPH8	Lack of experience in handling construction projects	0.731	30	0.584	18	0.725	16
CPH9	Schedule delay	0.820	8	0.693	1	0.729	14
CPH10	Unforeseen ground conditions	0.578	38	0.400	39	0.824	5
D1	Deficient design and delays in design process	0.762	21	0.529	32	0.719	19
D2	Delay in approval of drawings	0.727	31	0.586	16	0.667	30
D3	Design errors and mistakes	0.798	14	0.513	33	0.768	11
D4	Frequent Design changes	0.871	1	0.606	8	0.844	1
D5	Incomplete design at time of tender	0.798	15	0.550	28	0.790	8
F1	Cash flow difficulties faced by contractor	0.794	16	0.584	19	0.717	21
F2	Delay in progress payment by owner for work completed	0.826	7	0.612	6	0.711	22
F3	Delay payment to supplier /subcontractor	0.762	22	0.606	9	0.701	24
F4	Financial difficulties of owner	0.816	10	0.493	36	0.747	12
F5	Poor financial control on site	0.752	25	0.558	26	0.725	17
L1	Inflation in the cost of labours	0.739	29	0.507	35	0.701	25
L2	Lack and shortage of skilled labours	0.810	12	0.636	3	0.699	26
L3	Low labour productivity	0.794	17	0.582	20	0.707	23
M&E1	Changes in material specs and types	0.749	26	0.572	24	0.721	18
M&E2	Fluctuation in raw material prices	0.816	11	0.552	27	0.719	20
M&E3	Insufficient number of equipment	0.671	35	0.550	29	0.636	35
M&E4	Late delivery of materials and equipment	0.784	18	0.596	13	0.681	29
PM1	Delays in decisions making	0.818	9	0.602	11	0.739	13
PM2	Errors in contract documents	0.808	13	0.531	31	0.770	9
PM3	Frequent changes to the scope of work	0.844	6	0.608	7	0.836	2
PM4	Inaccurate time and cost estimates of	0.853	5	0.614	5	0.808	6

	project						
PM5	Owner interference	0.721	32	0.566	25	0.646	34
PM6	Poor contract management	0.762	23	0.588	15	0.727	15
PM7	Poor project management	0.871	2	0.588	14	0.802	7
PM8	Unrealistic contract duration and requirements imposed	0.869	3	0.586	17	0.830	3

4.5 Ranking Comparison amongst Respondents

Ranking of the influential cost overrun attributes was also performed based on the views of experts from different backgrounds. Furthermore, the findings were compared in order to evaluate various perceptions of cost overrun within the construction field. As FCAII considers the frequency, the importance and the cost impact of the cost overrun factors on construction projects, it will be used as the main ranking tool for various groups of respondents in this section. The following comparisons will be conducted in this research:

Location:

- Qatar VS GCC

Organization type:

- Contractor VS consultant
- Contractor VS Subcontractor
- Contractor VS Owner
- Owner VS consultant

Job designation:

- Project / Construction manager VS Project Engineer

Industry type:

- Superstructure VS Infrastructure
- Superstructure VS all others

Size of company:

- Large (>250 employees) VS Medium (50 < employees < 250)

Years of experience in construction projects:

- Over 16 years VS ALL Less than 16

4.5.1 Location Comparison: Qatar VS the GCC:

The first Spearman's rank correlation factor comparison conducted between FCAII rankings of cost overrun attributes between respondents from Qatar and GCC. The computed value of **0.83** for Spearman's correlation factor from table 14 indicates a positive correlation and there is an agreement between the rankings from the two respondent groups.

Table 14 - Spearman's rank correlation factor between rankings for Qatar vs GCC

	Factor	Qatar Ranking	GCC Ranking	d	d^2
C1	Disputes on site	36	37	1	1
C2	Weak collaboration between management and labor	35	36	1	1
C3	Weak communication between project parties	25	25	0	0
C4	Weak coordination between project parties	24	33	9	81
CPH1	Insufficient site management and inspection	21	14	7	49
CPH10	Unforeseen ground conditions	38	38	0	0
CPH2	Schedule delay	1	2	1	1
CPH3	Improper planning and scheduling	2	1	1	1
CPH4	Improper monitoring and control	12	9	3	9
CPH5	Lack of experience in handling construction projects	23	13	10	100
CPH6	Delay in inspection and approval of completed work	32	21	11	121
CPH7	Errors during construction	30	30	0	0
CPH8	Accidents on site	37	29	8	64
CPH9	Effect of weather	39	39	0	0
D1	Frequent Design changes	3	4	1	1
D2	Design errors and mistakes	19	20	1	1
D3	Incomplete design at time of tender	11	11	0	0
D4	Deficient design and delays in design process	28	24	4	16

D5	Delay in approval of drawings	27	34	7	49
F1	Delay in progress payment by owner for work completed	10	19	9	81
F2	Financial difficulties of owner	29	17	12	144
F3	Cash flow difficulties faced by contractor	16	15	1	1
F4	Poor financial control on site	22	31	9	81
F5	Delay payment to supplier /subcontractor	14	26	12	144
L1	Inflation in the cost of labors	33	28	5	25
L2	Lack and shortage of skilled labors	8	18	10	100
L3	Low labor productivity	13	23	10	100
M&E1	Fluctuation in raw material prices	17	22	5	25
M&E2	Late delivery of materials and equipment	15	27	12	144
M&E3	Insufficient number of equipment	34	35	1	1
M&E4	Changes in material specs and types	26	16	10	100
PM1	Poor project management	7	5	2	4
PM2	Frequent changes to the scope of work	6	3	3	9
PM3	Delays in decisions making	9	12	3	9
PM4	Poor contract management	18	10	8	64
PM5	Errors in contract documents	20	8	12	144
PM6	Unrealistic contract duration and requirements imposed	5	6	1	1
PM7	Owner interference	31	32	1	1
PM8	Inaccurate time and cost estimates of project	4	7	3	9
				SUM	1682
				Spearman's Rank Correlation	**0.83**

4.5.2 Organization Type Comparison: Owner vs General Contractor (GC)

The computed value of 0.60 for Spearman's correlation factor from table 15 indicates that a positive agreement between the rankings from both respondents groups.

Table 15 - Spearman's rank correlation factor between rankings for Owner vs Contractor

Code	Factor	Owner FCAII	Rank	GC FCAII	Rank	d	d^2
C1	Disputes on site	0.131	38	0.167	37	1	1
C2	Weak collaboration between management and labor	0.193	31	0.219	32	1	1
C3	Weak communication between project parties	0.281	17	0.255	27	10	100
C4	Weak coordination between project parties	0.286	15	0.252	28	13	169
CPH1	Insufficient site management and inspection	0.234	26	0.360	7	19	361
CPH10	Unforeseen ground conditions	0.143	36	0.101	38	2	4
CPH2	Schedule delay	0.343	5	0.445	1	4	16
CPH3	Improper planning and scheduling	0.394	2	0.440	2	0	0
CPH4	Improper monitoring and control	0.253	21	0.359	8	13	169
CPH5	Lack of experience in handling construction projects	0.257	19	0.290	17	2	4
CPH6	Delay in inspection and approval of completed work	0.247	23	0.223	31	8	64
CPH7	Errors during construction	0.287	14	0.230	29	15	225
CPH8	Accidents on site	0.140	37	0.188	36	1	1
CPH9	Effect of weather	0.125	39	0.075	39	0	0
D1	Frequent Design changes	0.428	1	0.375	3	2	4
D2	Design errors and mistakes	0.305	9	0.270	24	15	225
D3	Incomplete design at time of tender	0.288	13	0.313	12	1	1
D4	Deficient design and delays in design process	0.252	22	0.268	25	3	9
D5	Delay in approval of drawings	0.166	33	0.258	26	7	49

F1	Delay in progress payment by owner for work completed	0.200	28	0.329	10	18	324
F2	Financial difficulties of owner	0.197	30	0.278	21	9	81
F3	Cash flow difficulties faced by contractor	0.240	25	0.291	16	9	81
F4	Poor financial control on site	0.155	35	0.289	19	16	256
F5	Delay payment to supplier /subcontractor	0.197	29	0.299	15	14	196
L1	Inflation in the cost of labors	0.155	34	0.227	30	4	16
L2	Lack and shortage of skilled labors	0.296	11	0.324	11	0	0
L3	Low labor productivity	0.301	10	0.305	13	3	9
M&E1	Fluctuation in raw material prices	0.171	32	0.303	14	18	324
M&E2	Late delivery of materials and equipment	0.286	16	0.271	23	7	49
M&E3	Insufficient number of equipment	0.215	27	0.199	34	7	49
M&E4	Changes in material specs and types	0.351	3	0.217	33	30	900
PM1	Poor project management	0.310	8	0.374	4	4	16
PM2	Frequent changes to the scope of work	0.317	7	0.364	5	2	4
PM3	Delays in decisions making	0.293	12	0.290	18	6	36
PM4	Poor contract management	0.246	24	0.271	22	2	4
PM5	Errors in contract documents	0.261	18	0.283	20	2	4
PM6	Unrealistic contract duration and requirements imposed	0.334	6	0.350	9	3	9
PM7	Owner interference	0.254	20	0.190	35	15	225
PM8	Inaccurate time and cost estimates of project	0.349	4	0.361	6	2	4
						SUM	3990
						Spearman's Rank Correlation	**0.60**

4.5.3 General Contractor vs Consultant

The computed value of 0.77 for Spearman's correlation factor from table 16 indicates that a positive agreement between the rankings from both respondents groups.

Table 16 - Spearman's rank correlation factor between rankings for Contactor vs Consultant

	Factor	GC FCAII	Rank	Cons FCAII	Rank	d	d^2
C1	Disputes on site	0.167	37	0.161	37	0	0
C2	Weak collaboration between management and labor	0.219	32	0.214	35	3	9
C3	Weak communication between project parties	0.255	27	0.327	20	7	49
C4	Weak coordination between project parties	0.252	28	0.363	15	13	169
CPH1	Insufficient site management and inspection	0.360	7	0.309	24	17	289
CPH10	Unforeseen ground conditions	0.101	38	0.155	38	0	0
CPH2	Schedule delay	0.445	1	0.544	3	2	4
CPH3	Improper planning and scheduling	0.440	2	0.493	6	4	16
CPH4	Improper monitoring and control	0.359	8	0.381	13	5	25
CPH5	Lack of experience in handling construction projects	0.290	17	0.279	28	11	121
CPH6	Delay in inspection and approval of completed work	0.223	31	0.256	31	0	0
CPH7	Errors during construction	0.230	29	0.275	29	0	0
CPH8	Accidents on site	0.188	36	0.183	36	0	0
CPH9	Effect of weather	0.075	39	0.075	39	0	0
D1	Frequent Design changes	0.375	3	0.538	4	1	1
D2	Design errors and mistakes	0.270	24	0.332	19	5	25
D3	Incomplete design at time of tender	0.313	12	0.477	8	4	16
D4	Deficient design and delays in design process	0.268	25	0.316	22	3	9
D5	Delay in approval of drawings	0.258	26	0.302	25	1	1
F1	Delay in progress payment by owner for work completed	0.329	10	0.467	9	1	1

F2	Financial difficulties of owner	0.278	21	0.406	11	10	100
F3	Cash flow difficulties faced by contractor	0.291	16	0.349	17	1	1
F4	Poor financial control on site	0.289	19	0.229	34	15	225
F5	Delay payment to supplier /subcontractor	0.299	15	0.299	27	12	144
L1	Inflation in the cost of labors	0.227	30	0.271	30	0	0
L2	Lack and shortage of skilled labors	0.324	11	0.339	18	7	49
L3	Low labor productivity	0.305	13	0.245	32	19	361
M&E1	Fluctuation in raw material prices	0.303	14	0.396	12	2	4
M&E2	Late delivery of materials and equipment	0.271	23	0.302	26	3	9
M&E3	Insufficient number of equipment	0.199	34	0.244	33	1	1
M&E4	Changes in material specs and types	0.217	33	0.311	23	10	100
PM1	Poor project management	0.374	4	0.482	7	3	9
PM2	Frequent changes to the scope of work	0.364	5	0.518	5	0	0
PM3	Delays in decisions making	0.290	18	0.425	10	8	64
PM4	Poor contract management	0.271	22	0.372	14	8	64
PM5	Errors in contract documents	0.283	20	0.318	21	1	1
PM6	Unrealistic contract duration and requirements imposed	0.350	9	0.597	1	8	64
PM7	Owner interference	0.190	35	0.349	16	19	361
PM8	Inaccurate time and cost estimates of project	0.361	6	0.553	2	4	16
						SUM	2308
						Spearman's Correlation	**0.77**

4.5.4 General Contractor vs Subcontractor

The computed value of 0.79 for Spearman's correlation factor from table 17 indicates that a positive agreement between the rankings from both respondents groups.

Table 17 - Spearman's rank correlation factor between rankings for Subcontractor vs Contractor

	Factor	Subcontractor FCAII	Rank	GC FCAII	Rank	d	d^2
C1	Disputes on site	0.295	34	0.167	37	3	9
C2	Weak collaboration between management and labor	0.266	36	0.219	32	4	16
C3	Weak communication between project parties	0.365	28	0.255	27	1	1
C4	Weak coordination between project parties	0.358	30	0.252	28	2	4
CPH1	Insufficient site management and inspection	0.368	27	0.360	7	20	400
CPH10	Unforeseen ground conditions	0.144	38	0.101	38	0	0
CPH2	Schedule delay	0.572	3	0.445	1	2	4
CPH3	Improper planning and scheduling	0.622	1	0.440	2	1	1
CPH4	Improper monitoring and control	0.455	17	0.359	8	9	81
CPH5	Lack of experience in handling construction projects	0.355	31	0.290	17	14	196
CPH6	Delay in inspection and approval of completed work	0.443	18	0.223	31	13	169
CPH7	Errors during construction	0.390	25	0.230	29	4	16
CPH8	Accidents on site	0.345	33	0.188	36	3	9
CPH9	Effect of weather	0.141	39	0.075	39	0	0
D1	Frequent Design changes	0.596	2	0.375	3	1	1
D2	Design errors and mistakes	0.423	20	0.270	24	4	16
D3	Incomplete design at time of tender	0.415	23	0.313	12	11	121
D4	Deficient design and delays in design process	0.362	29	0.268	25	4	16
D5	Delay in approval of drawings	0.391	24	0.258	26	2	4
F1	Delay in progress payment by owner for work completed	0.528	7	0.329	10	3	9
F2	Financial difficulties of owner	0.420	22	0.278	21	1	1
F3	Cash flow difficulties faced by contractor	0.464	14	0.291	16	2	4
F4	Poor financial control on site	0.457	16	0.289	19	3	9
F5	Delay payment to supplier /subcontractor	0.493	9	0.299	15	6	36
L1	Inflation in the cost of labors	0.347	32	0.227	30	2	4
L2	Lack and shortage of skilled labors	0.489	11	0.324	11	0	0
L3	Low labor productivity	0.469	13	0.305	13	0	0
M&E1	Fluctuation in raw material prices	0.420	21	0.303	14	7	49
M&E2	Late delivery of materials and equipment	0.530	6	0.271	23	17	289
M&E3	Insufficient number of equipment	0.287	35	0.199	34	1	1
M&E4	Changes in material specs and types	0.462	15	0.217	33	18	324

PM1	Poor project management	0.484	12	0.374	4	8	64
PM2	Frequent changes to the scope of work	0.567	4	0.364	5	1	1
PM3	Delays in decisions making	0.501	8	0.290	18	10	100
PM4	Poor contract management	0.425	19	0.271	22	3	9
PM5	Errors in contract documents	0.387	26	0.283	20	6	36
PM6	Unrealistic contract duration and requirements imposed	0.538	5	0.350	9	4	16
PM7	Owner interference	0.249	37	0.190	35	2	4
PM8	Inaccurate time and cost estimates of project	0.491	10	0.361	6	4	16
						SUM	**2036**
						S.C.F	**0.79**

4.5.5 Owner VS Consultant

The computed value of 0.68 for Spearman's correlation factor from table 18 indicates that a positive agreement between the rankings from both respondents groups.

Table 18 - Spearman's rank correlation factor between rankings for Consultant vs Owner

	Factor	Cons FCAII	Rank	Owner FCAII	Rank	d	d^2
C1	Disputes on site	0.161	37	0.131	38	1	1
C2	Weak collaboration between management and labor	0.214	35	0.193	31	4	16
C3	Weak communication between project parties	0.327	20	0.281	17	3	9
C4	Weak coordination between project parties	0.363	15	0.286	15	0	0
CPH1	Insufficient site management and inspection	0.309	24	0.234	26	2	4
CPH10	Unforeseen ground conditions	0.155	38	0.143	36	2	4
CPH2	Schedule delay	0.544	3	0.343	5	2	4
CPH3	Improper planning and scheduling	0.493	6	0.394	2	4	16
CPH4	Improper monitoring and control	0.381	13	0.253	21	8	64
CPH5	Lack of experience in handling construction projects	0.279	28	0.257	19	9	81
CPH6	Delay in inspection and approval of completed work	0.256	31	0.247	23	8	64
CPH7	Errors during construction	0.275	29	0.287	14	15	225
CPH8	Accidents on site	0.183	36	0.140	37	1	1
CPH9	Effect of weather	0.075	39	0.125	39	0	0
D1	Frequent Design changes	0.538	4	0.428	1	3	9
D2	Design errors and mistakes	0.332	19	0.305	9	10	100
D3	Incomplete design at time of tender	0.477	8	0.288	13	5	25
D4	Deficient design and delays in design process	0.316	22	0.252	22	0	0
D5	Delay in approval of drawings	0.302	25	0.166	33	8	64

F1	Delay in progress payment by owner for work completed	0.467	9	0.200	28	19	361
F2	Financial difficulties of owner	0.406	11	0.197	30	19	361
F3	Cash flow difficulties faced by contractor	0.349	17	0.240	25	8	64
F4	Poor financial control on site	0.229	34	0.155	35	1	1
F5	Delay payment to supplier /subcontractor	0.299	27	0.197	29	2	4
L1	Inflation in the cost of labors	0.271	30	0.155	34	4	16
L2	Lack and shortage of skilled labors	0.339	18	0.296	11	7	49
L3	Low labor productivity	0.245	32	0.301	10	22	484
M&E1	Fluctuation in raw material prices	0.396	12	0.171	32	20	400
M&E2	Late delivery of materials and equipment	0.302	26	0.286	16	10	100
M&E3	Insufficient number of equipment	0.244	33	0.215	27	6	36
M&E4	Changes in material specs and types	0.311	23	0.351	3	20	400
PM1	Poor project management	0.482	7	0.310	8	1	1
PM2	Frequent changes to the scope of work	0.518	5	0.317	7	2	4
PM3	Delays in decisions making	0.425	10	0.293	12	2	4
PM4	Poor contract management	0.372	14	0.246	24	10	100
PM5	Errors in contract documents	0.318	21	0.261	18	3	9
PM6	Unrealistic contract duration and requirements imposed	0.597	1	0.334	6	5	25
PM7	Owner interference	0.349	16	0.254	20	4	16
PM8	Inaccurate time and cost estimates of project	0.553	2	0.349	4	2	4
						SUM	**3126**
						S.C.F	**0.68**

4.5.6 Ranking of FCAII Among All Organization Types Using Mean Score Method

Chan and Kumaraswamy in 1996 proposed the following equation to calculate the mean score (MS) for each cause of Cost Overrun in civil engineering projects in Hong Kong:

$$MS_i = \frac{\sum fi * S}{N}$$

Where,

S = Score given to each cause of Cost overrun by the respondents.

f =frequency of responses to each score for each cause of Cost overrun.

N =total number of responses in the respective groups for the respective cause of Cost overrun.

i =respective cause of Cost overrun.

To suit the case of this study, this formula was adopted to calculate the importance, the frequency and the cost impact of the causes of cost overrun all together, and then used to rank the factors based on the overall FCAII ranking.

Table 19 -Ranking of FCAII among All Organization Types Using Mean Score Method

Factor	Code	FCAII score for Owner group	Ranking for client group	FCAII Score for GC group	Ranking for GC group	FCAII Score for Consultant group	Ranking for Consultant group	Overall FCAII score	Overall Ranking
Improper planning and scheduling	CPH3	0.394	2	0.440	2	0.493	6	0.487	1
Frequent Design changes	D1	0.428	1	0.375	3	0.538	4	0.484	2
Schedule delay	CPH2	0.343	5	0.445	1	0.544	3	0.476	3
Unrealistic contract duration and requirements imposed	PM6	0.334	6	0.350	9	0.597	1	0.455	4
Frequent changes to the scope of work	PM2	0.317	7	0.364	5	0.518	5	0.441	5
Inaccurate time and cost estimates of project	PM8	0.349	4	0.361	6	0.553	2	0.439	6
Poor project management	PM1	0.310	8	0.374	4	0.482	7	0.413	7
Delay in progress payment by owner for work completed	F1	0.200	28	0.329	10	0.467	9	0.381	8
Delays in decisions making	PM3	0.293	12	0.290	18	0.425	10	0.377	9
Incomplete design at time of tender	D3	0.288	13	0.313	12	0.477	8	0.373	10
Improper monitoring and control	CPH4	0.253	21	0.359	8	0.381	13	0.362	11
Lack and shortage of skilled labors	L2	0.296	11	0.324	11	0.339	18	0.362	12
Late delivery of materials and equipment	M&E2	0.286	16	0.271	23	0.302	26	0.347	13
Cash flow difficulties faced by contractor	F3	0.240	25	0.291	16	0.349	17	0.336	14
Changes in material specs and types	M&E4	0.351	3	0.217	33	0.311	23	0.335	15

Design errors and mistakes	D2	0.305	9	0.270	24	0.332	19	0.332	16
Low labor productivity	L3	0.301	10	0.305	13	0.245	32	0.330	17
Poor contract management	PM4	0.246	24	0.271	22	0.372	14	0.328	18
Financial difficulties of owner	F2	0.197	30	0.278	21	0.406	11	0.325	19
Fluctuation in raw material prices	M&E1	0.171	32	0.303	14	0.396	12	0.323	20
Delay payment to supplier /subcontractor	F5	0.197	29	0.299	15	0.299	27	0.322	21
Insufficient site management and inspection	CPH1	0.234	26	0.360	7	0.309	24	0.318	22
Weak coordination between project parties	C4	0.286	15	0.252	28	0.363	15	0.315	23
Errors in contract documents	PM5	0.261	18	0.283	20	0.318	21	0.312	24
Weak communication between project parties	C3	0.281	17	0.255	27	0.327	20	0.307	25
Deficient design and delays in design process	D4	0.252	22	0.268	25	0.316	22	0.299	26
Lack of experience in handling construction projects	CPH5	0.257	19	0.290	17	0.279	28	0.295	27
Errors during construction	CPH7	0.287	14	0.230	29	0.275	29	0.295	28
Delay in inspection and approval of completed work	CPH6	0.247	23	0.223	31	0.256	31	0.292	29
Poor financial control on site	F4	0.155	35	0.289	19	0.229	34	0.283	30
Delay in approval	D5	0.166	33	0.258	26	0.302	25	0.279	31

of drawings									
Owner interference	PM7	0.254	20	0.190	35	0.349	16	0.261	32
Inflation in the cost of labors	L1	0.155	34	0.227	30	0.271	30	0.250	33
Insufficient number of equipment	M&E3	0.215	27	0.199	34	0.244	33	0.236	34
Weak collaboration between management and labor	C2	0.193	31	0.219	32	0.214	35	0.223	35
Accidents on site	CPH8	0.140	37	0.188	36	0.183	36	0.214	36
Disputes on site	C1	0.131	38	0.167	37	0.161	37	0.188	37
Unforeseen ground conditions	CPH10	0.143	36	0.101	38	0.155	38	0.136	38
Effect of weather	CPH9	0.125	39	0.075	39	0.075	39	0.104	39

4.5.7 Job designation

Project / Construction manager VS Project Engineer

The computed value of 0.61 for Spearman's correlation factor from table 20 indicates that a positive agreement between the rankings from both respondent groups.

Table 20 - Spearman's rank correlation factor between rankings for Project/Construction managers vs Project Engineers

	Factor	CM FCAII	Rank	PE FCAII	Rank	d	d^2
C1	Disputes on site	0.186	36	0.139	37	1	1
C2	Weak collaboration between management and labor	0.205	35	0.189	35	0	0
C3	Weak communication between project parties	0.276	26	0.249	22	4	16
C4	Weak coordination between project parties	0.328	16	0.193	34	18	324
CPH1	Insufficient site management and inspection	0.299	21	0.309	9	12	144
CPH10	Unforeseen ground conditions	0.153	38	0.091	38	0	0
CPH2	Schedule delay	0.555	1	0.308	10	9	81
CPH3	Improper planning and scheduling	0.428	5	0.425	1	4	16
CPH4	Improper monitoring and control	0.282	24	0.371	2	22	484
CPH5	Lack of experience in handling construction projects	0.272	27	0.315	8	19	361
CPH6	Delay in inspection and approval of completed work	0.209	34	0.245	24	10	100
CPH7	Errors during construction	0.263	30	0.257	19	11	121
CPH8	Accidents on site	0.159	37	0.235	27	10	100
CPH9	Effect of weather	0.083	39	0.078	39	0	0
D1	Frequent Design changes	0.460	2	0.320	6	4	16
D2	Design errors and mistakes	0.302	20	0.266	17	3	9
D3	Incomplete design at time of tender	0.334	14	0.279	15	1	1
D4	Deficient design and delays in design process	0.266	29	0.219	32	3	9
D5	Delay in approval of drawings	0.259	31	0.232	29	2	4
F1	Delay in progress payment by owner for work completed	0.316	17	0.283	14	3	9
F2	Financial difficulties of owner	0.307	18	0.249	23	5	25
F3	Cash flow difficulties faced by contractor	0.334	13	0.264	18	5	25
F4	Poor financial control on site	0.333	15	0.272	16	1	1
F5	Delay payment to supplier /subcontractor	0.283	23	0.296	12	11	121
L1	Inflation in the cost of labors	0.257	32	0.220	31	1	1

L2	Lack and shortage of skilled labors	0.415	9	0.233	28	19	361
L3	Low labor productivity	0.403	10	0.230	30	20	400
M&E1	Fluctuation in raw material prices	0.268	28	0.316	7	21	441
M&E2	Late delivery of materials and equipment	0.307	19	0.254	20	1	1
M&E3	Insufficient number of equipment	0.211	33	0.201	33	0	0
M&E4	Changes in material specs and types	0.296	22	0.241	25	3	9
PM1	Poor project management	0.424	8	0.340	4	4	16
PM2	Frequent changes to the scope of work	0.452	3	0.369	3	0	0
PM3	Delays in decisions making	0.424	7	0.236	26	19	361
PM4	Poor contract management	0.360	11	0.253	21	10	100
PM5	Errors in contract documents	0.337	12	0.287	13	1	1
PM6	Unrealistic contract duration and requirements imposed	0.436	4	0.298	11	7	49
PM7	Owner interference	0.278	25	0.180	36	11	121
PM8	Inaccurate time and cost estimates of project	0.425	6	0.339	5	1	1
						SUM	3830
						S.C.F	**0.61**

4.5.8 Years of Experience

More than 16 years of experience VS Less than 16 years of experience

The computed value of 0.74 for Spearman's correlation factor from table 21 indicates that a positive agreement between the rankings from both respondents groups.

Table 21 - Spearman's rank correlation factor between rankings for experts with more than 16 years of experience vs experts with less than 16 years of experience in construction

	Factor	More than 16 FCAII	Rank	Less than 16 FCAII	Rank	d	d^2
C1	Disputes on site	0.154	37	0.206	37	0	0
C2	Weak collaboration between management and labor	0.163	35	0.254	35	0	0
C3	Weak communication between project parties	0.302	22	0.298	26	4	16
C4	Weak coordination between project parties	0.323	18	0.284	28	10	100
CPH1	Insufficient site management and inspection	0.273	31	0.352	11	20	400
CPH10	Unforeseen ground conditions	0.154	36	0.112	38	2	4
CPH2	Schedule delay	0.581	1	0.421	4	3	9
CPH3	Improper planning and scheduling	0.485	4	0.459	1	3	9
CPH4	Improper monitoring and control	0.330	16	0.368	9	7	49
CPH5	Lack of experience in handling construction projects	0.292	25	0.316	19	6	36
CPH6	Delay in inspection and approval of completed work	0.274	29	0.280	30	1	1
CPH7	Errors during construction	0.252	32	0.292	27	5	25
CPH8	Accidents on site	0.114	39	0.260	34	5	25
CPH9	Effect of weather	0.119	38	0.083	39	1	1
D1	Frequent Design changes	0.537	2	0.405	6	4	16
D2	Design errors and mistakes	0.295	24	0.323	17	7	49
D3	Incomplete design at time of tender	0.360	11	0.339	14	3	9
D4	Deficient design and delays in design process	0.312	20	0.277	31	11	121
D5	Delay in approval of drawings	0.323	17	0.265	32	15	225
F1	Delay in progress payment by owner for work completed	0.339	15	0.368	8	7	49
F2	Financial difficulties of owner	0.291	27	0.305	24	3	9
F3	Cash flow difficulties faced by contractor	0.378	8	0.310	22	14	196
F4	Poor financial control on site	0.278	28	0.320	18	10	100

F5	Delay payment to supplier /subcontractor	0.345	14	0.314	20	6	36
L1	Inflation in the cost of labors	0.221	33	0.282	29	4	16
L2	Lack and shortage of skilled labors	0.351	13	0.365	10	3	9
L3	Low labor productivity	0.377	9	0.306	23	14	196
M&E1	Fluctuation in raw material prices	0.274	30	0.347	12	18	324
M&E2	Late delivery of materials and equipment	0.304	21	0.327	16	5	25
M&E3	Insufficient number of equipment	0.182	34	0.261	33	1	1
M&E4	Changes in material specs and types	0.320	19	0.304	25	6	36
PM1	Poor project management	0.369	10	0.436	2	8	64
PM2	Frequent changes to the scope of work	0.449	6	0.422	3	3	9
PM3	Delays in decisions making	0.429	7	0.337	15	8	64
PM4	Poor contract management	0.358	12	0.311	21	9	81
PM5	Errors in contract documents	0.298	23	0.346	13	10	100
PM6	Unrealistic contract duration and requirements imposed	0.529	3	0.378	7	4	16
PM7	Owner interference	0.292	26	0.251	36	10	100
PM8	Inaccurate time and cost estimates of project	0.458	5	0.409	5	0	0
						SUM	2526
						S.C.F	**0.74**

4.5.9 Size of Company

Large Companies (More than 250 employees) VS Medium Size Companies (50 to 250 employees)

The computed value of 0.71 for Spearman's correlation factor from table 22 indicates that a positive agreement between the rankings from both respondents groups.

Table 22 - Spearman's rank correlation factor between rankings for large companies vs medium companies

	Factor	Large Companies FCAII	Rank	Small Companies FCAII	Rank	d	d^2
C1	Disputes on site	0.286	17	0.376	19	2	4
C2	Weak collaboration between management and labor	0.459	1	0.461	5	4	16
C3	Weak communication between project parties	0.434	2	0.481	3	1	1
C4	Weak coordination between project parties	0.309	11	0.436	9	2	4
CPH1	Insufficient site management and inspection	0.254	27	0.367	22	5	25
CPH10	Unforeseen ground conditions	0.214	32	0.371	21	11	121
CPH2	Schedule delay	0.235	30	0.330	26	4	16
CPH3	Improper planning and scheduling	0.139	37	0.330	27	10	100
CPH4	Improper monitoring and control	0.074	39	0.120	39	0	0
CPH5	Lack of experience in handling construction projects	0.112	38	0.123	38	0	0
CPH6	Delay in inspection and approval of completed work	0.425	3	0.466	4	1	1
CPH7	Errors during construction	0.293	13	0.320	29	16	256
CPH8	Accidents on site	0.314	10	0.372	20	10	100
CPH9	Effect of weather	0.270	22	0.287	33	11	121
D1	Frequent Design changes	0.263	25	0.294	31	6	36
D2	Design errors and mistakes	0.287	15	0.489	2	13	169
D3	Incomplete design at time of tender	0.230	31	0.413	16	15	225
D4	Deficient design and delays in design process	0.265	24	0.419	13	11	121
D5	Delay in approval of drawings	0.244	29	0.389	18	11	121
F1	Delay in progress payment by owner for work completed	0.270	21	0.412	17	4	16
F2	Financial difficulties of owner	0.272	19	0.309	30	11	121
F3	Cash flow difficulties faced by contractor	0.286	16	0.287	32	16	256
F4	Poor financial control on site	0.202	33	0.229	36	3	9
F5	Delay payment to supplier	0.166	36	0.204	37	1	1

	/subcontractor						
L1	Inflation in the cost of labors	0.317	8	0.327	28	20	400
L2	Lack and shortage of skilled labors	0.299	12	0.427	12	0	0
L3	Low labor productivity	0.184	35	0.357	24	11	121
M&E1	Fluctuation in raw material prices	0.259	26	0.416	14	12	144
M&E2	Late delivery of materials and equipment	0.290	14	0.343	25	11	121
M&E3	Insufficient number of equipment	0.190	34	0.282	34	0	0
M&E4	Changes in material specs and types	0.266	23	0.366	23	0	0
PM1	Poor project management	0.372	7	0.455	6	1	1
PM2	Frequent changes to the scope of work	0.379	6	0.506	1	5	25
PM3	Delays in decisions making	0.315	9	0.428	11	2	4
PM4	Poor contract management	0.279	18	0.414	15	3	9
PM5	Errors in contract documents	0.270	20	0.435	10	10	100
PM6	Unrealistic contract duration and requirements imposed	0.419	4	0.448	7	3	9
PM7	Owner interference	0.250	28	0.263	35	7	49
PM8	Inaccurate time and cost estimates of project	0.406	5	0.439	8	3	9
						SUM	2832
						S.C.F	**0.71**

4.5.10 Industry Type

Superstructure VS Infrastructure

The computed value of 0.62 for Spearman's correlation factor from table 23 indicates that a positive agreement between the rankings from both respondents groups.

Table 23 - Spearman's rank correlation factor between rankings for Superstructure vs Infrastructure

	Factor	Superstructure FCAII	Rank	Infrastructure FCAII	Rank	d	d^2
C1	Disputes on site	0.322	23	0.324	11	12	144
C2	Weak collaboration between management and labor	0.426	8	0.520	1	7	49
C3	Weak communication between project parties	0.459	5	0.473	2	3	9
C4	Weak coordination between project parties	0.366	14	0.335	9	5	25
CPH1	Insufficient site management and inspection	0.321	24	0.267	20	4	16
CPH10	Unforeseen ground conditions	0.271	32	0.267	21	11	121
CPH2	Schedule delay	0.293	30	0.243	27	3	9
CPH3	Improper planning and scheduling	0.201	36	0.176	36	0	0
CPH4	Improper monitoring and control	0.090	39	0.089	39	0	0
CPH5	Lack of experience in handling construction projects	0.103	38	0.160	37	1	1
CPH6	Delay in inspection and approval of completed work	0.499	1	0.379	5	4	16
CPH7	Errors during construction	0.338	17	0.235	30	13	169
CPH8	Accidents on site	0.338	18	0.309	15	3	9
CPH9	Effect of weather	0.294	29	0.249	24	5	25
D1	Frequent Design changes	0.306	27	0.248	25	2	4
D2	Design errors and mistakes	0.431	7	0.286	16	9	81
D3	Incomplete design at time of tender	0.330	22	0.261	22	0	0
D4	Deficient design and delays in design proces	0.417	9	0.243	26	17	289
D5	Delay in approval of drawings	0.331	21	0.256	23	2	4
F1	Delay in progress payment by owner for work completed	0.399	11	0.229	32	21	441
F2	Financial difficulties of owner	0.306	28	0.277	18	10	100
F3	Cash flow difficulties faced by contractor	0.334	19	0.239	28	9	81

F4	Poor financial control on site	0.230	33	0.198	34	1	1
F5	Delay payment to supplier /subcontractor	0.204	35	0.157	38	3	9
L1	Inflation in the cost of labors	0.352	15	0.333	10	5	25
L2	Lack and shortage of skilled labors	0.317	25	0.407	3	22	484
L3	Low labor productivity	0.201	37	0.318	13	24	576
M&E1	Fluctuation in raw material prices	0.308	26	0.319	12	14	196
M&E2	Late delivery of materials and equipment	0.332	20	0.285	17	3	9
M&E3	Insufficient number of equipment	0.227	34	0.210	33	1	1
M&E4	Changes in material specs and types	0.391	13	0.189	35	22	484
PM1	Poor project management	0.437	6	0.381	4	2	4
PM2	Frequent changes to the scope of work	0.474	3	0.349	7	4	16
PM3	Delays in decisions making	0.406	10	0.315	14	4	16
PM4	Poor contract management	0.347	16	0.277	19	3	9
PM5	Errors in contract documents	0.391	12	0.235	29	17	289
PM6	Unrealistic contract duration and requirements imposed	0.466	4	0.355	6	2	4
PM7	Owner interference	0.276	31	0.231	31	0	0
PM8	Inaccurate time and cost estimates of projct	0.494	2	0.347	8	6	36
						SUM	**3752**
						S.C.F	**0.62**

Superstructure VS All Other Industry Types

The computed value of 0.79 for Spearman's correlation factor from table 24 indicates that a positive agreement between the rankings from both respondents groups.

Table 24 - Spearman's rank correlation factor between rankings for Superstructure vs all other industry types

	Factor	Superstructure FCAII	Rank	All other industry types FCAII	Rank	d	d^2
C1	Disputes on site	0.322	23	0.346	16	7	49
C2	Weak collaboration between management and labor	0.426	8	0.455	4	4	16
C3	Weak communication between project parties	0.459	5	0.465	3	2	4
C4	Weak coordination between project parties	0.366	14	0.355	13	1	1
CPH1	Insufficient site management and inspection	0.321	24	0.319	19	5	25
CPH10	Unforeseen ground conditions	0.271	32	0.314	21	11	121
CPH2	Schedule delay	0.293	30	0.299	26	4	16
CPH3	Improper planning and scheduling	0.201	36	0.281	29	7	49
CPH4	Improper monitoring and control	0.090	39	0.089	38	1	1
CPH5	Lack of experience in handling construction projects	0.103	38	0.087	39	1	1
CPH6	Delay in inspection and approval of completed work	0.499	1	0.419	6	5	25
CPH7	Errors during construction	0.338	17	0.358	12	5	25
CPH8	Accidents on site	0.338	18	0.376	11	7	49
CPH9	Effect of weather	0.294	29	0.311	22	7	49
D1	Frequent Design changes	0.306	27	0.300	25	2	4
D2	Design errors and mistakes	0.431	7	0.333	18	11	121
D3	Incomplete design at time of tender	0.330	22	0.271	33	11	121
D4	Deficient design and delays in design process	0.417	9	0.282	28	19	361
D5	Delay in approval of drawings	0.331	21	0.278	30	9	81
F1	Delay in progress payment by owner for work completed	0.399	11	0.309	23	12	144

F2	Financial difficulties of owner	0.306	28	0.314	20	8	64
F3	Cash flow difficulties faced by contractor	0.334	19	0.276	31	12	144
F4	Poor financial control on site	0.230	33	0.269	34	1	1
F5	Delay payment to supplier /subcontractor	0.204	35	0.220	37	2	4
L1	Inflation in the cost of labors	0.352	15	0.288	27	12	144
L2	Lack and shortage of skilled labors	0.317	25	0.378	10	15	225
L3	Low labor productivity	0.201	37	0.242	35	2	4
M&E1	Fluctuation in raw material prices	0.308	26	0.303	24	2	4
M&E2	Late delivery of materials and equipment	0.332	20	0.348	15	5	25
M&E3	Insufficient number of equipment	0.227	34	0.273	32	2	4
M&E4	Changes in material specs and types	0.391	13	0.394	9	4	16
PM1	Poor project management	0.437	6	0.435	5	1	1
PM2	Frequent changes to the scope of work	0.474	3	0.488	2	1	1
PM3	Delays in decisions making	0.406	10	0.354	14	4	16
PM4	Poor contract management	0.347	16	0.402	8	8	64
PM5	Errors in contract documents	0.391	12	0.334	17	5	25
PM6	Unrealistic contract duration and requirements imposed	0.466	4	0.489	1	3	9
PM7	Owner interference	0.276	31	0.233	36	5	25
PM8	Inaccurate time and cost estimates of project	0.494	2	0.408	7	5	25
						SUM	2064
						S.C.F	**0.79**

4.6 T Test:

T-test is a tool which is used to statistically identify if there is any significant difference between two independent categories groups. In this research, T-test is used to identify which cost overrun attributes has significant level of disagreement among the independent set of groups. Probability (p) value less than 0.1 shows a significant disagreement. Table 25 show the results of the T-test which represent significant disagreement among various groups based on location, job designation, organization type, industry type, total construction experience, and size of the company.

Table 25 - T-Test Results

Code	Attributes	T-Test (p)
	Qatar VS GCC	
CPH8	Accidents on site	0.0252
CPH9	Effect of weather	0.0633
	Project Managers VS Project Engineers	
CPH2	Schedule delay	0.0338
CPH4	Improper monitoring and control	0.0061
CPH6	Delay in inspection and approval of completed work	0.0257
CPH8	Accidents on site	0.0627
C2	Weak coordination between project parties	0.0179
L1	Low labor productivity	0.0879
L2	Lack and shortage of skilled labors	0.0514
PM3	Delays in decisions making	0.0651
	Superstructure VS Infrastructure	
CPH2	Schedule delay	0.0454
CPH10	Unforeseen ground conditions	0.0841
F5	Delay payment to supplier /subcontractor	0.0122
L2	Lack and shortage of skilled labors	0.0825
L3	Inflation in the cost of labors	0.0672
M&E4	Changes in material specs and types	0.0058
PM5	Errors in contract documents	0.0180
	More than 16 years experience VS less than 16 years experience	
CPH1	Insufficient site management and inspection	0.0735
CPH2	Schedule delay	0.0001

CPH4	Improper monitoring and control	0.0804
CPH8	Accidents on site	0.0024
D5	Delay in approval of drawings	0.0735
L3	Inflation in the cost of labors	0.0172
M&E1	Fluctuation in raw material prices	0.0067
PM5	Errors in contract documents	0.0328
	Large Companies VS Medium Companies	
CPH1	Insufficient site management and inspection	0.0707
CPH4	Improper monitoring and control	0.0011
CPH5	Lack of experience in handling construction projects	0.0511
CPH8	Accidents on site	0.0001
CPH9	Effect of weather	0.0595
D1	Frequent Design changes	0.0105
D3	Incomplete design at time of tender	0.0111
D5	Delay in approval of drawings	0.0804
F1	Delay in progress payment by owner for work completed	0.0000
F2	Financial difficulties of owner	0.0000
F3	Cash flow difficulties faced by contractor	0.0026
F4	Poor financial control on site	0.0007
F5	Delay payment to supplier /subcontractor	0.0001
L3	Inflation in the cost of labors	0.0000
M&E1	Fluctuation in raw material prices	0.0001
M&E2	Late delivery of materials and equipment	0.0095
M&E3	Insufficient number of equipment	0.0062
M&E4	Changes in material specs and types	0.0273
PM2	Frequent changes to the scope of work	0.0046
PM3	Delays in decisions making	0.0012
PM4	Poor contract management	0.0015
PM5	Errors in contract documents	0.0002
PM6	Unrealistic contract duration and requirements imposed	0.0065
	GC VS Owner	
CPH1	Insufficient site management and inspection	0.0082
CPH2	Schedule delay	0.0212
CPH3	Improper planning and scheduling	0.0250
CPH4	Improper monitoring and control	0.0095
D3	Incomplete design at time of tender	0.0718
D5	Delay in approval of drawings	0.0285
F2	Financial difficulties of owner	0.0086
F3	Cash flow difficulties faced by contractor	0.0974
F4	Poor financial control on site	0.0376
L2	Lack and shortage of skilled labors	0.0932
M&E1	Fluctuation in raw material prices	0.0021
PM1	Poor project management	0.0128
PM8	Inaccurate time and cost estimates of project	0.0418
	GC VS Consultant	

D1	Frequent Design changes	0.0032
C2	Weak coordination between project parties	0.0186
M&E4	Changes in material specs and types	0.0840
PM2	Frequent changes to the scope of work	0.0594
PM3	Delays in decisions making	0.0520
PM4	Poor contract management	0.0443
PM6	Unrealistic contract duration and requirements imposed	0.0005
PM7	Owner interference	0.0253
PM8	Inaccurate time and cost estimates of project	0.0263
	GC VS Subcontractor	
CPH5	Lack of experience in handling construction projects	0.0335
CPH7	Errors during construction	0.0220
CPH8	Accidents on site	0.0556
D1	Frequent Design changes	0.0165
D5	Delay in approval of drawings	0.0851
F1	Delay in progress payment by owner for work completed	0.0000
F2	Financial difficulties of owner	0.0404
F3	Cash flow difficulties faced by contractor	0.0230
F4	Poor financial control on site	0.0181
F5	Delay payment to supplier /subcontractor	0.0000
C4	Disputes on site	0.0782
L1	Low labor productivity	0.0422
L2	Lack and shortage of skilled labors	0.0444
M&E1	Fluctuation in raw material prices	0.0716
M&E2	Late delivery of materials and equipment	0.0000
M&E4	Changes in material specs and types	0.0003
PM2	Frequent changes to the scope of work	0.0100
PM3	Delays in decisions making	0.0059
PM4	Poor contract management	0.0014
PM6	Unrealistic contract duration and requirements imposed	0.0088
	Owner VS Consultant	
CPH2	Schedule delay	0.0006
CPH3	Improper planning and scheduling	0.0301
CPH4	Improper monitoring and control	0.0586
D1	Frequent Design changes	0.0168
D3	Incomplete design at time of tender	0.0083
D5	Delay in approval of drawings	0.0016
F1	Delay in progress payment by owner for work completed	0.0509
F2	Financial difficulties of owner	0.0161
C2	Weak coordination between project parties	0.0192
L3	Inflation in the cost of labors	0.0592
M&E1	Fluctuation in raw material prices	0.0049
PM1	Poor project management	0.0179
PM2	Frequent changes to the scope of work	0.0048
PM3	Delays in decisions making	0.0755

PM4	Poor contract management	0.0866
PM6	Unrealistic contract duration and requirements imposed	0.0025
PM7	Owner interference	0.0266
PM8	Inaccurate time and cost estimates of project	0.0003

4.7 Ranking Percentage Agreement and Disagreement

Okpala and Aniekwu [61] proposed to evaluate the extent of agreement in ranking between different pairs of respondent groups, and called it the ranking agreement factor (RAF).

For any two groups, assuming the ranking of the i^{th} item in group 1 is Ri_1, and in group 2 is Ri_2, For any two groups, let the rank of the i^{th} item in group 1 be Ri_1 and in group 2 be Ri_2 . Then the absolute difference Di, between any ranking of the, between any ranking of the i^{th} item by the groups would be

$Di = |Ri1 - Ri2|$
Where i = 1, 2, . . . , N
And there are N items

$D\max = |Ri1 - Rj2|$
Where $j = N - i + 1$,

i.e., if i=1 and N=39, j=39−1+1=39

The percentage disagreement (PD) and the percentage agreement (PA) by the following equations:

$$PD = 100x \frac{\sum_{i=1}^{N} |Ri1 - Ri2|}{\sum_{x=1}^{N} |Rx1 - Rj2|}$$

PA = 100 – PD

According to the above formula of the PA, and PD of the FCAII of the various cost overrun causes and the effectiveness of the mitigation measures for different pairs of groups, respectively, were examined to see the extent of the difference among different groups of respondents.

Referring to table 26, the values of PD for the Qatar vs GCC groups regarding the FCAII of cost overrun causes were the smallest compared with the other pairs of groups. This

indicates that there was a relatively strong consensus between these two groups (i.e. PA=74.47 % regarding the FCAII of cost overrun causes).

Greatest difference of viewpoint existed between the General Contractor group (GC) and the Owner group regarding the FCAII of cost overrun causes (PD=37.89%).

Table 26 - Percentage Agreement and Disagreement for FCAII of Various Causes of Cost Overrun from Viewpoints of Different Pairs of Groups

Groups	**Ranking Disagreement %**	**Ranking Agreement %**
Qatar VS GCC	25.53	74.47
Contractors VS consultants	27.37	72.63
Contractors VS Subcontractors	25.79	74.21
Contractors VS Owners	37.89	62.11
Owners VS consultants	33.16	66.84
Project / Construction managers VS Project Engineers	36.32	63.68
Superstructure VS Infrastructure Industry	36.05	63.95
Superstructure VS All Other Industries	30	70
Large Companies VS Medium Companies	33.68	66.32
Experts With Over 16 Years Experience VS Less Than 16 years Experience	32.89	67.11

4.8 Risk mapping:

Risk mapping matrix, is a tool used to help in identifying in which risk zone each cost overrun factor falls for all responses by visual representation of each attribute average value of mean importance VS mean frequency, mean importance VS mean impact on cost, mean frequency VS mean impact on cost, and finally drawing them all together in one 3D scattered plot using MATLAB. Table 26 shows the mean values.

Table 27 - Mean Value Results for Data Collected from All Responses

Factor (Title of the point)	Importance Mean value (x-axis)	Frequency Mean value (y-axis)	Impact on Cost Mean value (Z-axis)
Insufficient site management and inspection	3.73	2.99	3.62
Schedule delay	4.10	3.47	4.12
Improper planning and scheduling	4.33	3.27	4.13
Improper monitoring and control	3.84	3.01	3.84
Lack of experience in handling construction projects	3.65	2.92	3.64
Delay in inspection and approval of completed work	3.35	3.16	3.32
Errors during construction	3.53	2.86	3.47
Accidents on site	3.70	2.09	3.32
Effect of weather	2.49	2.15	2.23
Unforeseen ground conditions	2.89	2.00	2.73
Frequent Design changes	4.36	3.03	4.22
Design errors and mistakes	3.99	2.56	3.84
Incomplete design at time of tender	3.99	2.75	3.95
Deficient design and delays in design process	3.81	2.64	3.59
Delay in approval of drawings	3.63	2.93	3.34
Delay in progress payment by owner for work completed	4.13	3.06	3.55
Financial difficulties of owner	4.08	2.47	3.73
Cash flow difficulties faced by contractor	3.97	2.92	3.58
Poor financial control on site	3.76	2.79	3.62
Delay payment to supplier /subcontractor	3.81	3.03	3.50
Weak communication between project parties	3.78	2.88	3.42
Weak coordination between project parties	3.85	2.89	3.32

Weak collaboration between management and labour	3.39	2.74	2.98
Disputes on site	3.14	2.56	2.92
Low labour productivity	3.97	2.91	3.53
Lack and shortage of skilled labours	4.05	3.18	3.50
Inflation in the cost of labours	3.69	2.53	3.50
Fluctuation in raw material prices	4.08	2.76	3.59
Late delivery of materials and equipment	3.92	2.98	3.41
Insufficient number of equipment	3.36	2.75	3.18
Changes in material specs and types	3.74	2.86	3.60
Poor project management	4.36	2.94	4.01
Frequent changes to the scope of work	4.22	3.04	4.18
Delays in decisions making	4.09	3.01	3.69
Poor contract management	3.81	2.94	3.63
Errors in contract documents	4.04	2.65	3.85
Unrealistic contract duration and requirements imposed	4.35	2.93	4.15
Owner interference	3.60	2.83	3.23
Inaccurate time and cost estimates of project	4.27	3.07	4.04

Next step, will be presenting each group of cost overrun factors risk matrix using these mean values.

4.8.1 All Responses Risk Matrix: For Attributes Related To Construction Phase

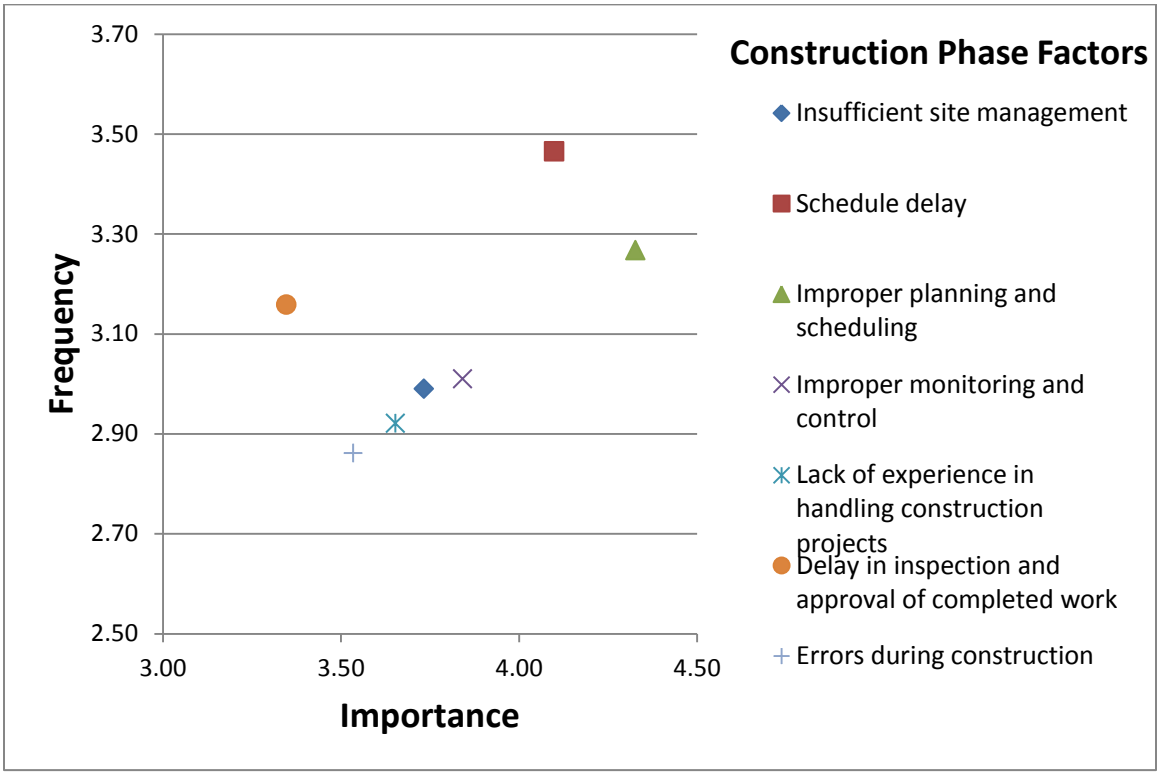

Figure 8 - Risk matrix chart for cost overruns related to Construction Phase (F vs I)

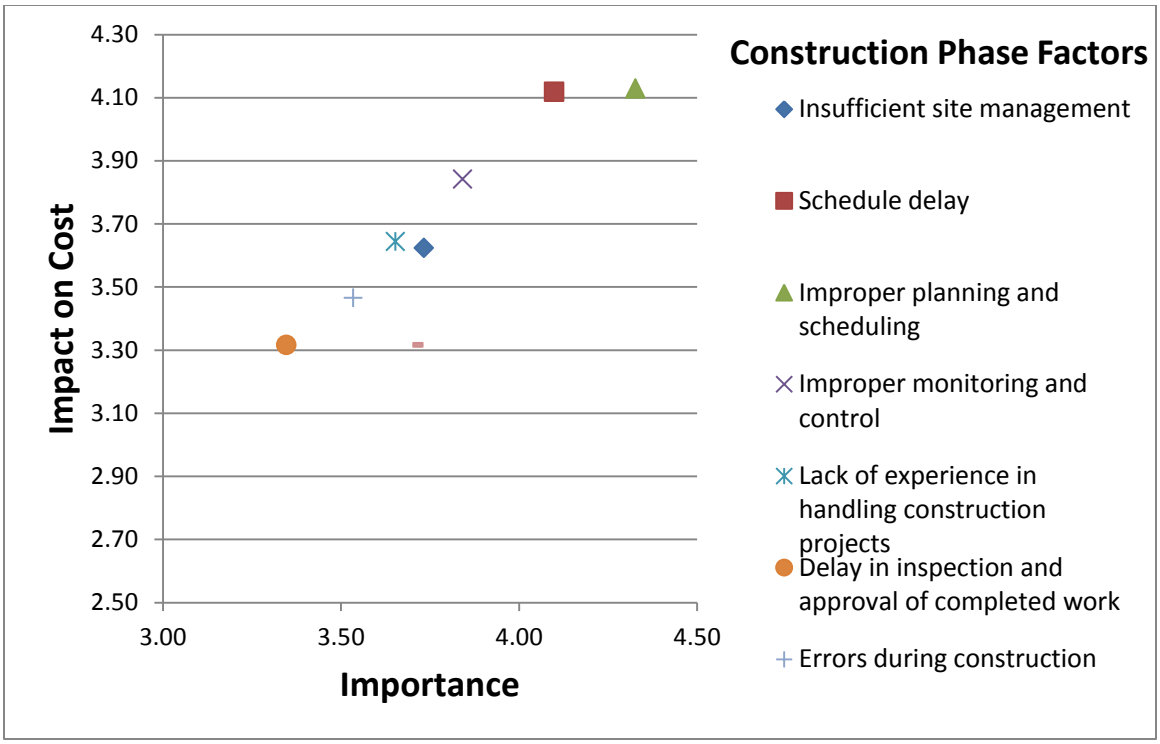

Figure 9 - Risk matrix chart for cost overruns related to Construction Phase (CI vs I)

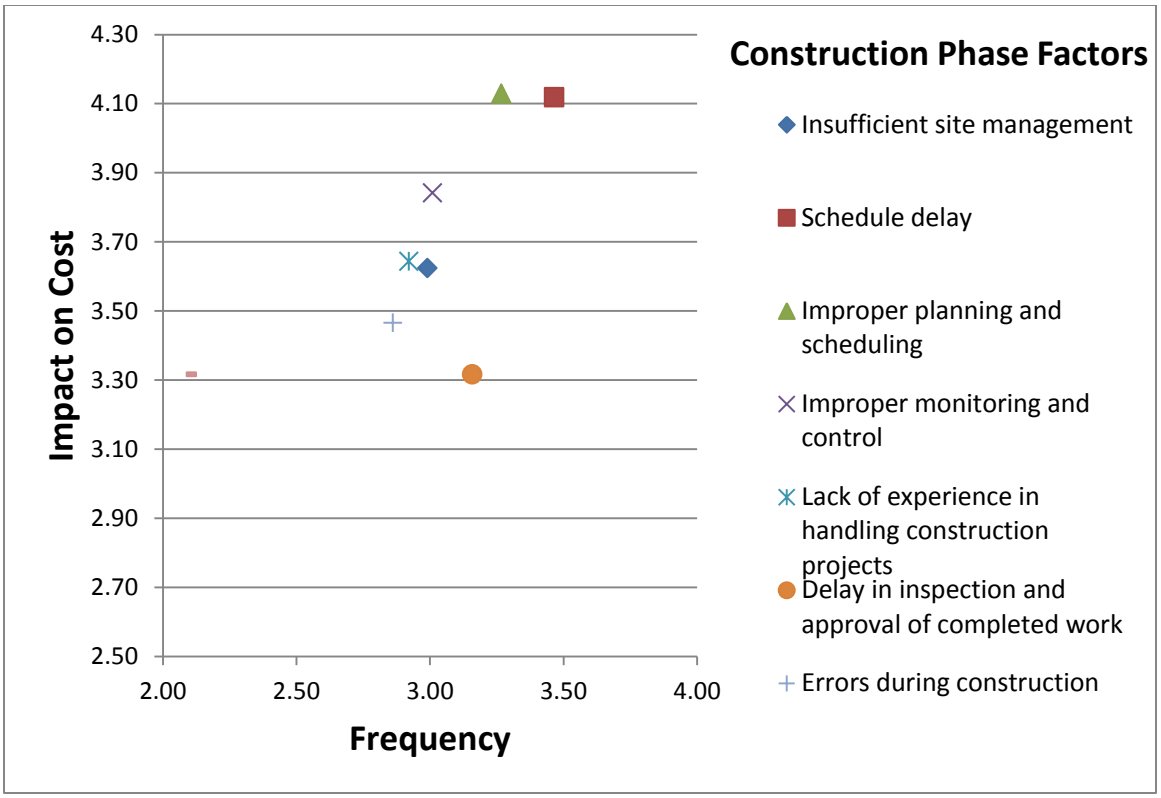

Figure 10 - Risk matrix chart for cost overruns related to Construction Phase (CI vs F)

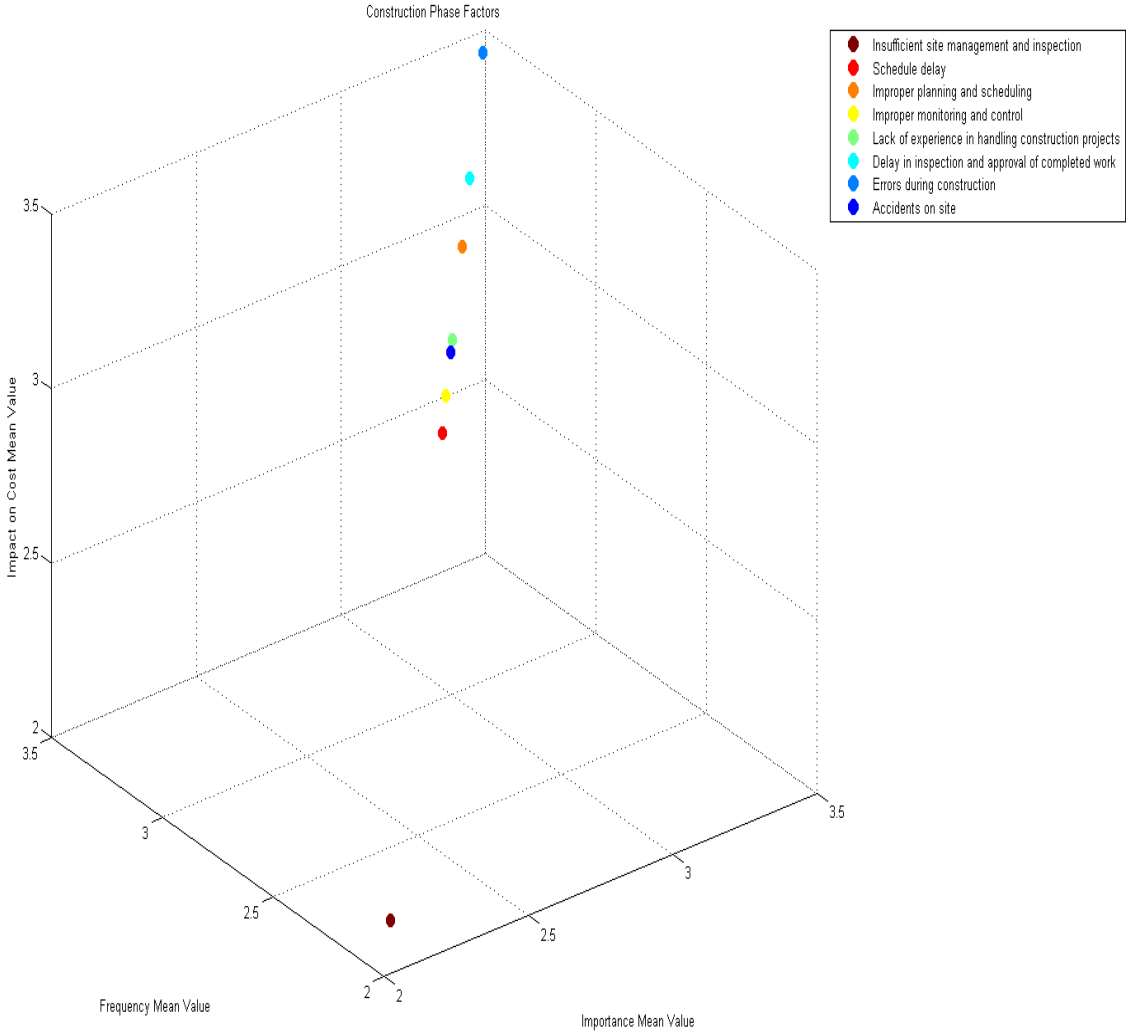

Figure 11 - 3D Risk matrix chart for cost overruns related to Construction Phase (CI vs F vs I)

4.8.2 All Responses Risk Matrix: For Attributes Related To Design

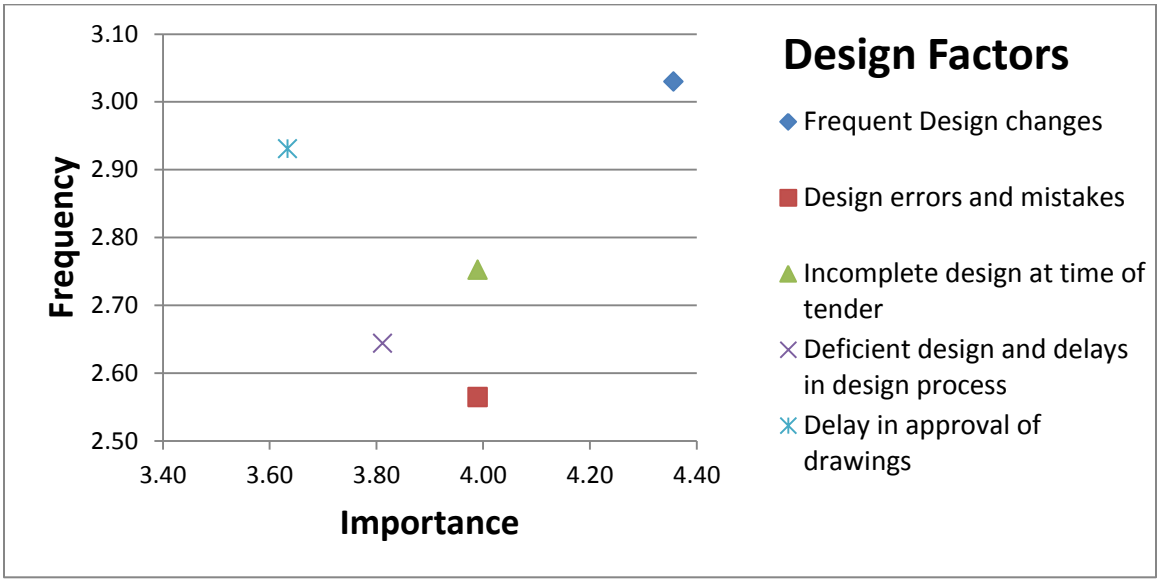

Figure 12 - Risk matrix chart for cost overruns related to Design (F vs I)

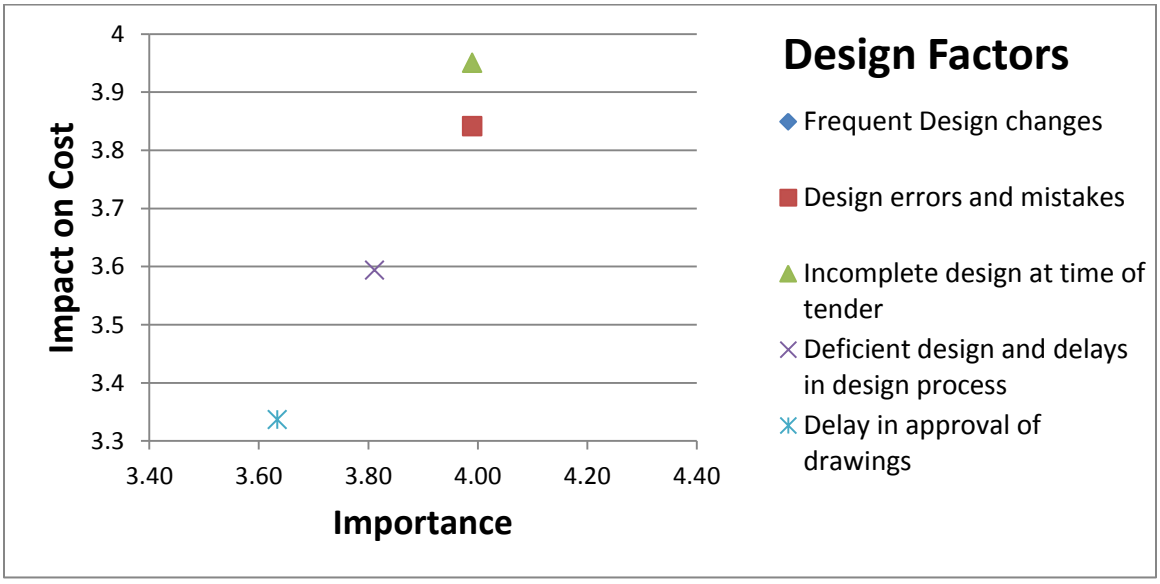

Figure 13 - Risk matrix chart for cost overruns related to Design (CI vs I)

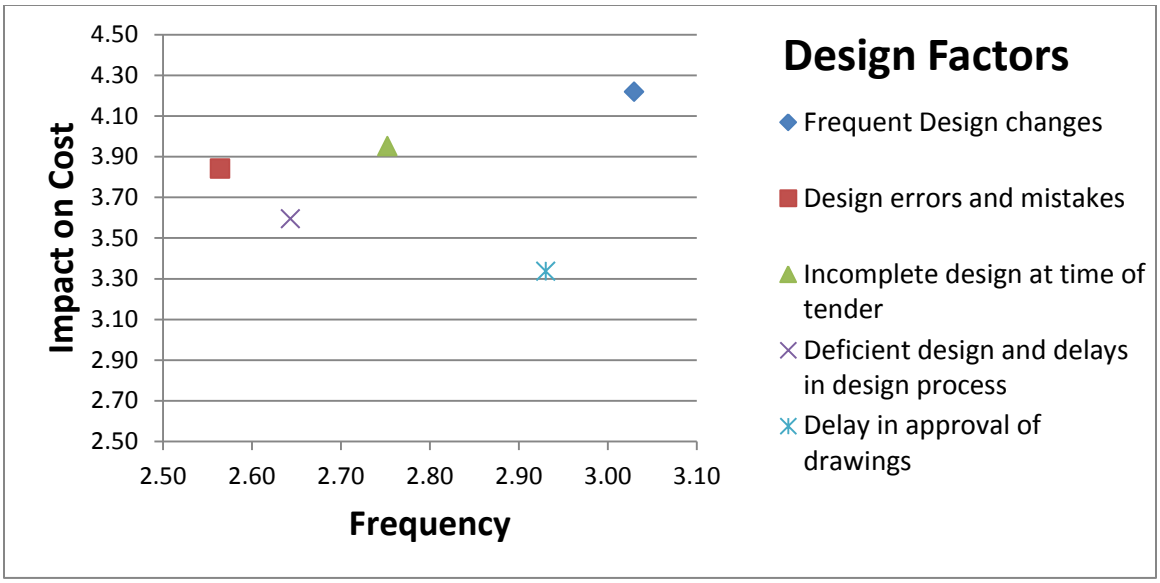

Figure 14 - Risk matrix chart for cost overruns related to Design (CI vs F)

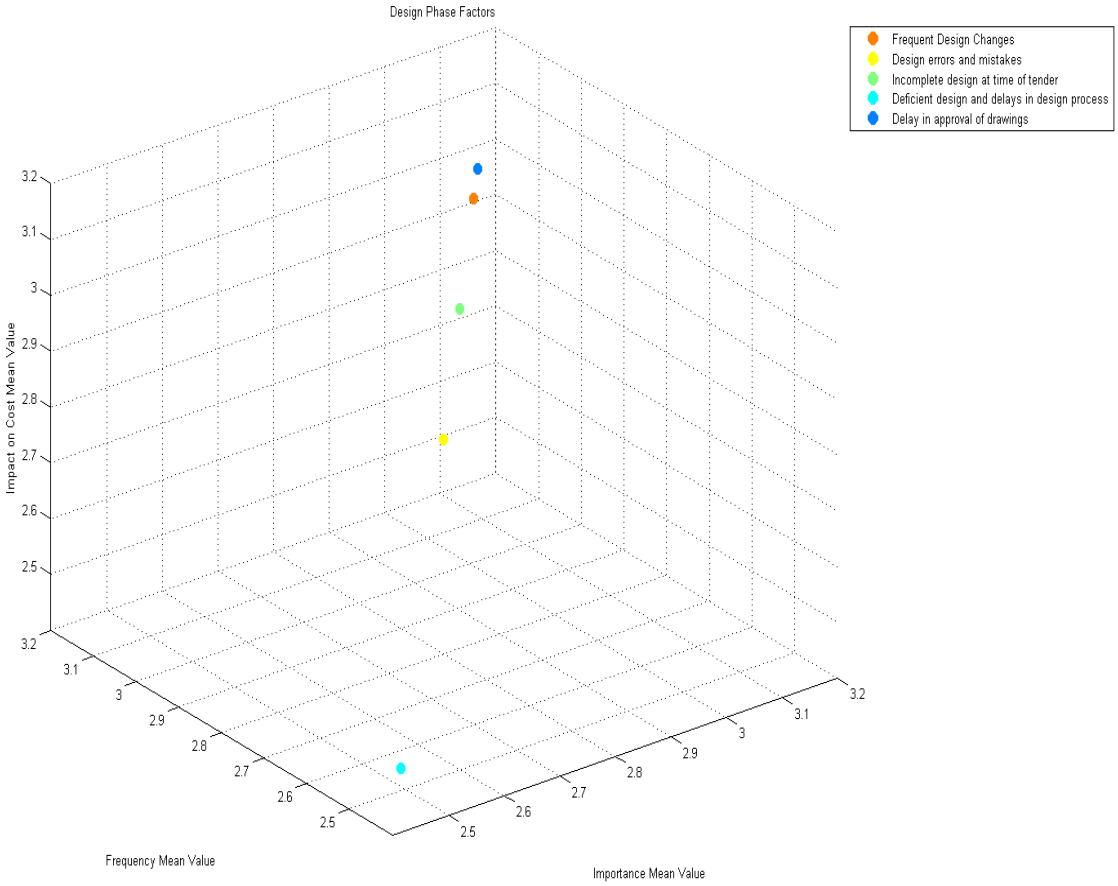

Figure 15 - 3D Risk matrix chart for cost overruns related to Design Phase (CI vs F vs I)

4.8.3 All Responses Risk Matrix: For Attributes Related To Finance

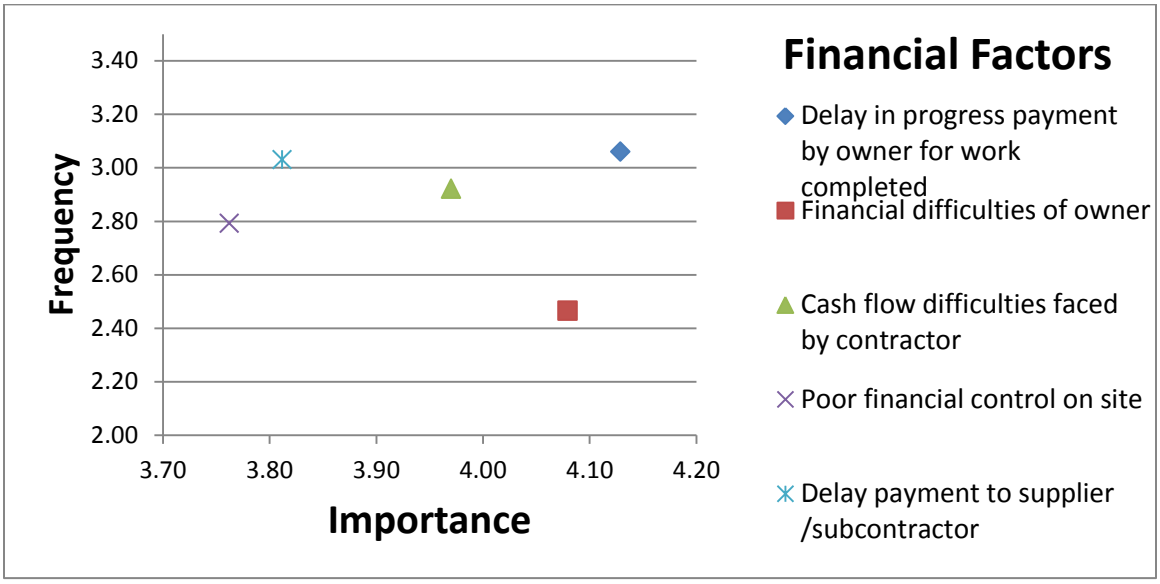

Figure 16 - Risk matrix chart for cost overruns related to finance (F vs I)

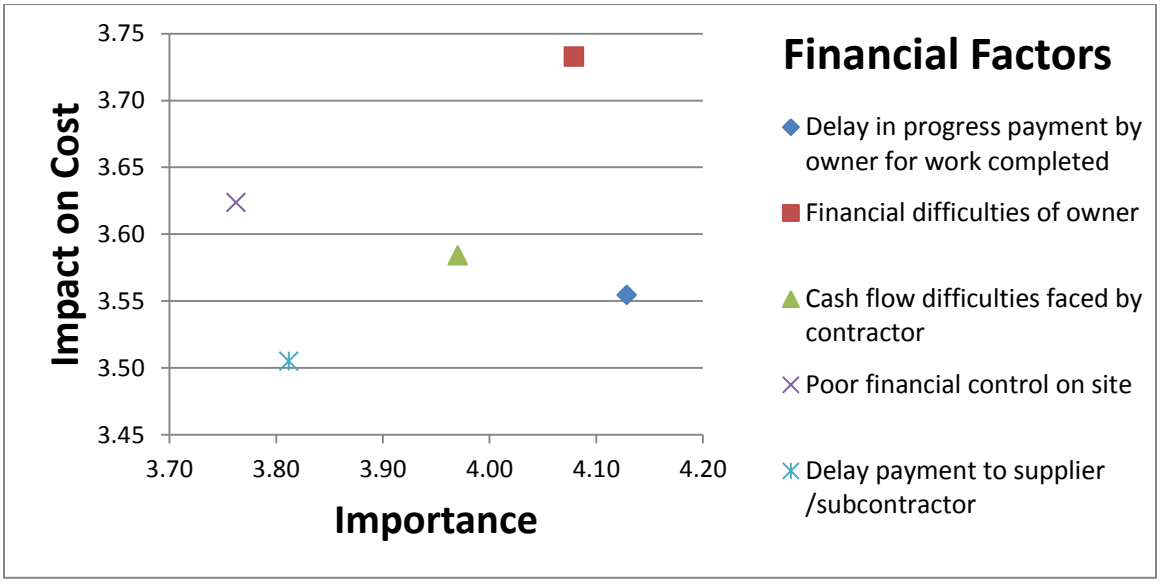

Figure 17 - Risk matrix chart for cost overruns related to Design (CI vs I)

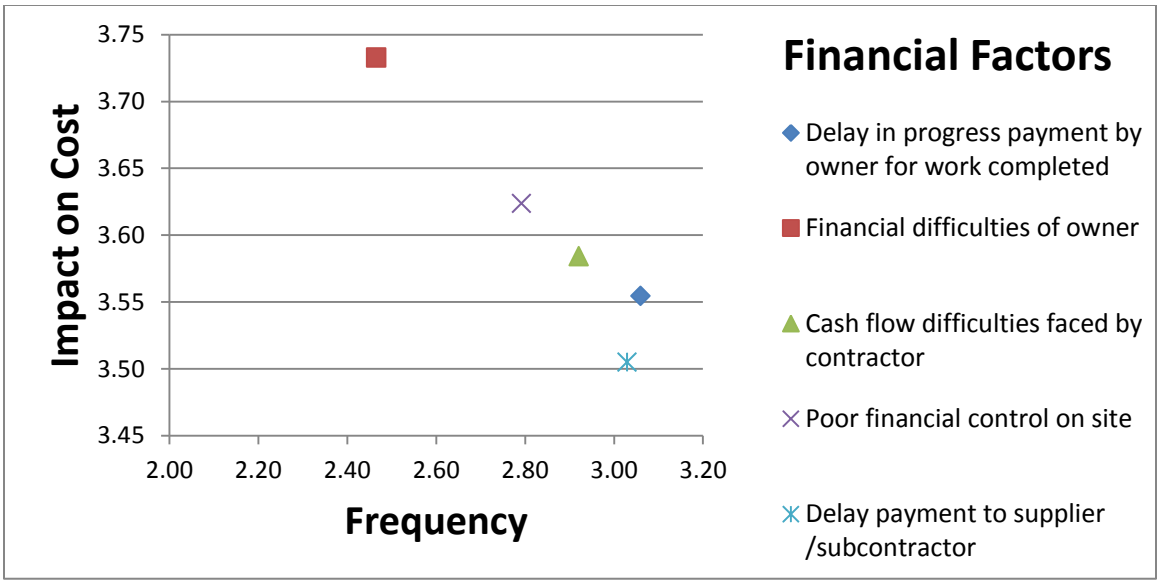

Figure 18 - Risk matrix chart for cost overruns related to Design (CI vs F)

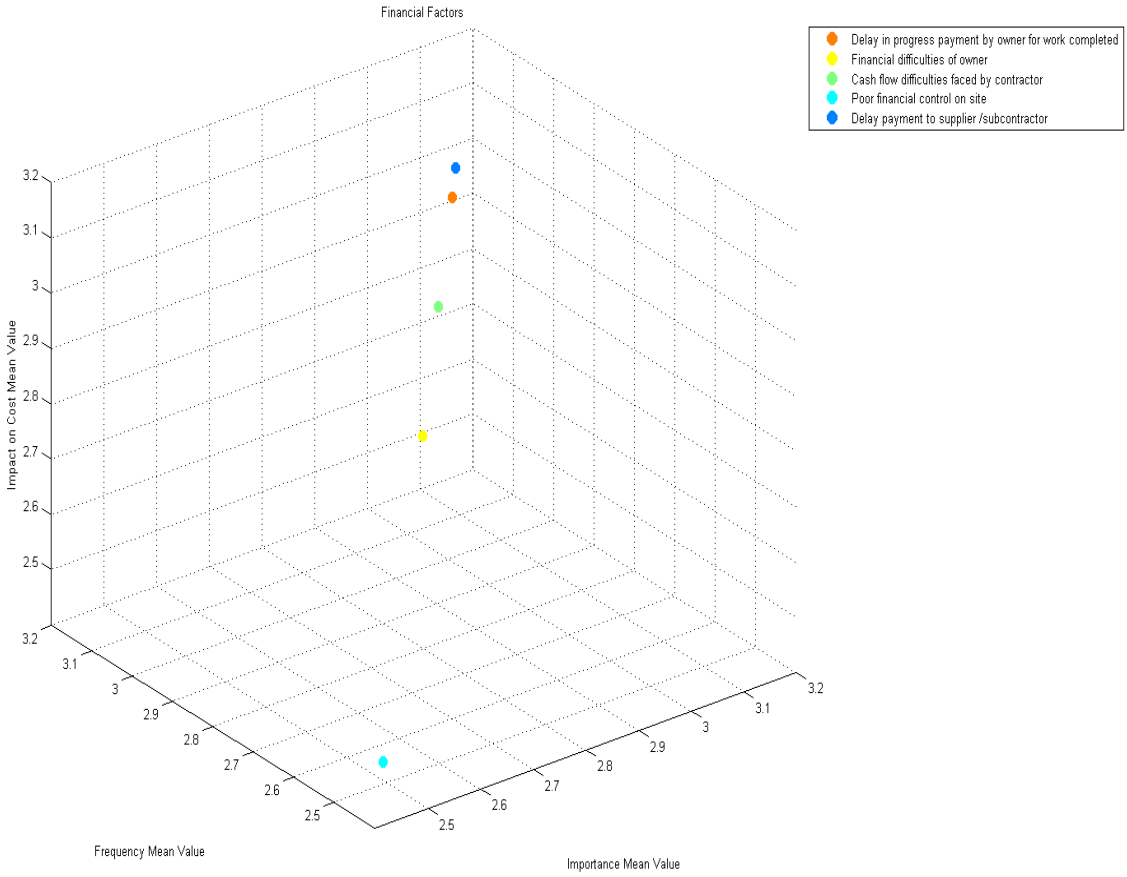

Figure 19 - 3D Risk matrix chart for cost overruns related to Finance (CI vs F vs I)

4.8.4 All Responses Risk Matrix: For Attributes Related To Communications

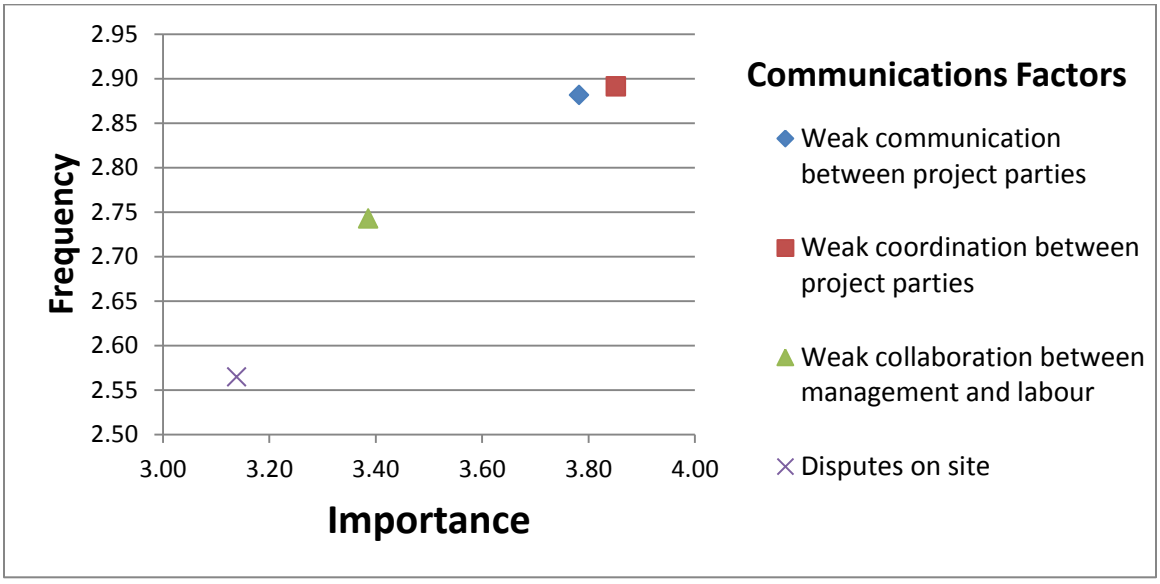

Figure 20 - Risk matrix chart for cost overruns related to Communications (F vs I)

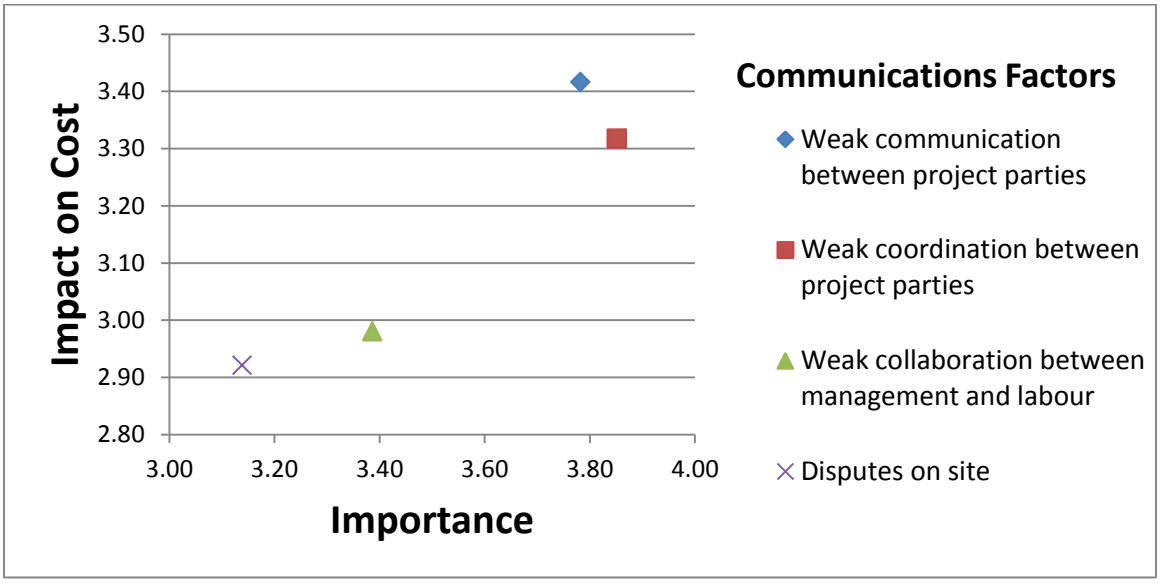

Figure 21 - Risk matrix chart for cost overruns related to Design (CI vs I)

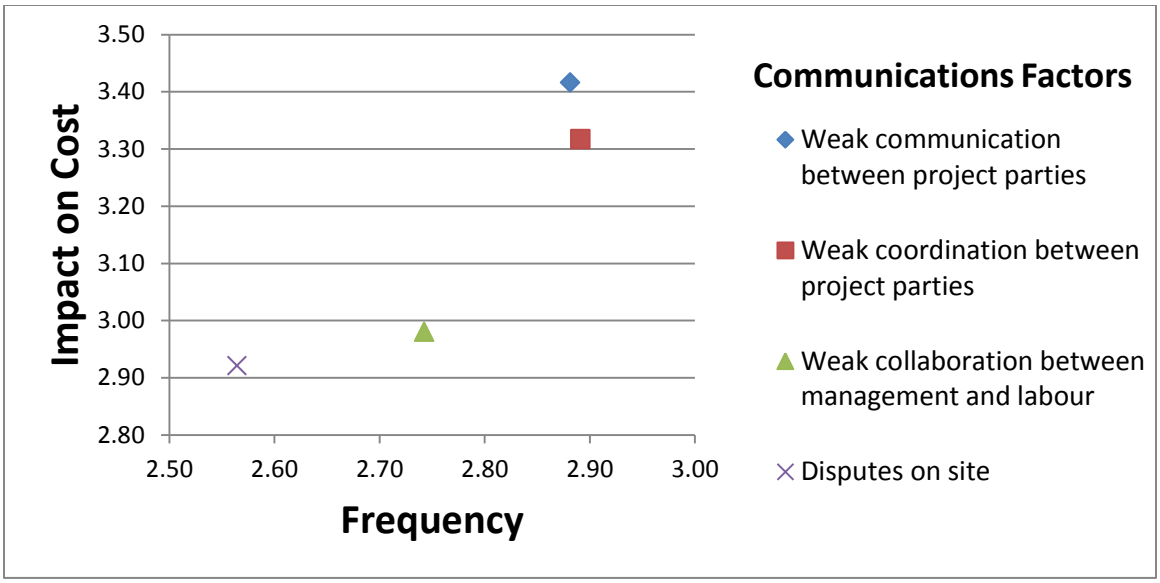

Figure 22 - Risk matrix chart for cost overruns related to Communications (CI vs F)

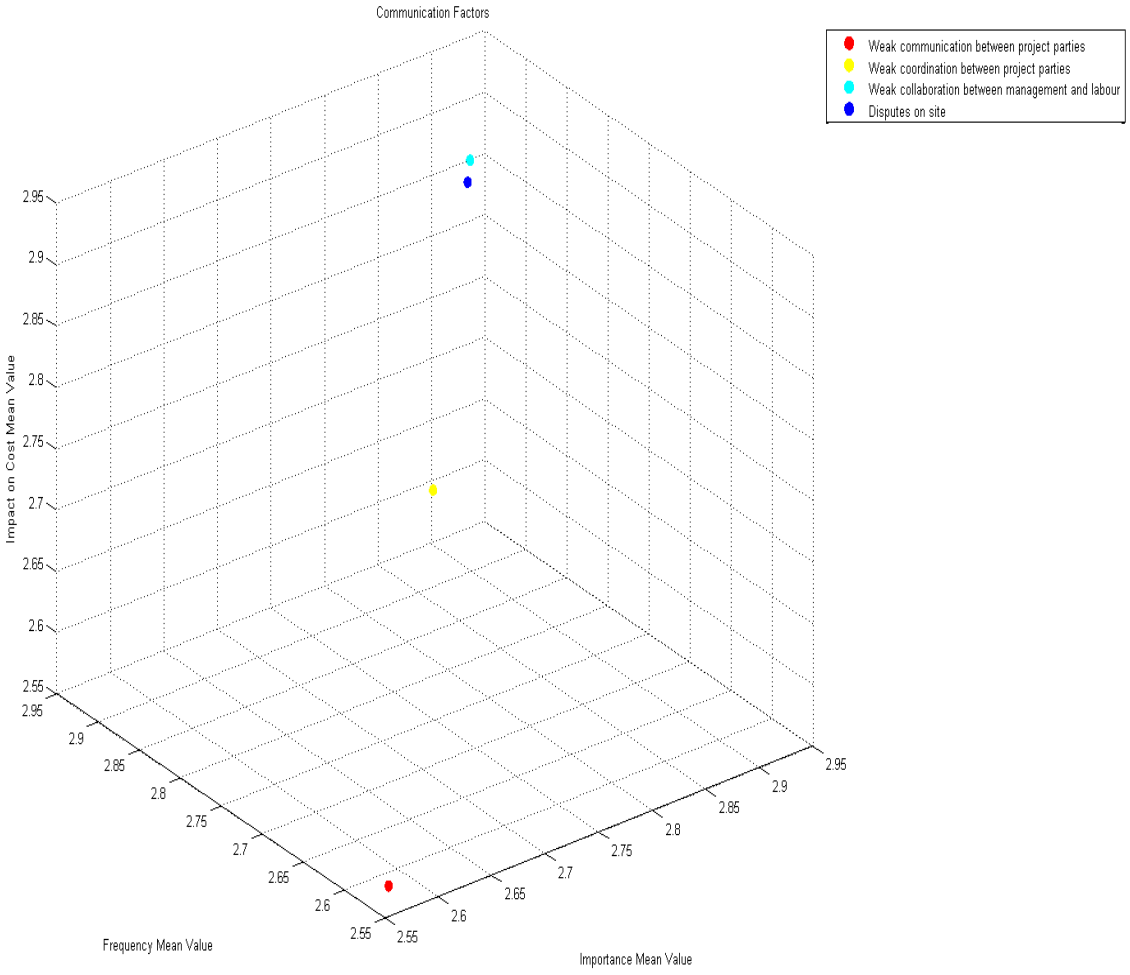

Figure 23 - 3D Risk matrix chart for cost overruns related to Communications (CI vs F vs I)

4.8.5 All Responses Risk Matrix: For Attributes Related To Labors

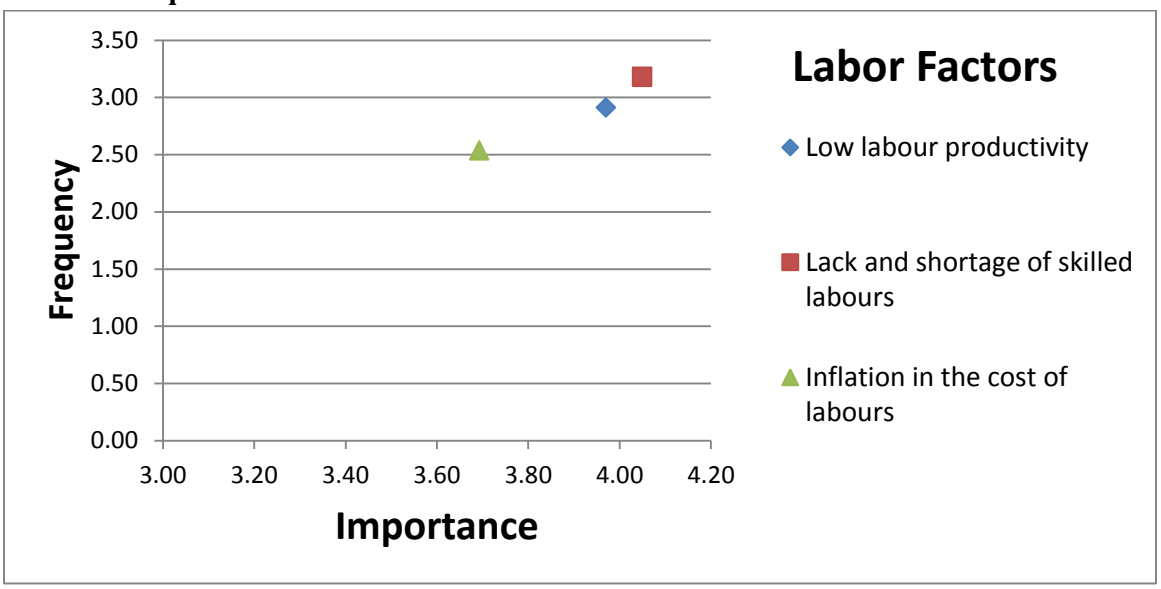

Figure 24 - Risk matrix chart for cost overruns related to Labors (F vs I)

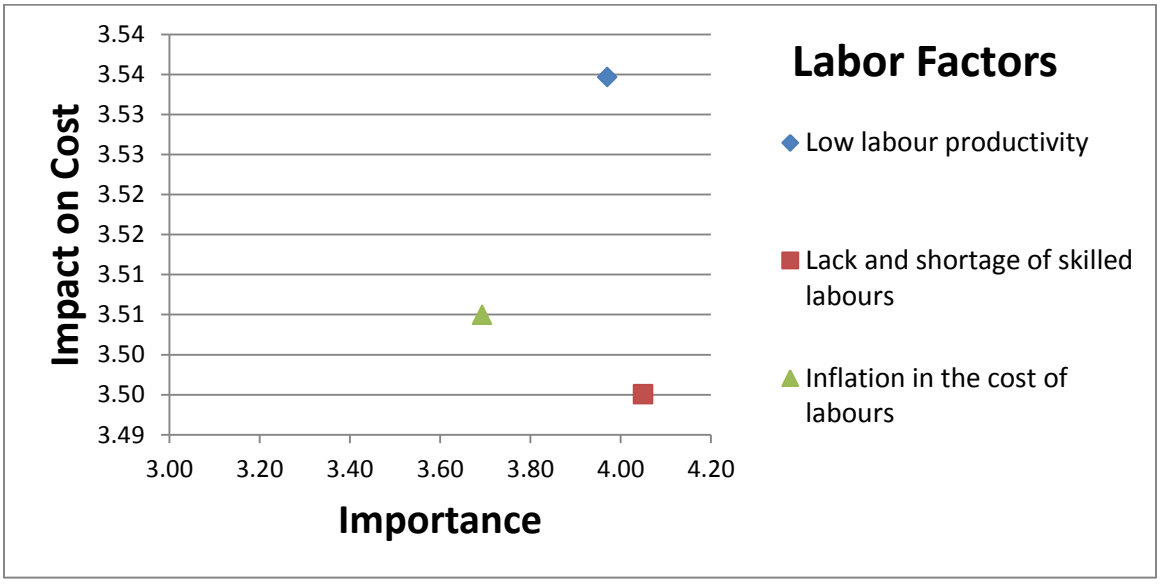

Figure 25 - Risk matrix chart for cost overruns related to Labors (CI vs I)

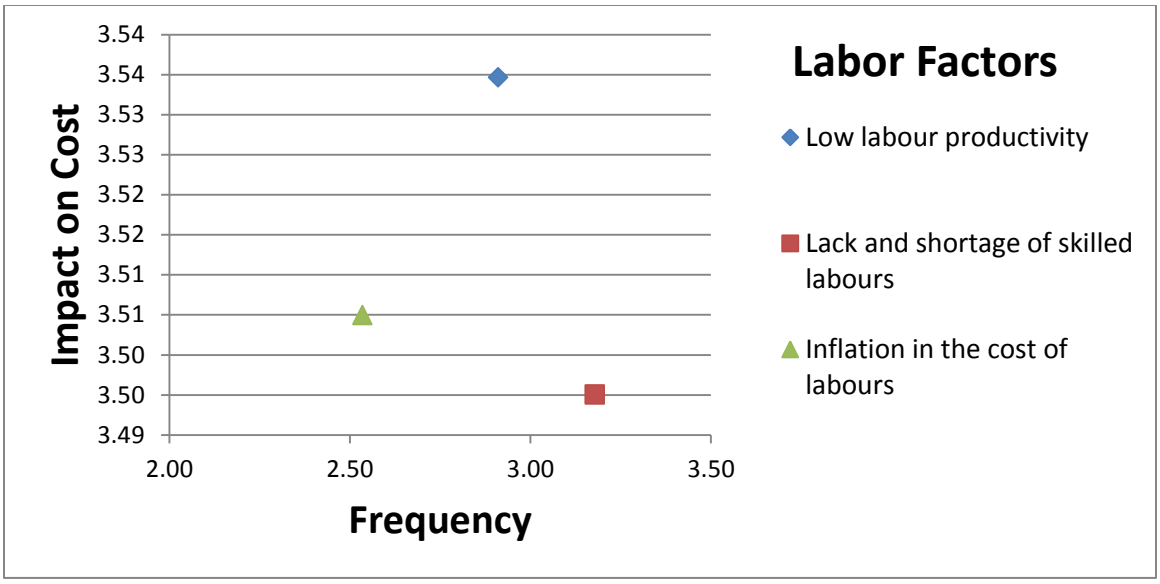

Figure 26 - Risk matrix chart for cost overruns related to Labors (CI vs F)

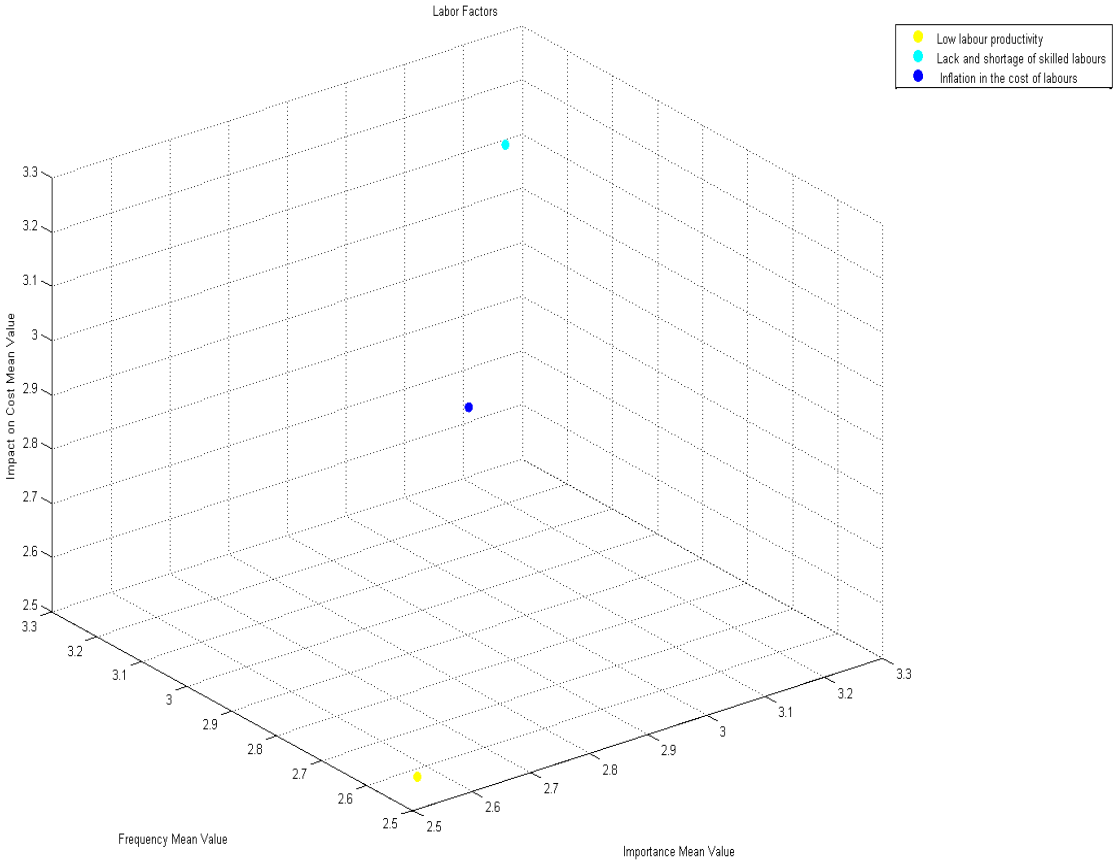

Figure 27 - 3D Risk matrix chart for cost overruns related to Labors (CI vs F vs I)

4.8.6 All Responses Risk Matrix: For Attributes Related To Materials and Equipment

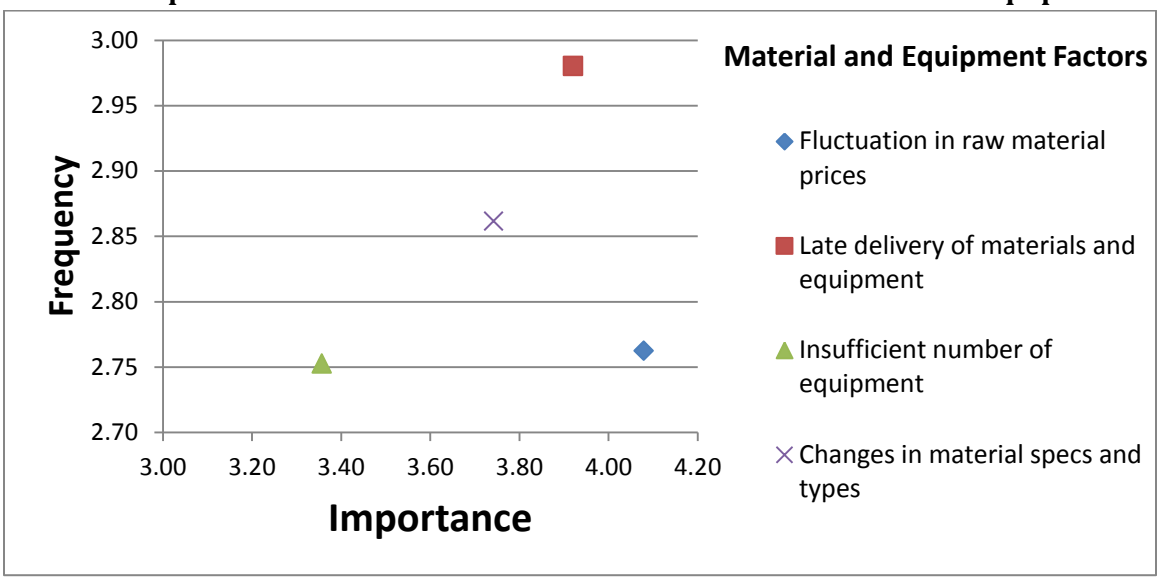

Figure 28 - Risk matrix chart for cost overruns related to M&E (F vs I)

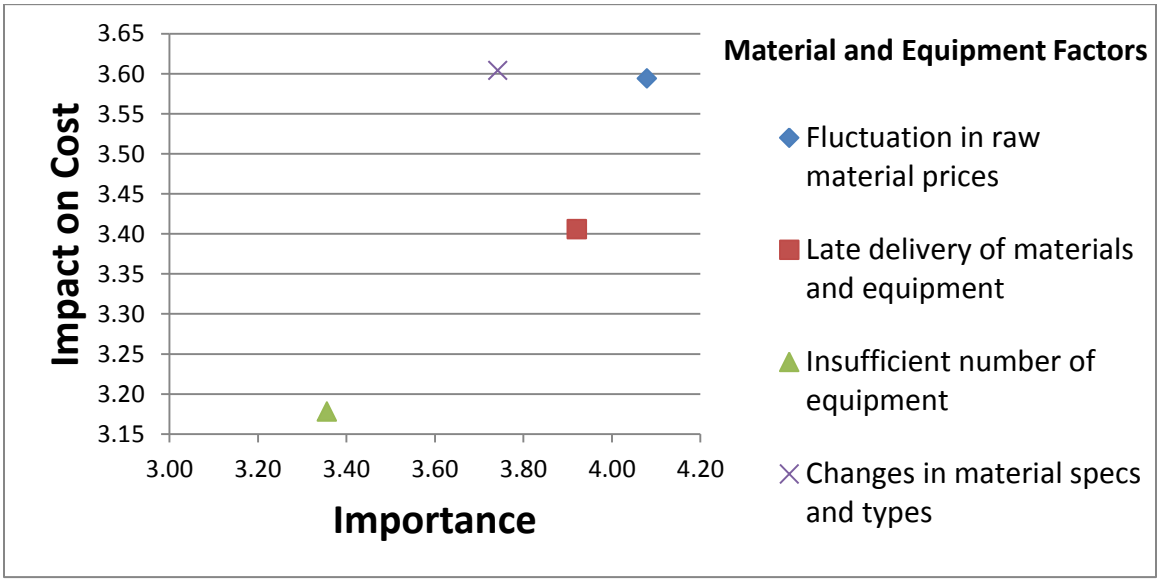

Figure 29 - Risk matrix chart for cost overruns related to M&E (CI vs I)

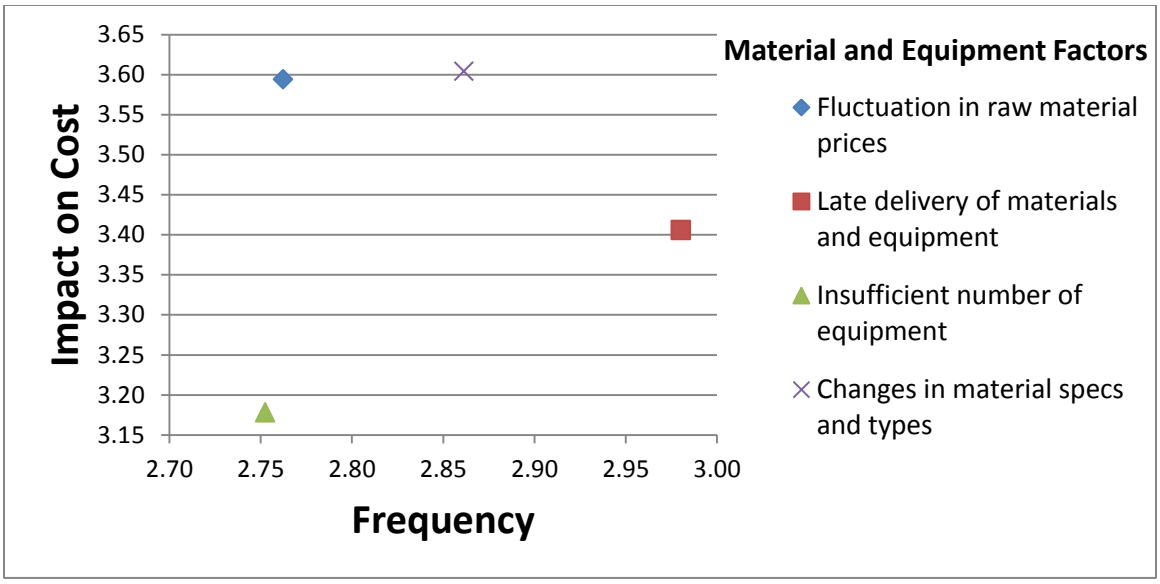

Figure 30 - Risk matrix chart for cost overruns related to M&E (CI vs F)

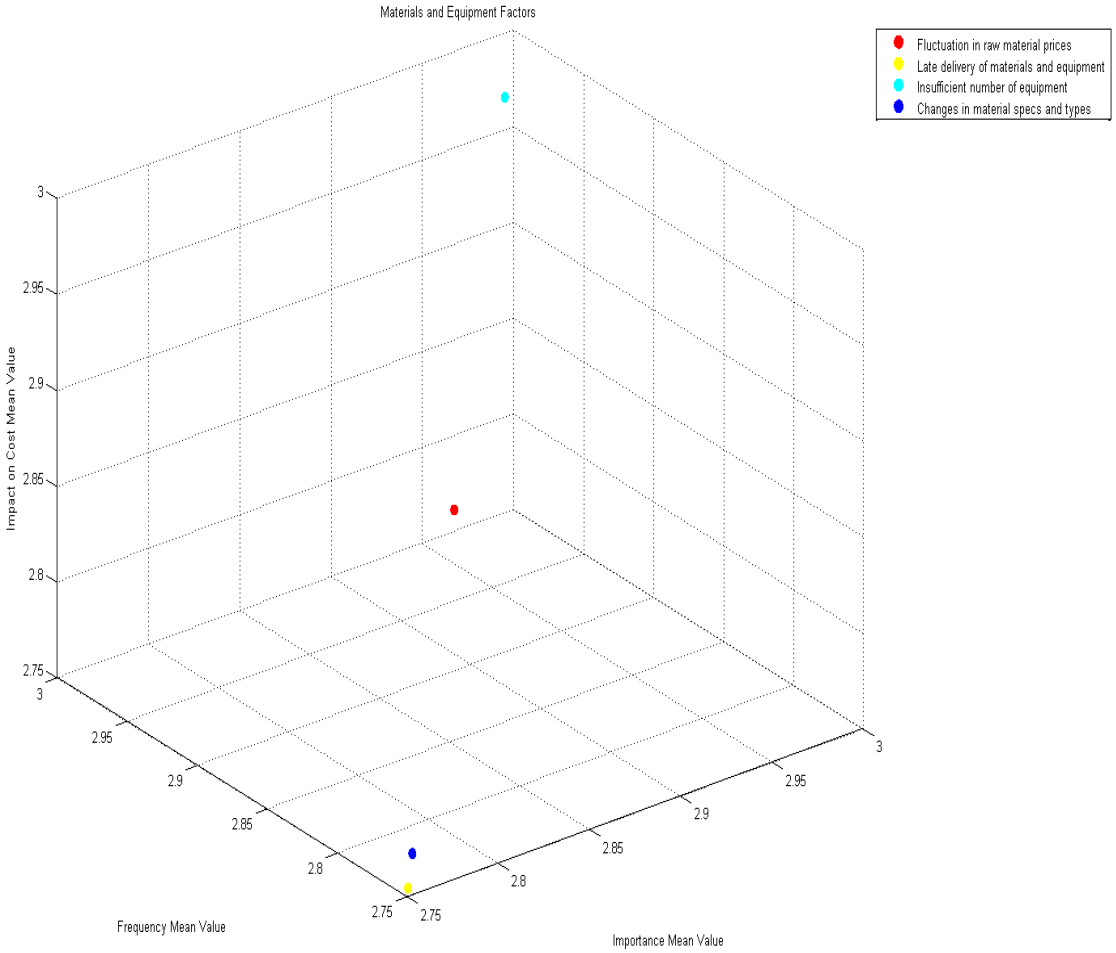

Figure 31 - 3D Risk matrix chart for cost overruns related to Materials and Equipment (CI vs F vs I)

4.8.7 All Responses Risk Matrix: For Attributes Related To Project Management

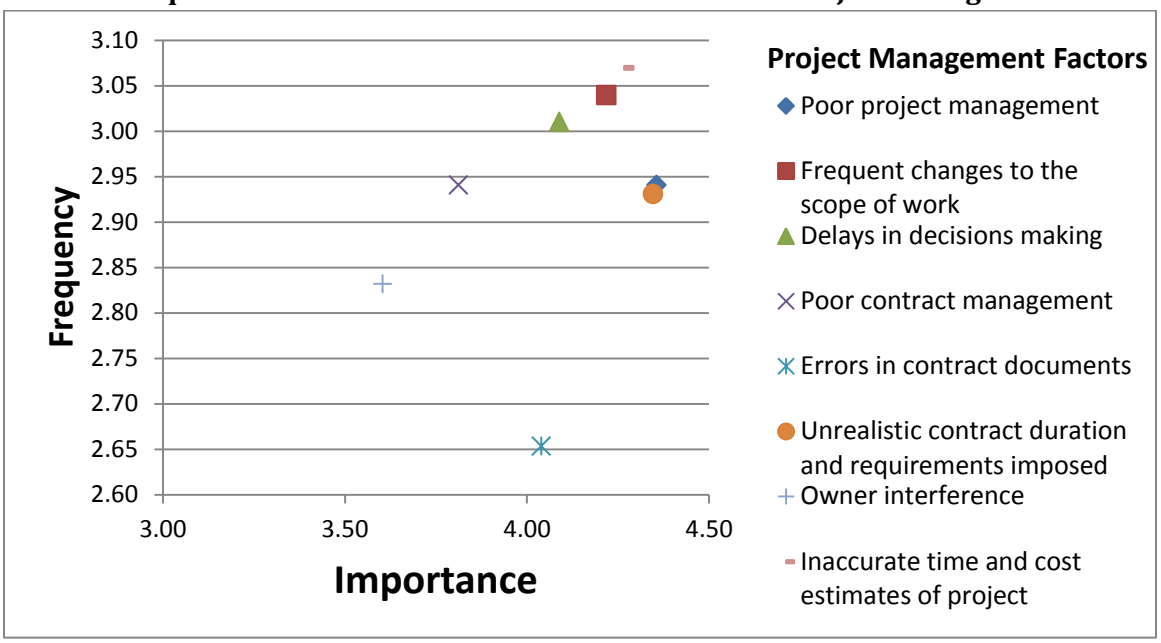

Figure 32 - Risk matrix chart for cost overruns related to Project Management (F vs I)

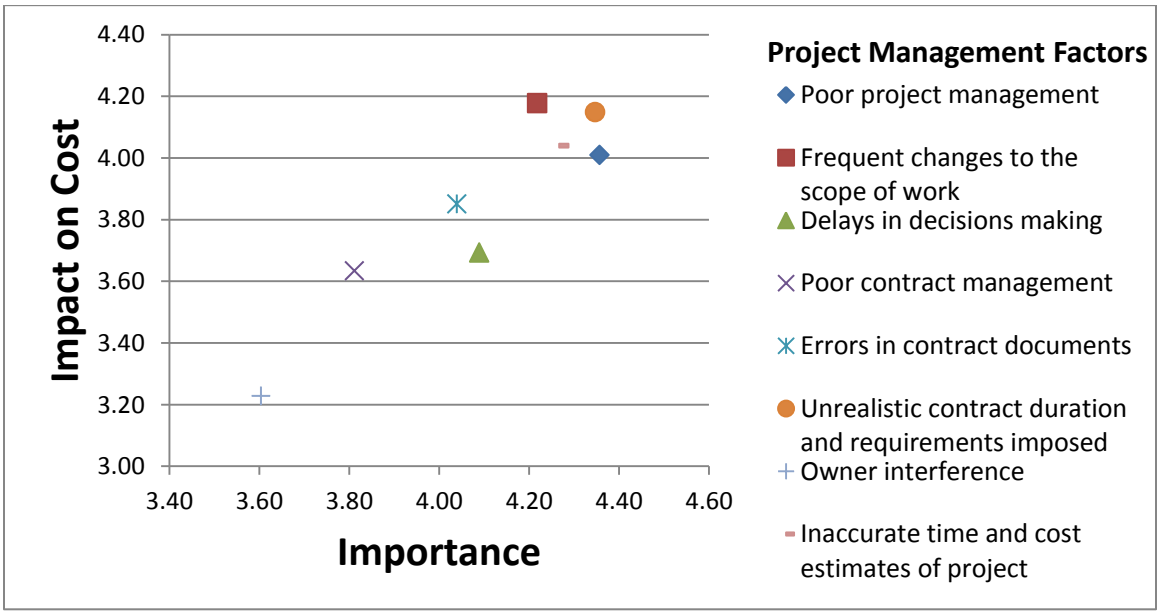

Figure 33 - Risk matrix chart for cost overruns related to Project Management (CI vs I)

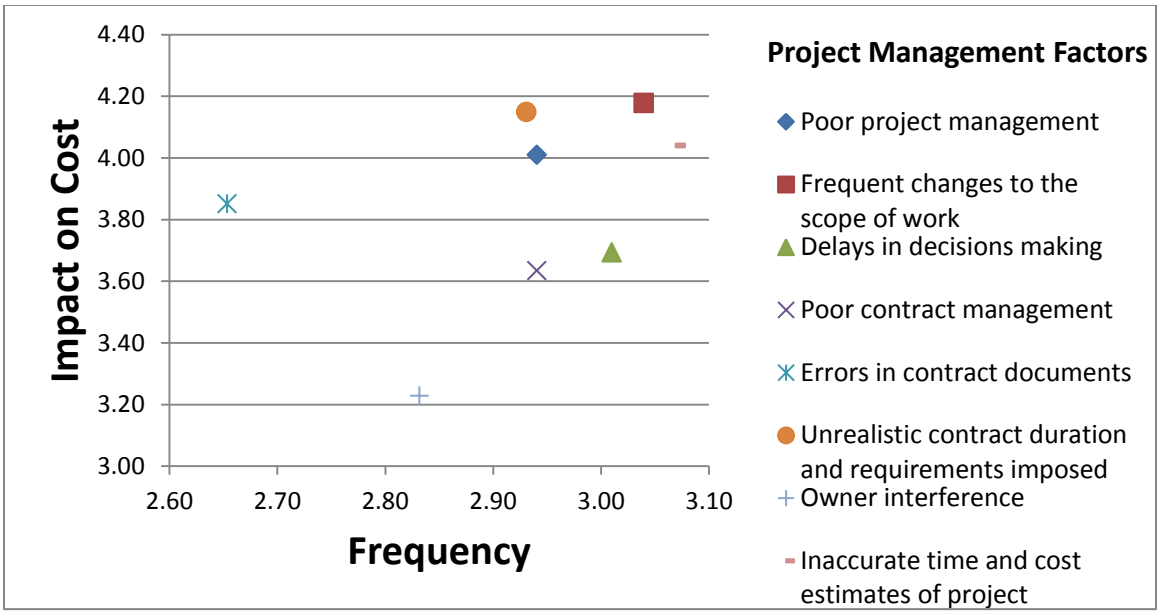

Figure 34 - Risk matrix chart for cost overruns related to Project Management (CI vs F)

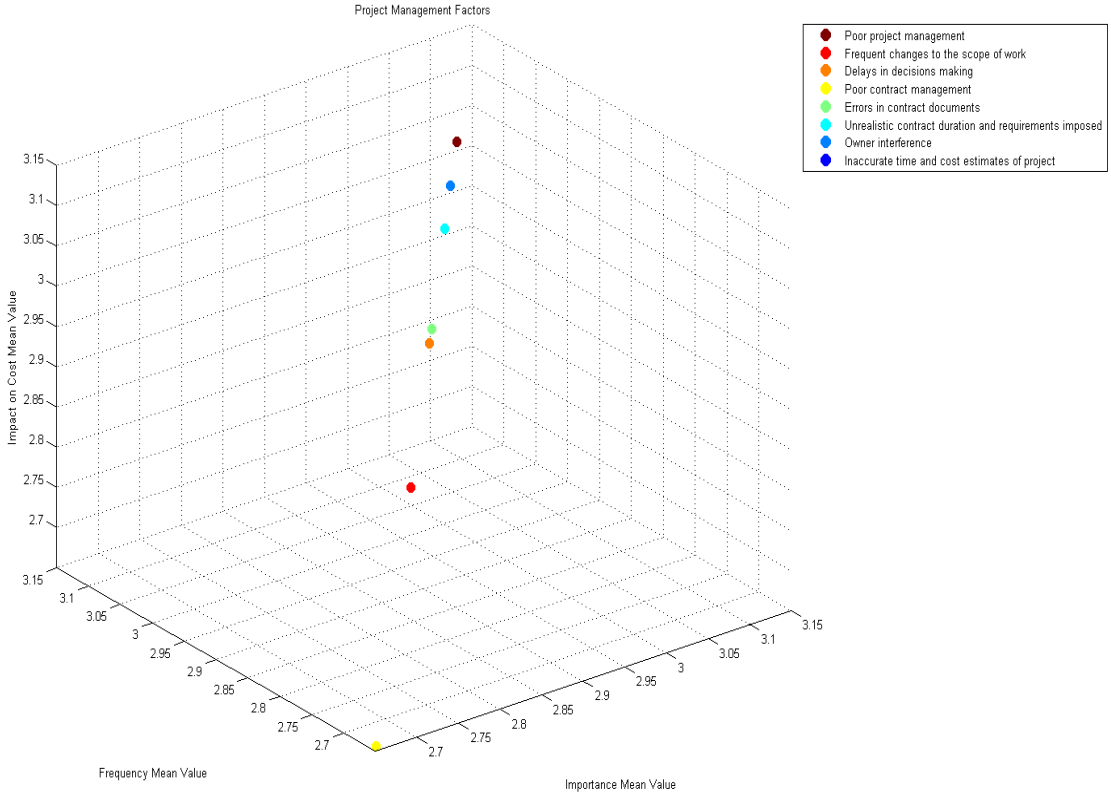

Figure 35 - 3D Risk matrix chart for cost overruns related to Project Management (CI vs F vs I)

4.8.8 All Responses Risk Matrix: Groups Top Cost Overrun Factor

The most benefit from risk mapping matrix is to visually determine the red-zone factors that affect cost overrun, based on impact, frequency and cost impact mean values. Table28 below summarizes the red zone factors of all the groups. Figure 36 shows risk mapping matrix zones used to present cost overrun factor, where values from 0 to 4.99 represent green zone factors, values from 5 to 9.99 represent yellow zone factors, and values from 10 to 25 represent red zone factors.

Risk Matrix					
5 - Very High	5	9.99	15	20	25
4 - High	4	8	12	16	20
3 - Moderate	3	6	9	12	15
2 - Low	2	4	6	8	10
1 - Very Low	1	2	3	4	5
	1 - Very Low	2 - Low	3 - Moderate	4 - High	5 - Very High

Figure 36 - Scale used to present factor's risk related to importance, frequency and impact on cost

Table 28 - Cost Overrun factor group risk matrix top factors Importance VS Frequency

Code	Factor (Title of the point)	Importance (I) Mean value	Frequency (F) Mean value	I*F	Zone
CPH	Insufficient site management and inspection	3.73	2.99	11.16	Red
CPH	Schedule delay	4.10	3.47	14.20	Red
CPH	Improper planning and scheduling	4.33	3.27	14.14	Red
CPH	Improper monitoring and control project parties	3.84	3.01	11.56	Red
CPH	Lack of experience in handling construction projects	3.65	2.92	10.67	Red
CPH	Delay in inspection and approval of completed work	3.35	3.16	10.57	Red
CPH	Errors during construction	3.53	2.86	10.11	Red
D	Frequent Design changes	4.36	3.03	13.20	Red
D	Design errors and mistakes	3.99	2.56	10.23	Red
D	Incomplete design at time of tender	3.99	2.75	10.98	Red
D	Deficient design and delays in design process	3.81	2.64	10.08	Red
D	Delay in approval of drawings	3.63	2.93	10.65	Red
F	Delay in progress payment by owner for work completed	4.13	3.06	12.63	Red
F	Financial difficulties of owner	4.08	2.47	10.06	Red
F	Cash flow difficulties faced by contractor	3.97	2.92	11.60	Red
F	Poor financial control on site	3.76	2.79	10.50	Red
F	Delay payment to supplier /subcontractor	3.81	3.03	11.55	Red

C	Weak communication between project parties	3.78	2.88	10.90	Red
C	Weak coordination between	3.85	2.89	11.13	Red
L	Low labour productivity	3.97	2.91	11.56	Red
L	Lack and shortage of skilled labours	4.05	3.18	12.87	Red
M&E	Fluctuation in raw material prices	4.08	2.76	11.27	Red
M&E	Late delivery of materials and equipment	3.92	2.98	11.68	Red
M&E	Changes in material specs and types	3.74	2.86	10.71	Red
PM	Poor project management	4.36	2.94	12.81	Red
PM	Frequent changes to the scope of work	4.22	3.04	12.82	Red
PM	Delays in decisions making	4.09	3.01	12.31	Red
PM	Poor contract management	3.81	2.94	11.21	Red
PM	Errors in contract documents	4.04	2.65	10.72	Red
PM	Unrealistic contract duration and requirements imposed	4.35	2.93	12.74	Red
PM	Owner interference	3.60	2.83	10.21	Red
PM	Inaccurate time and cost estimates of project	4.27	3.07	13.10	Red

Table 29 - Cost Overrun factor group risk matrix top factors Importance VS Impact on Cost

Code	Factor (Title of the point)	Importance (I) Mean value	Impact on Cost (CI) Mean value	I*CI	Zone
CPH	Insufficient site management and inspection	3.73	3.62	13.53	Red
CPH	Schedule delay	4.10	4.12	16.88	Red
CPH	Improper planning and scheduling	4.33	4.13	17.86	Red
CPH	Improper monitoring and control	3.84	3.84	14.76	Red
CPH	Lack of experience in handling construction projects	3.65	3.64	13.31	Red
CPH	Delay in inspection and approval of completed work	3.35	3.32	11.10	Red
CPH	Errors during construction	3.53	3.47	12.25	Red
CPH	Accidents on site	3.70	3.32	12.28	Red
D	Frequent Design changes	4.36	4.22	18.37	Red
D	Design errors and mistakes	3.99	3.84	15.33	Red
D	Incomplete design at time of tender	3.99	3.95	15.76	Red
D	Deficient design and delays in design process	3.81	3.59	13.70	Red
D	Delay in approval of drawings	3.63	3.34	12.12	Red
F	Delay in progress payment by owner for work completed	4.13	3.55	14.68	Red
F	Financial difficulties of owner	4.08	3.73	15.23	Red
F	Cash flow difficulties faced by contractor	3.97	3.58	14.23	Red
F	Poor financial control on site	3.76	3.62	13.63	Red

F	Delay payment to supplier /subcontractor	3.81	3.50	13.36	Red
C	Weak communication between project parties	3.78	3.42	12.92	Red
C	Weak coordination between project parties	3.85	3.32	12.77	Red
C	Weak collaboration between management and labour	3.39	2.98	10.09	Red
L	Low labour productivity	3.97	3.53	14.03	Red
L	Lack and shortage of skilled labours	4.05	3.50	14.15	Red
L	Inflation in the cost of labours	3.69	3.50	12.94	Red
M&E	Fluctuation in raw material prices	4.08	3.59	14.66	Red
M&E	Late delivery of materials and equipment	3.92	3.41	13.35	Red
M&E	Insufficient number of equipment	3.36	3.18	10.67	Red
M&E	Changes in material specs and types	3.74	3.60	13.49	Red
PM	Poor project management	4.36	4.01	17.47	Red
PM	Frequent changes to the scope of work	4.22	4.18	17.62	Red
PM	Delays in decisions making	4.09	3.69	15.10	Red
PM	Poor contract management	3.81	3.63	13.85	Red
PM	Errors in contract documents	4.04	3.85	15.56	Red
PM	Unrealistic contract duration and requirements imposed	4.35	4.15	18.03	Red
PM	Owner interference	3.60	3.23	11.63	Red
PM	Inaccurate time and cost estimates of project	4.27	4.04	17.24	Red

Table 30 - Cost Overrun factor group risk matrix top factors Importance VS Frequency

Code	Factor (Title of the point)	Frequency Mean value	Impact on Cost Mean value	F*CI	Zone
CPH	Insufficient site management and inspection	2.99	3.62	10.84	Red
CPH	Schedule delay	3.47	4.12	14.27	Red
CPH	Improper planning and scheduling	3.27	4.13	13.49	Red
CPH	Improper monitoring and control	3.01	3.84	11.56	Red
CPH	Lack of experience in handling construction projects	2.92	3.64	10.64	Red
CPH	Delay in inspection and approval of completed work	3.16	3.32	10.48	Red
D	Frequent Design changes	3.03	4.22	12.78	Red
D	Incomplete design at time of tender	2.75	3.95	10.87	Red
F	Delay in progress payment by owner for work completed	3.06	3.55	10.87	Red
F	Cash flow difficulties faced by contractor	2.92	3.58	10.47	Red
F	Poor financial control on site	2.79	3.62	10.12	Red
F	Delay payment to supplier	3.03	3.50	10.62	Red
L	Low labour productivity	2.91	3.53	10.29	Red
L	Lack and shortage of skilled labours	3.18	3.50	11.11	Red
M&E	Late delivery of materials and equipment	2.98	3.41	10.15	Red
M&E	Changes in material specs and types	2.86	3.60	10.31	Red

PM	Poor project management	2.94	4.01	11.79	Red
PM	Frequent changes to the scope of work	3.04	4.18	12.70	Red
PM	Delays in decisions making	3.01	3.69	11.12	Red
PM	Poor contract management	2.94	3.63	10.69	Red
PM	Errors in contract documents	2.65	3.85	10.22	Red
PM	Unrealistic contract duration and requirements imposed	2.93	4.15	12.16	Red
PM	Inaccurate time and cost estimates of project	3.07	4.04	12.40	Red

5. Discussion, Recommendations and Conclusions.

5.1 Discussion

The objective of this project is to identify the most influential cost overrun attributes affecting the construction industry. After a review of past literature, a list of 39 cost overrun attributes was produced and presented in a questionnaire survey. The survey was distributed to various experts in the field of construction industry. 101 respondents evaluated the 39 cost overrun attributes based on importance (The cost overrun factor importance for a construction project), frequency (How often the attribute is implemented or considered) and the impact on cost (The extent of direct impact on project's cost overrun). The gathered data of 101 complete responses were then analyzed by Importance Index, Spearman's Rank Correlation, T-Test, Risk Mapping, and the following findings were discovered:

- The amount of cost overrun was commonly in the range of 11-20% of project's contract price as per the respondents.
- From Table 9, it can be concluded that the first most significant factors are the schedule delay (47%). This emphasizes what have been reported by the other journals which states that the project delay is of the main reasons for the project cost overrun.
- The second most significant factor was the improper planning and scheduling (47%). This shows that investing a little amount of money in hiring skilled planners and estimators will save the project from exceeding the budgeted cost and this will save the company's profit, reputation and continuity.

- Frequent Design changes (45%) and frequent changes to the scope of work (43%) were seen as the third and fourth most important factors. These factors have a major consequence on any project, because changing the design of a single beam in a whole building might affect the scope, the cost and the duration of the whole project. In addition, it will require re-estimating the cost and the schedule required to complete the project and this needs resources and time. All these add very high additional costs to the project and therefore have a high Cost Index overrun in any project.
- Inaccurate time and cost estimates of project (42%) was the fifth important factor. This reflects the importance of hiring skilled and experienced planners and estimators in order to accurately estimate the required time and budget to complete the project.
- Looking at the value of Spearman's rank correlation factor, it can be concluded that there is a positive correlation between the RII and FCAII.

On comparing ranking of the attributes by experts in Qatar and GCC, it was recognized that:

- Qatar prioritizes Schedule delay, Improper planning and scheduling, Frequent Design changes, Inaccurate time and cost estimates of project and Unrealistic contract duration and requirements imposed. These attributes could be considered as the main reasons for the cost overrun in the Qatari construction projects, including superstructure, infrastructure and all other types of projects.
- On the other hand, experts from the rest of the GCC countries confirm that Improper planning and scheduling, Schedule delay, Frequent changes to the scope of work,

Frequent Design changes and Poor project management are the top 5 reasons for the construction cost overrun in the GCC.

- It can be seen that Schedule delay, Improper planning and scheduling and Frequent Design changes are common top 5 attributes of construction cost overrun between Qatar and the rest of the GCC countries.
- Table 31 below summarizes the top 5 ranked cost overrun attributes based on the views of various compared groups.

Table 31 - Summary the top 5 ranked delay attributes by various views

	Qatar Ranking	FCAII	Rank
CPH2	Schedule delay	0.467	1
CPH3	Improper planning and scheduling	0.461	2
D1	Frequent Design changes	0.440	3
PM8	Inaccurate time and cost estimates of project	0.434	4
PM6	Unrealistic contract duration and requirements imposed	0.431	5

	GCC Ranking	FCAII	Rank
CPH3	Improper planning and scheduling	0.493	1
CPH2	Schedule delay	0.471	2
PM2	Frequent changes to the scope of work	0.466	3
D1	Frequent Design changes	0.442	4
PM1	Poor project management	0.437	5

	Owner Ranking	FCAII	Rank
D1	Frequent Design changes	0.428	1
CPH3	Improper planning and scheduling	0.394	2
M&E4	Changes in material specs and types	0.351	3
PM8	Inaccurate time and cost estimates of project	0.349	4
CPH2	Schedule delay	0.343	5

	Contractor Ranking	FCAII	Rank
CPH2	Schedule delay	0.445	1
CPH3	Improper planning and scheduling	0.440	2
D1	Frequent Design changes	0.375	3
PM1	Poor project management	0.374	4
PM2	Frequent changes to the scope of work	0.364	5

	Consultant Ranking	FCAII	Rank
PM8	Inaccurate time and cost estimates of project	0.553	2
CPH2	Schedule delay	0.544	3
D1	Frequent Design changes	0.538	4
PM2	Frequent changes to the scope of work	0.518	5

	Subcontractor Ranking	FCAII	Rank
D1	Frequent Design changes	0.596	2
CPH2	Schedule delay	0.572	3
PM2	Frequent changes to the scope of work	0.567	4
PM6	Unrealistic contract duration and requirements imposed	0.538	5

	Project/Construction Manager Ranking	FCAII	Rank
CPH2	Schedule delay	0.555	1
D1	Frequent Design changes	0.460	2
PM2	Frequent changes to the scope of work	0.452	3
PM6	Unrealistic contract duration and requirements imposed	0.436	4
CPH3	Improper planning and scheduling	0.428	5

	Project Engineers Ranking	FCAII	Rank
CPH3	Improper planning and scheduling	0.425	1
CPH4	Improper monitoring and control	0.371	2
PM2	Frequent changes to the scope of work	0.369	3
PM1	Poor project management	0.340	4
PM8	Inaccurate time and cost estimates of project	0.339	5

	Superstructure Ranking	FCAII	Rank
CPH6	Delay in inspection and approval of completed work	0.499	1
PM8	Inaccurate time and cost estimates of project	0.494	2
PM2	Frequent changes to the scope of work	0.474	3
PM6	Unrealistic contract duration and requirements imposed	0.466	4
C3	Weak communication between project parties	0.459	5

	Infrastructure Ranking	FCAII	Rank
C2	Weak collaboration between management and labour	0.520	1
C3	Weak communication between project parties	0.473	2
L2	Lack and shortage of skilled labours	0.407	3
PM1	Poor project management	0.381	4
CPH6	Delay in inspection and approval of completed work	0.379	5

	Experts with More than 16 years Experience	FCAII	Rank
CPH2	Schedule delay	0.581	1
D1	Frequent Design changes	0.537	2
PM6	Unrealistic contract duration and requirements imposed	0.529	3
CPH3	Improper planning and scheduling	0.485	4
PM8	Inaccurate time and cost estimates of project	0.458	5

	Experts with Less than 16 years Experience	FCAII	RanK
CPH3	Improper planning and scheduling	0.459	1
PM1	Poor project management	0.436	2
PM2	Frequent changes to the scope of work	0.422	3
CPH2	Schedule delay	0.421	4
PM8	Inaccurate time and cost estimates of project	0.409	5

	Large Companies Ranking	FCAII	Rank
C2	Weak collaboration between management and labour	0.459	1
C3	Weak communication between project parties	0.434	2
CPH6	Delay in inspection and approval of completed work	0.425	3
PM6	Unrealistic contract duration and requirements imposed	0.419	4
PM8	Inaccurate time and cost estimates of project	0.406	5

	Medium Companies Ranking	FCAII	Rank
PM2	Frequent changes to the scope of work	0.506	1
D2	Design errors and mistakes	0.489	2
C3	Weak communication between project parties	0.481	3
CPH6	Delay in inspection and approval of completed work	0.466	4
C2	Weak collaboration between management and labour	0.461	5

Another ranking tool used was the risk mapping matrix. From Tables 28, 29 and 30, it can be concluded that the most ranked factor of each cost overrun category based on mean values are Frequent Design changes, Unrealistic contract duration and requirements imposed, Improper planning and scheduling, Frequent changes to the scope of work, Fluctuation in raw material prices, Schedule delay and Delay in progress payment by owner for work completed. It can be seen that the majority of factors can be controlled by hiring experienced designers, estimators, planners and project managers.

5.2 Recommendations

5.2.1 Qatar

In Qatar, the top 5 ranked influential cost overrun attributes by experts, as shown in Table 31, were:

1- Schedule delay
2- Improper planning and scheduling
3- Frequent Design changes
4- Inaccurate time and cost estimates of project
5- Unrealistic contract duration and requirements imposed

It is strongly recommended to all construction project participants in Qatar to strictly avoid the project delay attributes as they proved to be a key reason that leads to cost overruns. It is also recommended that the contractors in Qatar invest their money in hiring skilled planners and estimators as their work accuracy plays a crucial role in avoiding cost overruns due to unrealistic contract duration and improper planning and estimating.

5.2.2 Owner

It is recommended to for the owners to hire an experienced architect/designer to avoid design mistakes and errors. In addition, the owner, with the assistance of the designer, should choose the right contractor by studying the contractors' history. This includes

their past projects, their organizational structure, their management systems, their list of subcontractors, etc. It is also strongly recommended for the owners not to start any tender without making sure that they have the enough cash flow to run the project until the end with no single delay in any progress payment.

5.2.3 Contractor

As per table 9, the first and second causes of the cost overrun based on FCAII ranking are the schedule delay and the improper planning and scheduling, respectively. This indicates that contractors have the main role in influencing construction projects performance from the schedule and budget sides. The contractors should always have updated list of materials and equipment unit prices and potential suppliers to eliminate the possibility of materials or equipment stock-outs. It is recommended to the contractors to keep monitoring and inspecting their labors work in order to assure an acceptable labors productivity. Since the contractor is responsible for the subcontractor's work, he is strongly recommended to keep a close eye on the sub-contractors work and performance including revising the work progress, budget and even making sure that the subcontractor is adhering to the health and safety instructions and regulations. Investing a certain amount of money labors training, hiring skilled estimators, site inspectors, project managers and experienced subcontractors, will yield to a profit with much higher amount of money than what have been invested.

5.3 Conclusions

Various researches were conducted to understand the factors affecting the construction projects cost overrun. However, no study was conducted to identify the factors affecting Qatari construction industry and its comparison with the rest of the GCC countries.

This study focused on identifying the influential cost overrun attributes affecting construction industry including the Qatari construction industry. 39 cost overrun attributes were collected based on literature review. In order to rank these attributes, an online survey questionnaire was distributed among various professionals with various backgrounds, expertise, and locations, involved in remarkable numerous projects within the construction field. Analysis of the questionnaire results were performed by various statistical ranking tools such as relative importance index, frequency importance index, cost impact index, frequency-cost adjusted importance index, Spearman's rank correlation, T-Test, and risk mapping. Comparisons to results were discussed and recommendations were made.

5.4 Future Works

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

- Since the higher number of respondents reflects a more reliable results and conclusions, the survey of this project can be distributed to more professionals with various backgrounds and different industry experiences from Qatar, GCC, and rest of the world.

- More face-to-face interviews. The face-to-face interviews result in new ideas and allow the interviewer to understand the concept of the interviewee. This will open new horizons for any research to go further and deeper.
- Each attribute of the 39 ones mentioned in this research can be studied separately to draw conclusions that help in eliminating it.
- Despite its difficulty due to the high confidentiality, conducting case studies on real cost overruns in Qatari construction projects will help in minimizing the future ones. This can be done by a governmental agency or a ministry in order to be able to access those confidential data and records.

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