QATAR UNIVERSITY
COLLEGE OF ENGINEERING

Causes of Cost-Overrun in Construction Projects

BY
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for the Degree of
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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.
Acknowledgments

I would like to express my gratitude to all those who gave me the possibility to complete this project. I am deeply grateful to my supervisor Prof. Dr. Murat Gunduz whose help, stimulating suggestions and encouragement helped me in all the time in writing this project.

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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, Omorogie [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 have attempted to 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]: 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.

Frimpong [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

<table>
<thead>
<tr>
<th>1- Construction Phase Factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient site management and inspection</td>
<td>[3], [5], [6], [23], [36], [38], [39], [43], [44], [48], [49], [57]</td>
</tr>
<tr>
<td>Schedule delay</td>
<td>[3], [10], [37]</td>
</tr>
<tr>
<td>Improper planning and scheduling</td>
<td>[2], [3], [4], [5], [6], [8], [15], [20], [23]</td>
</tr>
<tr>
<td>Improper monitoring and control</td>
<td>[3], [4], [5], [6], [20], [39], [45], [48]</td>
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<tr>
<td>Lack of experience in handling construction projects</td>
<td>[8], [15], [23], [36], [38], [39], [40], [42], [44]</td>
</tr>
<tr>
<td>Delay in inspection and approval of completed work</td>
<td>[34], [57], [36], [39], [43], [44], [45], [48], [49], [50], [51], [55]</td>
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<tr>
<td>Errors during construction</td>
<td>[34], [57], [35], [36], [44], [45], [49], [58], [54]</td>
</tr>
<tr>
<td>Accidents on site</td>
<td>[40], [43], [49], [50]</td>
</tr>
<tr>
<td>Effect of weather</td>
<td>[3], [34], [36], [20], [39], [40], [41], [42], [43], [44], [46]</td>
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<tr>
<td>Unforeseen ground conditions</td>
<td>[36], [57], [38], [39], [40], [44], [45]</td>
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<tr>
<th>2- Design Factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent Design changes</td>
<td>[2], [3], [6], [8], [10], [15], [20], [23]</td>
</tr>
<tr>
<td>Design errors and mistakes</td>
<td>[4], [22], [34], [49], [50], [51], [57]</td>
</tr>
<tr>
<td>Incomplete design at time of tender</td>
<td>[4], [6], [15]</td>
</tr>
<tr>
<td>Deficient design and delays in design process</td>
<td>[43], [59]</td>
</tr>
<tr>
<td>Delay in approval of drawings</td>
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<tr>
<th>3- Financial Factors</th>
<th>References</th>
</tr>
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<tr>
<td>Delay in progress payment by owner for work completed</td>
<td>[2], [4], [6], [20], [34], [43], [44], [45], [48], [50], [51]</td>
</tr>
<tr>
<td>Financial difficulties of owner</td>
<td>[6], [20], [30], [57], [20], [39], [41], [42], [51], [52]</td>
</tr>
<tr>
<td>Cash flow difficulties faced by contractor</td>
<td>[4], [6], [20], [30], [34], [39], [57], [45], [49], [50], [51]</td>
</tr>
<tr>
<td>Poor financial control on site</td>
<td>[6], [8], [35], [46]</td>
</tr>
<tr>
<td>Delay payment to supplier/subcontractor</td>
<td>[10], [30], [51]</td>
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</tbody>
</table>

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<thead>
<tr>
<th>4- Communication Factors</th>
<th>References</th>
</tr>
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<tbody>
<tr>
<td>Weak communication between project parties</td>
<td>[8], [2], [5], [6], [15], [23], [22], [34], [36], [38], [39]</td>
</tr>
<tr>
<td>Weak coordination between project parties</td>
<td>[34], [40], [46], [48], [50], [51], [58], [55]</td>
</tr>
<tr>
<td>Weak collaboration between management and labour</td>
<td>[39], [46], [50]</td>
</tr>
<tr>
<td>Disputes on site</td>
<td>[34], [36], [43], [44], [46], [48]</td>
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<tr>
<th>5- Labour Factors</th>
<th>References</th>
</tr>
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<tbody>
<tr>
<td>Low labour productivity</td>
<td>[3], [30], [36], [38], [43], [44], [54], [56]</td>
</tr>
<tr>
<td>Lack and shortage of skilled labours</td>
<td>[3], [4], [6], [8], [20], [22], [23], [30], [34], [38], [40]</td>
</tr>
<tr>
<td>Inflation in the cost of labours</td>
<td>[4], [6], [8]</td>
</tr>
</tbody>
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<tr>
<th>6- Material and equipment Factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluctuation in raw material prices</td>
<td>[4], [6], [8], [10], [15], [20], [22], [23]</td>
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<tr>
<td>Late delivery of materials and equipment</td>
<td>[2], [3], [4], [6], [10], [20], [22], [30], [34], [43], [45], [49]</td>
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<tr>
<td>Insufficient number of equipment</td>
<td>[3], [34], [43], [48], [50], [51], [52], [53]</td>
</tr>
<tr>
<td>Changes in material specs and types</td>
<td>[3], [34], [43], [48], [50], [51]</td>
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<td>------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>7- Project Management Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Poor project management</td>
<td>[2], [6], [22], [57], [39], [49]</td>
</tr>
<tr>
<td>Frequent changes to the scope of work</td>
<td>[3], [4], [6], [15], [20], [23], [30], [40], [43]</td>
</tr>
<tr>
<td>Delays in decisions making</td>
<td>[15], [20], [23], [34], [36], [38], [39], [43], [44]</td>
</tr>
<tr>
<td>Poor contract management</td>
<td>[36], [39], [44], [45], [46], [57]</td>
</tr>
<tr>
<td>Errors in contract documents</td>
<td>[36], [40], [43], [44], [48], [49]</td>
</tr>
<tr>
<td>Unrealistic contract duration and requirements imposed</td>
<td>[36], [38], [39], [40], [43], [44], [46], [48]</td>
</tr>
<tr>
<td>Owner interference</td>
<td>[35], [36], [39], [43], [51], [56]</td>
</tr>
<tr>
<td>Inaccurate time and cost estimates of project</td>
<td>[3], [4], [5], [10], [20], [57], [37], [39], [45], [56]</td>
</tr>
</tbody>
</table>
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:

\[ RII = \sum_{i=1}^{5} \frac{W_i \times X_i}{A \times N} \]

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.

\[ RII = \sum_{i=1}^{5} \frac{W_i \times X_i}{A+N} \]

\[ FI = \frac{\sum W_i \times X_i}{A(N)} \]

\[ CII = \frac{\sum W_i \times X_i}{A(N)} \]

\[ FCAII = RII \times FI \times CII \]
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.

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

where,
\(x_1\) = Mean of first set of values, \(x_2\) = Mean of second set of values
\(s_1\) = Standard deviation of first set of values, \(s_2\) = Standard deviation of second set of values
\(n_1\) = Total number of values in first set
\(n_2\) = Total number of values in second set

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 $D_i$, between any ranking of the, between any ranking of the $i^{th}$ item by the groups would be

$$D_i = |Ri1 − Ri2|$$

Where $i = 1, 2, \ldots, N$

And there are $N$ items

$$D_{\text{max}} = |Ri1 − Rj2|$$

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:

$$\text{PD} = 100 \times \frac{\sum_{i=1}^{N} |Ri1 − Ri2|}{\sum_{X=1}^{N} |Rx1 − Rj2|}$$

$$\text{PA} = 100 − \text{PD}$$

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

<table>
<thead>
<tr>
<th>Risk Matrix</th>
<th>5 - Very High</th>
<th>4 - High</th>
<th>3 - Moderate</th>
<th>2 - Low</th>
<th>1 - Very Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Very Low</td>
<td>5</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2 - Low</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>3 - Moderate</td>
<td>15</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>4 - High</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>5 - Very High</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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

![Pie chart showing location distribution]

<table>
<thead>
<tr>
<th>Location</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar</td>
<td>71.6%</td>
</tr>
<tr>
<td>GCC (Saudi Arabia, Kuwait, Bahrain, Oman, UAE)</td>
<td>28.4%</td>
</tr>
</tbody>
</table>

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

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

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

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

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

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

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

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

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4.3.1 Hierarchical 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**

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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

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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

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<td>D</td>
<td>Design errors and mistakes</td>
<td>8</td>
<td>6</td>
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<td>34</td>
<td>0.768</td>
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<tr>
<td>F</td>
<td>Financial difficulties of owner</td>
<td>10</td>
<td>8</td>
<td>19</td>
<td>26</td>
<td>38</td>
<td>0.747</td>
<td>12</td>
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<tr>
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<td>Delays in decisions making</td>
<td>4</td>
<td>12</td>
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<td>0.739</td>
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<tr>
<td>PM</td>
<td>Lack of experience in handling construction projects</td>
<td>7</td>
<td>9</td>
<td>20</td>
<td>42</td>
<td>23</td>
<td>0.729</td>
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<tr>
<td>CPH</td>
<td>Poor contract management</td>
<td>8</td>
<td>7</td>
<td>20</td>
<td>45</td>
<td>21</td>
<td>0.727</td>
<td>15</td>
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<tr>
<td>CPH</td>
<td>Insufficient site management and inspection</td>
<td>7</td>
<td>6</td>
<td>22</td>
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<td>Poor financial control on site</td>
<td>10</td>
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<td>Changes in material specs and types</td>
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<td>0.721</td>
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<td>Deficient design and delays in design process</td>
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<td>13</td>
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<td>39</td>
<td>22</td>
<td>0.719</td>
<td>19</td>
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<tr>
<td>M&amp;E</td>
<td>Fluctuation in raw material prices</td>
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<td>20</td>
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<tr>
<td>F</td>
<td>Cash flow difficulties faced by contractor</td>
<td>9</td>
<td>8</td>
<td>19</td>
<td>45</td>
<td>20</td>
<td>0.717</td>
<td>21</td>
</tr>
<tr>
<td>F</td>
<td>Delay in progress payment by owner for work completed</td>
<td>14</td>
<td>6</td>
<td>16</td>
<td>40</td>
<td>25</td>
<td>0.711</td>
<td>22</td>
</tr>
<tr>
<td>L</td>
<td>Low labor productivity</td>
<td>5</td>
<td>16</td>
<td>23</td>
<td>34</td>
<td>23</td>
<td>0.707</td>
<td>23</td>
</tr>
<tr>
<td>F</td>
<td>Delay payment to supplier/subcontractor</td>
<td>11</td>
<td>7</td>
<td>22</td>
<td>42</td>
<td>19</td>
<td>0.701</td>
<td>24</td>
</tr>
<tr>
<td>L</td>
<td>Inflation in the cost of labors</td>
<td>13</td>
<td>17</td>
<td>12</td>
<td>24</td>
<td>35</td>
<td>0.701</td>
<td>25</td>
</tr>
</tbody>
</table>
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:

\[ \text{FCAII} = \text{RI} \times \text{FI} \times \text{CII} \]

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Factor</th>
<th>RI</th>
<th>FI</th>
<th>CII</th>
<th>FCAII</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPH</td>
<td>Schedule delay</td>
<td>0.820</td>
<td>0.693</td>
<td>0.824</td>
<td>0.47</td>
<td>1</td>
</tr>
<tr>
<td>CPH</td>
<td>Improper planning and scheduling</td>
<td>0.865</td>
<td>0.653</td>
<td>0.826</td>
<td>0.47</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>Frequent Design changes</td>
<td>0.871</td>
<td>0.606</td>
<td>0.844</td>
<td>0.45</td>
<td>3</td>
</tr>
<tr>
<td>PM</td>
<td>Frequent changes to the scope of work</td>
<td>0.844</td>
<td>0.608</td>
<td>0.836</td>
<td>0.43</td>
<td>4</td>
</tr>
<tr>
<td>PM</td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.853</td>
<td>0.614</td>
<td>0.808</td>
<td>0.42</td>
<td>5</td>
</tr>
<tr>
<td>PM</td>
<td>Unrealistic contract duration and requirements imposed</td>
<td>0.869</td>
<td>0.586</td>
<td>0.830</td>
<td>0.42</td>
<td>6</td>
</tr>
<tr>
<td>PM</td>
<td>Poor project management</td>
<td>0.871</td>
<td>0.588</td>
<td>0.802</td>
<td>0.41</td>
<td>7</td>
</tr>
<tr>
<td>PM</td>
<td>Delays in decisions making</td>
<td>0.818</td>
<td>0.602</td>
<td>0.739</td>
<td>0.36</td>
<td>8</td>
</tr>
<tr>
<td>L</td>
<td>Lack and shortage of skilled labors</td>
<td>0.810</td>
<td>0.636</td>
<td>0.699</td>
<td>0.36</td>
<td>9</td>
</tr>
<tr>
<td>F</td>
<td>Delay in progress payment by owner for work completed</td>
<td>0.826</td>
<td>0.612</td>
<td>0.711</td>
<td>0.36</td>
<td>10</td>
</tr>
<tr>
<td>CPH</td>
<td>Improper monitoring and control</td>
<td>0.768</td>
<td>0.602</td>
<td>0.768</td>
<td>0.36</td>
<td>11</td>
</tr>
<tr>
<td>D</td>
<td>Incomplete design at time of tender</td>
<td>0.798</td>
<td>0.550</td>
<td>0.790</td>
<td>0.35</td>
<td>12</td>
</tr>
<tr>
<td>F</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.794</td>
<td>0.584</td>
<td>0.717</td>
<td>0.33</td>
<td>13</td>
</tr>
<tr>
<td>PM</td>
<td>Errors in contract documents</td>
<td>0.808</td>
<td>0.531</td>
<td>0.770</td>
<td>0.33</td>
<td>14</td>
</tr>
<tr>
<td>L</td>
<td>Low labor productivity</td>
<td>0.794</td>
<td>0.582</td>
<td>0.707</td>
<td>0.33</td>
<td>15</td>
</tr>
<tr>
<td>PM</td>
<td>Poor contract management</td>
<td>0.762</td>
<td>0.588</td>
<td>0.727</td>
<td>0.33</td>
<td>16</td>
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<tr>
<td>M&amp;E</td>
<td>Fluctuation in raw material prices</td>
<td>0.816</td>
<td>0.552</td>
<td>0.719</td>
<td>0.32</td>
<td>17</td>
</tr>
<tr>
<td>F</td>
<td>Delay payment to supplier /subcontractor</td>
<td>0.762</td>
<td>0.606</td>
<td>0.701</td>
<td>0.32</td>
<td>18</td>
</tr>
<tr>
<td>CPH</td>
<td>Insufficient site management and inspection</td>
<td>0.747</td>
<td>0.598</td>
<td>0.725</td>
<td>0.32</td>
<td>19</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Late delivery of materials and equipment</td>
<td>0.784</td>
<td>0.596</td>
<td>0.681</td>
<td>0.32</td>
<td>20</td>
</tr>
<tr>
<td>D</td>
<td>Design errors and mistakes</td>
<td>0.798</td>
<td>0.513</td>
<td>0.768</td>
<td>0.31</td>
<td>21</td>
</tr>
<tr>
<td>CPH</td>
<td>Lack of experience in handling construction projects</td>
<td>0.731</td>
<td>0.584</td>
<td>0.729</td>
<td>0.31</td>
<td>22</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Changes in material specs and types</td>
<td>0.749</td>
<td>0.572</td>
<td>0.721</td>
<td>0.31</td>
<td>23</td>
</tr>
<tr>
<td>-------------</td>
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<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
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</tr>
<tr>
<td>F</td>
<td>Poor financial control on site</td>
<td>0.752</td>
<td>0.558</td>
<td>0.725</td>
<td>0.30</td>
<td>24</td>
</tr>
<tr>
<td>F</td>
<td>Financial difficulties of owner</td>
<td>0.816</td>
<td>0.493</td>
<td>0.747</td>
<td>0.30</td>
<td>25</td>
</tr>
<tr>
<td>C</td>
<td>Weak communication between project parties</td>
<td>0.756</td>
<td>0.576</td>
<td>0.683</td>
<td>0.30</td>
<td>26</td>
</tr>
<tr>
<td>C</td>
<td>Weak coordination between project parties</td>
<td>0.770</td>
<td>0.578</td>
<td>0.663</td>
<td>0.30</td>
<td>27</td>
</tr>
<tr>
<td>D</td>
<td>Deficient design and delays in design process</td>
<td>0.762</td>
<td>0.529</td>
<td>0.719</td>
<td>0.29</td>
<td>28</td>
</tr>
<tr>
<td>D</td>
<td>Delay in approval of drawings</td>
<td>0.727</td>
<td>0.586</td>
<td>0.667</td>
<td>0.28</td>
<td>29</td>
</tr>
<tr>
<td>CPH</td>
<td>Delay in inspection and approval of completed work</td>
<td>0.669</td>
<td>0.632</td>
<td>0.663</td>
<td>0.28</td>
<td>30</td>
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<tr>
<td>CPH</td>
<td>Errors during construction</td>
<td>0.707</td>
<td>0.572</td>
<td>0.693</td>
<td>0.28</td>
<td>31</td>
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<tr>
<td>PM</td>
<td>Owner interference</td>
<td>0.721</td>
<td>0.566</td>
<td>0.646</td>
<td>0.26</td>
<td>32</td>
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<td>L</td>
<td>Inflation in the cost of labors</td>
<td>0.739</td>
<td>0.507</td>
<td>0.701</td>
<td>0.26</td>
<td>33</td>
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<tr>
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<td>Insufficient number of equipment</td>
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<td>0.550</td>
<td>0.636</td>
<td>0.23</td>
<td>34</td>
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<tr>
<td>C</td>
<td>Weak collaboration between management and labor</td>
<td>0.677</td>
<td>0.549</td>
<td>0.596</td>
<td>0.22</td>
<td>35</td>
</tr>
<tr>
<td>CPH</td>
<td>Accidents on site</td>
<td>0.741</td>
<td>0.418</td>
<td>0.663</td>
<td>0.21</td>
<td>36</td>
</tr>
<tr>
<td>C</td>
<td>Disputes on site</td>
<td>0.628</td>
<td>0.513</td>
<td>0.584</td>
<td>0.19</td>
<td>37</td>
</tr>
<tr>
<td>CPH</td>
<td>Unforeseen ground conditions</td>
<td>0.578</td>
<td>0.400</td>
<td>0.547</td>
<td>0.13</td>
<td>38</td>
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<tr>
<td>CPH</td>
<td>Effect of weather</td>
<td>0.497</td>
<td>0.430</td>
<td>0.446</td>
<td>0.10</td>
<td>39</td>
</tr>
</tbody>
</table>

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 Fl rankings for all respondents

<table>
<thead>
<tr>
<th>Category</th>
<th>Factors</th>
<th>RI</th>
<th>RI Rank</th>
<th>FI</th>
<th>FI rank</th>
<th>d</th>
<th>d^2</th>
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</thead>
<tbody>
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<td>C1</td>
<td>Disputes on site</td>
<td>0.628</td>
<td>37</td>
<td>0.513</td>
<td>34</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>C2</td>
<td>Weak collaboration between management and labor</td>
<td>0.677</td>
<td>34</td>
<td>0.549</td>
<td>30</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>C3</td>
<td>Weak communication between project parties</td>
<td>0.756</td>
<td>24</td>
<td>0.576</td>
<td>22</td>
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<td>4</td>
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<td>Weak coordination between project parties</td>
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<td>0.578</td>
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<td>2</td>
<td>4</td>
</tr>
<tr>
<td>CPH1</td>
<td>Accidents on site</td>
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<td>28</td>
<td>0.418</td>
<td>38</td>
<td>10</td>
<td>100</td>
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<td>Delay in inspection and approval of completed work</td>
<td>0.669</td>
<td>36</td>
<td>0.632</td>
<td>4</td>
<td>32</td>
<td>1024</td>
</tr>
<tr>
<td>CPH3</td>
<td>Effect of weather</td>
<td>0.497</td>
<td>39</td>
<td>0.430</td>
<td>37</td>
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<td>4</td>
</tr>
<tr>
<td>CPH4</td>
<td>Errors during construction</td>
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<td>33</td>
<td>0.572</td>
<td>23</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>CPH5</td>
<td>Improper monitoring and control</td>
<td>0.768</td>
<td>20</td>
<td>0.602</td>
<td>10</td>
<td>10</td>
<td>100</td>
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<tr>
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<td>Improper planning and scheduling</td>
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<td>4</td>
<td>0.653</td>
<td>2</td>
<td>2</td>
<td>4</td>
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<tr>
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<td>Insufficient site management and inspection</td>
<td>0.747</td>
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<td>0.598</td>
<td>12</td>
<td>15</td>
<td>225</td>
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<td>Lack of experience in handling construction projects</td>
<td>0.731</td>
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<td>0.584</td>
<td>18</td>
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<td>0.400</td>
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<td>1</td>
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<td>D1</td>
<td>Deficient design and delays in design process</td>
<td>0.762</td>
<td>21</td>
<td>0.529</td>
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<td>121</td>
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<tr>
<td>D2</td>
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<td>31</td>
<td>0.586</td>
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<td>15</td>
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<td>0.513</td>
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<td>0.606</td>
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<td>7</td>
<td>49</td>
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<tr>
<td>D5</td>
<td>Incomplete design at time of tender</td>
<td>0.798</td>
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<td>0.550</td>
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<td>13</td>
<td>169</td>
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<tr>
<td>F1</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.794</td>
<td>16</td>
<td>0.584</td>
<td>19</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>F2</td>
<td>Delay in progress payment by owner for work completed</td>
<td>0.826</td>
<td>7</td>
<td>0.612</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>F3</td>
<td>Delay payment to supplier/subcontractor</td>
<td>0.762</td>
<td>22</td>
<td>0.606</td>
<td>9</td>
<td>13</td>
<td>169</td>
</tr>
<tr>
<td>F4</td>
<td>Financial difficulties of owner</td>
<td>0.816</td>
<td>10</td>
<td>0.493</td>
<td>36</td>
<td>26</td>
<td>676</td>
</tr>
<tr>
<td>F5</td>
<td>Poor financial control on site</td>
<td>0.752</td>
<td>25</td>
<td>0.558</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>L1</td>
<td>Inflation in the cost of labors</td>
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<td>29</td>
<td>0.507</td>
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<td>6</td>
<td>36</td>
</tr>
<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
<td>0.810</td>
<td>12</td>
<td>0.636</td>
<td>3</td>
<td>9</td>
<td>81</td>
</tr>
<tr>
<td>L3</td>
<td>Low labor productivity</td>
<td>0.794</td>
<td>17</td>
<td>0.582</td>
<td>20</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>M&amp;E1</td>
<td>Changes in material specs and types</td>
<td>0.749</td>
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**Sum** 4794

Spearman’s Rank Correlation 0.515
### Table 11 - Spearman's rank correlation factor for RI vs CI rankings for all respondents

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**SUM**

| Spearman's Rank Correlation | 0.665 |

50
Table 12 - Spearman's rank correlation factor for FI vs CI rankings for all respondents

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

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<th>CI Rank</th>
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<td>Cash flow difficulties faced by contractor</td>
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<td>21</td>
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<td>17</td>
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<td>25</td>
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<td>17</td>
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<td>13</td>
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<td>Delays in decisions making</td>
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<td>11</td>
<td>13</td>
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<td>Errors in contract documents</td>
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</table>
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

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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.

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<th>GC FCAII</th>
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<td>D5</td>
<td>Deficient design and delays in design process</td>
<td>0.252</td>
<td>22</td>
<td>0.268</td>
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<td>Delay in approval of drawings</td>
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<td>Rank</td>
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<td>Duration</td>
<td>Correlation</td>
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<td>Delay in progress payment by owner for work completed</td>
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<td>0.329</td>
<td>10</td>
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<td>F2</td>
<td>Financial difficulties of owner</td>
<td>0.197</td>
<td>30</td>
<td>0.278</td>
<td>21</td>
<td>9</td>
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<td>F3</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.240</td>
<td>25</td>
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<td>16</td>
<td>9</td>
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<tr>
<td>F4</td>
<td>Poor financial control on site</td>
<td>0.155</td>
<td>35</td>
<td>0.289</td>
<td>19</td>
<td>16</td>
<td>256</td>
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<tr>
<td>F5</td>
<td>Delay payment to supplier/subcontractor</td>
<td>0.197</td>
<td>29</td>
<td>0.299</td>
<td>15</td>
<td>14</td>
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<tr>
<td>L1</td>
<td>Inflation in the cost of labors</td>
<td>0.155</td>
<td>34</td>
<td>0.227</td>
<td>30</td>
<td>4</td>
<td>16</td>
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<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
<td>0.296</td>
<td>11</td>
<td>0.324</td>
<td>11</td>
<td>0</td>
<td>0</td>
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<tr>
<td>L3</td>
<td>Low labor productivity</td>
<td>0.301</td>
<td>10</td>
<td>0.305</td>
<td>13</td>
<td>3</td>
<td>9</td>
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<td>M&amp;E1</td>
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<td>32</td>
<td>0.303</td>
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<td>Late delivery of materials and equipment</td>
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<td>16</td>
<td>0.271</td>
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<td>Insufficient number of equipment</td>
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<td>34</td>
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<td>Changes in material specs and types</td>
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<td>Delays in decisions making</td>
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<td>Poor contract management</td>
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<td>0.271</td>
<td>22</td>
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<td>4</td>
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<td>Errors in contract documents</td>
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<td>18</td>
<td>0.283</td>
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<td>4</td>
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<tr>
<td>PM6</td>
<td>Unrealistic contract duration and requirements imposed</td>
<td>0.334</td>
<td>6</td>
<td>0.350</td>
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<td>9</td>
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<tr>
<td>PM7</td>
<td>Owner interference</td>
<td>0.254</td>
<td>20</td>
<td>0.190</td>
<td>35</td>
<td>15</td>
<td>225</td>
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<td>Inaccurate time and cost estimates of project</td>
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<td>4</td>
<td>0.361</td>
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</table>

SUM 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

<table>
<thead>
<tr>
<th>Factor</th>
<th>GC FCAII</th>
<th>Rank</th>
<th>Cons FCAII</th>
<th>Rank</th>
<th>d</th>
<th>d^2</th>
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</thead>
<tbody>
<tr>
<td>C1 Disputes on site</td>
<td>0.167</td>
<td>37</td>
<td>0.161</td>
<td>37</td>
<td>0</td>
<td>0</td>
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<tr>
<td>C2 Weak collaboration between management and labor</td>
<td>0.219</td>
<td>32</td>
<td>0.214</td>
<td>35</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>C3 Weak communication between project parties</td>
<td>0.255</td>
<td>27</td>
<td>0.327</td>
<td>20</td>
<td>7</td>
<td>49</td>
</tr>
<tr>
<td>C4 Weak coordination between project parties</td>
<td>0.252</td>
<td>28</td>
<td>0.363</td>
<td>15</td>
<td>13</td>
<td>169</td>
</tr>
<tr>
<td>CPH1 Insufficient site management and inspection</td>
<td>0.360</td>
<td>7</td>
<td>0.309</td>
<td>24</td>
<td>17</td>
<td>289</td>
</tr>
<tr>
<td>CPH10 Unforeseen ground conditions</td>
<td>0.101</td>
<td>38</td>
<td>0.155</td>
<td>38</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CPH2 Schedule delay</td>
<td>0.445</td>
<td>1</td>
<td>0.544</td>
<td>3</td>
<td>2</td>
<td>4</td>
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<tr>
<td>CPH3 Improper planning and scheduling</td>
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<td>2</td>
<td>0.493</td>
<td>6</td>
<td>4</td>
<td>16</td>
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<tr>
<td>CPH4 Improper monitoring and control</td>
<td>0.359</td>
<td>8</td>
<td>0.381</td>
<td>13</td>
<td>5</td>
<td>25</td>
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<tr>
<td>CPH5 Lack of experience in handling construction projects</td>
<td>0.290</td>
<td>17</td>
<td>0.279</td>
<td>28</td>
<td>11</td>
<td>121</td>
</tr>
<tr>
<td>CPH6 Delay in inspection and approval of completed work</td>
<td>0.223</td>
<td>31</td>
<td>0.256</td>
<td>31</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CPH7 Errors during construction</td>
<td>0.230</td>
<td>29</td>
<td>0.275</td>
<td>29</td>
<td>0</td>
<td>0</td>
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<tr>
<td>CPH8 Accidents on site</td>
<td>0.188</td>
<td>36</td>
<td>0.183</td>
<td>36</td>
<td>0</td>
<td>0</td>
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<tr>
<td>CPH9 Effect of weather</td>
<td>0.075</td>
<td>39</td>
<td>0.075</td>
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<td>0</td>
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<td>D1 Frequent Design changes</td>
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<td>3</td>
<td>0.538</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>D2 Design errors and mistakes</td>
<td>0.270</td>
<td>24</td>
<td>0.332</td>
<td>19</td>
<td>5</td>
<td>25</td>
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<tr>
<td>D3 Incomplete design at time of tender</td>
<td>0.313</td>
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<tr>
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<td>25</td>
<td>0.316</td>
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<tr>
<td>D5 Delay in approval of drawings</td>
<td>0.258</td>
<td>26</td>
<td>0.302</td>
<td>25</td>
<td>1</td>
<td>1</td>
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<tr>
<td>F1 Delay in progress payment by owner for work completed</td>
<td>0.329</td>
<td>10</td>
<td>0.467</td>
<td>9</td>
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<td>1</td>
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<td></td>
</tr>
<tr>
<td><strong>F2</strong></td>
<td>Financial difficulties of owner</td>
<td>0.278</td>
<td>21</td>
<td>0.406</td>
<td>11</td>
<td>10</td>
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<tr>
<td><strong>F3</strong></td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.291</td>
<td>16</td>
<td>0.349</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td><strong>F4</strong></td>
<td>Poor financial control on site</td>
<td>0.289</td>
<td>19</td>
<td>0.229</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td><strong>F5</strong></td>
<td>Delay payment to supplier/subcontractor</td>
<td>0.299</td>
<td>15</td>
<td>0.299</td>
<td>27</td>
<td>12</td>
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<tr>
<td><strong>L1</strong></td>
<td>Inflation in the cost of labors</td>
<td>0.227</td>
<td>30</td>
<td>0.271</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td><strong>L2</strong></td>
<td>Lack and shortage of skilled labors</td>
<td>0.324</td>
<td>11</td>
<td>0.339</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td><strong>L3</strong></td>
<td>Low labor productivity</td>
<td>0.305</td>
<td>13</td>
<td>0.245</td>
<td>32</td>
<td>19</td>
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<tr>
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<td>Fluctuation in raw material prices</td>
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<td>14</td>
<td>0.396</td>
<td>12</td>
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<tr>
<td><strong>M&amp;E2</strong></td>
<td>Late delivery of materials and equipment</td>
<td>0.271</td>
<td>23</td>
<td>0.302</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td><strong>M&amp;E3</strong></td>
<td>Insufficient number of equipment</td>
<td>0.199</td>
<td>34</td>
<td>0.244</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td><strong>M&amp;E4</strong></td>
<td>Changes in material specs and types</td>
<td>0.217</td>
<td>33</td>
<td>0.311</td>
<td>23</td>
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<td><strong>PM1</strong></td>
<td>Poor project management</td>
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<td>0.482</td>
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<td>0.518</td>
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<td>Unrealistic contract duration and requirements imposed</td>
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<td>0.597</td>
<td>1</td>
<td>8</td>
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<tr>
<td><strong>PM7</strong></td>
<td>Owner interference</td>
<td>0.190</td>
<td>35</td>
<td>0.349</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td><strong>PM8</strong></td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.361</td>
<td>6</td>
<td>0.553</td>
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</tbody>
</table>

**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 there is a positive agreement between the rankings from both respondents groups.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Subcontractor FCAII</th>
<th>Rank</th>
<th>GC FCAII</th>
<th>Rank</th>
<th>d</th>
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<td>C1 Disputes on site</td>
<td>0.295</td>
<td>34</td>
<td>0.167</td>
<td>37</td>
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<tr>
<td>C2 Weak collaboration</td>
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<td>0.219</td>
<td>32</td>
<td>4</td>
<td>16</td>
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<tr>
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<td>28</td>
<td>0.255</td>
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<td>1</td>
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<tr>
<td>C4 Weak coordination</td>
<td>0.358</td>
<td>30</td>
<td>0.252</td>
<td>28</td>
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<td>4</td>
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<td>0.360</td>
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<td>0.101</td>
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<td>4</td>
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<td>0.290</td>
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<td>CPH7 Errors during</td>
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<td>0.230</td>
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<tr>
<td>CPH8 Accidents on site</td>
<td>0.345</td>
<td>33</td>
<td>0.188</td>
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<td>9</td>
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<tr>
<td>CPH9 Effect of weather</td>
<td>0.141</td>
<td>39</td>
<td>0.075</td>
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<td>0</td>
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<td>1</td>
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<td>16</td>
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<tr>
<td>D3 Incomplete design</td>
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<td>0.313</td>
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<td>121</td>
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<td>D4 Deficient design</td>
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<td>0.268</td>
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<td>D5 Delay in approval of</td>
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<td>0.258</td>
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<td>4</td>
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<td>F1 Delay in progress</td>
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<td>3</td>
<td>9</td>
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<td>1</td>
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<td>F4 Poor financial control</td>
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<tr>
<td>F5 Delay payment to supplier</td>
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<td>0.299</td>
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<td>6</td>
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<td>0.227</td>
<td>30</td>
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<td>4</td>
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<tr>
<td>L2 Lack and shortage of</td>
<td>0.489</td>
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<td>0.324</td>
<td>11</td>
<td>0</td>
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</tr>
<tr>
<td>L3 Low labor productivity</td>
<td>0.469</td>
<td>13</td>
<td>0.305</td>
<td>13</td>
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<tr>
<td>M&amp;E1 Fluctuation in raw</td>
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<td>0.303</td>
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<td>49</td>
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<td>M&amp;E2 Late delivery of</td>
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<td>6</td>
<td>0.271</td>
<td>23</td>
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<td>289</td>
</tr>
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<td>M&amp;E3 Insufficient number</td>
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<td>35</td>
<td>0.199</td>
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<td>1</td>
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<tr>
<td>M&amp;E4 Changes in material</td>
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<td>15</td>
<td>0.217</td>
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<tr>
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<td>1</td>
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<td>Delays in decisions making</td>
<td>0.501</td>
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<td>0.290</td>
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<td>10</td>
</tr>
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<td>PM4</td>
<td>Poor contract management</td>
<td>0.425</td>
<td>19</td>
<td>0.271</td>
<td>22</td>
<td>3</td>
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<td>PM5</td>
<td>Errors in contract documents</td>
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<td>PM6</td>
<td>Unrealistic contract duration and requirements imposed</td>
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<td>0.350</td>
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<td>4</td>
</tr>
<tr>
<td>PM7</td>
<td>Owner interference</td>
<td>0.249</td>
<td>37</td>
<td>0.190</td>
<td>35</td>
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</tr>
<tr>
<td>PM8</td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.491</td>
<td>10</td>
<td>0.361</td>
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</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cons FCAII</th>
<th>Rank</th>
<th>Owner FCAII</th>
<th>Rank</th>
<th>d</th>
<th>d^2</th>
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<tbody>
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<td>37</td>
<td>0.131</td>
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<td>35</td>
<td>0.193</td>
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<tr>
<td>C3</td>
<td>0.327</td>
<td>20</td>
<td>0.281</td>
<td>17</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>C4</td>
<td>0.363</td>
<td>15</td>
<td>0.286</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CPH1</td>
<td>0.309</td>
<td>24</td>
<td>0.234</td>
<td>26</td>
<td>2</td>
<td>4</td>
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<td>CPH10</td>
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<td>38</td>
<td>0.143</td>
<td>36</td>
<td>2</td>
<td>4</td>
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<tr>
<td>CPH2</td>
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<td>3</td>
<td>0.343</td>
<td>5</td>
<td>2</td>
<td>4</td>
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<tr>
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<td>0.394</td>
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<td>8</td>
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<td>0.257</td>
<td>19</td>
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<td>0.247</td>
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<td>0.287</td>
<td>14</td>
<td>15</td>
<td>225</td>
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<tr>
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<td>0.140</td>
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<td>1</td>
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<tr>
<td>D1</td>
<td>0.538</td>
<td>4</td>
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<td>3</td>
<td>9</td>
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<tr>
<td>D2</td>
<td>0.332</td>
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<td>0.305</td>
<td>9</td>
<td>10</td>
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<td>D3</td>
<td>0.477</td>
<td>8</td>
<td>0.288</td>
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<td>25</td>
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<td>D4</td>
<td>0.316</td>
<td>22</td>
<td>0.252</td>
<td>22</td>
<td>0</td>
<td>0</td>
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<tr>
<td>D5</td>
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<td>0.166</td>
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<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>F1</td>
<td>Delay in progress payment by owner for work completed</td>
<td>0.467</td>
<td></td>
<td>0.200</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>F2</td>
<td>Financial difficulties of owner</td>
<td>0.406</td>
<td></td>
<td>0.197</td>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td>F3</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.349</td>
<td></td>
<td>0.240</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>F4</td>
<td>Poor financial control on site</td>
<td>0.229</td>
<td></td>
<td>0.155</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>F5</td>
<td>Delay payment to supplier/subcontractor</td>
<td>0.299</td>
<td></td>
<td>0.197</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>L1</td>
<td>Inflation in the cost of labors</td>
<td>0.271</td>
<td></td>
<td>0.155</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
<td>0.339</td>
<td></td>
<td>0.296</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>L3</td>
<td>Low labor productivity</td>
<td>0.245</td>
<td></td>
<td>0.301</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>M&amp;E1</td>
<td>Fluctuation in raw material prices</td>
<td>0.396</td>
<td></td>
<td>0.171</td>
<td>32</td>
<td>20</td>
</tr>
<tr>
<td>M&amp;E2</td>
<td>Late delivery of materials and equipment</td>
<td>0.302</td>
<td></td>
<td>0.286</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>M&amp;E3</td>
<td>Insufficient number of equipment</td>
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<td></td>
<td>0.215</td>
<td>27</td>
<td>6</td>
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<td>Changes in material specs and types</td>
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<td>0.351</td>
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<td>20</td>
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<tr>
<td>PM1</td>
<td>Poor project management</td>
<td>0.482</td>
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<td>0.310</td>
<td>8</td>
<td>1</td>
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<tr>
<td>PM2</td>
<td>Frequent changes to the scope of work</td>
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<td>0.317</td>
<td>7</td>
<td>2</td>
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<tr>
<td>PM3</td>
<td>Delays in decisions making</td>
<td>0.425</td>
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<td>0.293</td>
<td>12</td>
<td>2</td>
</tr>
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<td>PM4</td>
<td>Poor contract management</td>
<td>0.372</td>
<td></td>
<td>0.246</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>PM5</td>
<td>Errors in contract documents</td>
<td>0.318</td>
<td></td>
<td>0.261</td>
<td>18</td>
<td>3</td>
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<tr>
<td>PM6</td>
<td>Unrealistic contract duration and requirements imposed</td>
<td>0.597</td>
<td></td>
<td>0.334</td>
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<td>5</td>
</tr>
<tr>
<td>PM7</td>
<td>Owner interference</td>
<td>0.349</td>
<td></td>
<td>0.254</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>PM8</td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.553</td>
<td></td>
<td>0.349</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**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:

\[ MS_i = \frac{\sum f_i \times S}{N} \]

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

<table>
<thead>
<tr>
<th>Factor</th>
<th>Code</th>
<th>FCAII Score for</th>
<th>Ranking for</th>
<th>FCAII Score for</th>
<th>Ranking for</th>
<th>FCAII Score for</th>
<th>Ranking for</th>
<th>Overall FCAII Score</th>
<th>Overall Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper planning and scheduling</td>
<td>CPH3</td>
<td>0.394</td>
<td>2</td>
<td>0.440</td>
<td>2</td>
<td>0.493</td>
<td>6</td>
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<td>Frequent Design changes</td>
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<td>0.428</td>
<td>1</td>
<td>0.375</td>
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<td>0.538</td>
<td>4</td>
<td>0.484</td>
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<tr>
<td>Schedule delay</td>
<td>CPH2</td>
<td>0.343</td>
<td>5</td>
<td>0.445</td>
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<td>0.544</td>
<td>3</td>
<td>0.476</td>
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</tr>
<tr>
<td>Unrealistic contract duration and requirements imposed</td>
<td>PM6</td>
<td>0.334</td>
<td>6</td>
<td>0.350</td>
<td>9</td>
<td>0.597</td>
<td>1</td>
<td>0.455</td>
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<tr>
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<td>0.364</td>
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<td>0.518</td>
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<td>0.441</td>
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<tr>
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<td>0.349</td>
<td>4</td>
<td>0.361</td>
<td>6</td>
<td>0.553</td>
<td>2</td>
<td>0.439</td>
<td>6</td>
</tr>
<tr>
<td>Poor project management</td>
<td>PM1</td>
<td>0.310</td>
<td>8</td>
<td>0.374</td>
<td>4</td>
<td>0.482</td>
<td>7</td>
<td>0.413</td>
<td>7</td>
</tr>
<tr>
<td>Delay in progress payment by owner for work completed</td>
<td>F1</td>
<td>0.200</td>
<td>28</td>
<td>0.329</td>
<td>10</td>
<td>0.467</td>
<td>9</td>
<td>0.381</td>
<td>8</td>
</tr>
<tr>
<td>Delays in decisions making</td>
<td>PM3</td>
<td>0.293</td>
<td>12</td>
<td>0.290</td>
<td>18</td>
<td>0.425</td>
<td>10</td>
<td>0.377</td>
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<tr>
<td>Incomplete design at time of tender</td>
<td>D3</td>
<td>0.288</td>
<td>13</td>
<td>0.313</td>
<td>12</td>
<td>0.477</td>
<td>8</td>
<td>0.373</td>
<td>10</td>
</tr>
<tr>
<td>Improper monitoring and control</td>
<td>CPH4</td>
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<td>21</td>
<td>0.359</td>
<td>8</td>
<td>0.381</td>
<td>13</td>
<td>0.362</td>
<td>11</td>
</tr>
<tr>
<td>Lack and shortage of skilled labors</td>
<td>L2</td>
<td>0.296</td>
<td>11</td>
<td>0.324</td>
<td>11</td>
<td>0.339</td>
<td>18</td>
<td>0.362</td>
<td>12</td>
</tr>
<tr>
<td>Late delivery of materials and equipment</td>
<td>M&amp;E2</td>
<td>0.286</td>
<td>16</td>
<td>0.271</td>
<td>23</td>
<td>0.302</td>
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<td>0.347</td>
<td>13</td>
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<tr>
<td>Cash flow difficulties faced by contractor</td>
<td>F3</td>
<td>0.240</td>
<td>25</td>
<td>0.291</td>
<td>16</td>
<td>0.349</td>
<td>17</td>
<td>0.336</td>
<td>14</td>
</tr>
<tr>
<td>Changes in material specs and types</td>
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<td>3</td>
<td>0.217</td>
<td>33</td>
<td>0.311</td>
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<td>Frequency</td>
<td>Severity</td>
<td>Probability</td>
<td>Frequency</td>
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</tr>
<tr>
<td>Design errors and mistakes</td>
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<td>0.270</td>
<td>24</td>
<td>0.332</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Low labor productivity</td>
<td>L3</td>
<td>0.301</td>
<td>10</td>
<td>0.305</td>
<td>13</td>
<td>0.245</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor contract management</td>
<td>PM4</td>
<td>0.246</td>
<td>24</td>
<td>0.271</td>
<td>22</td>
<td>0.372</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial difficulties of owner</td>
<td>F2</td>
<td>0.197</td>
<td>30</td>
<td>0.278</td>
<td>21</td>
<td>0.406</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluctuation in raw material prices</td>
<td>M&amp;E1</td>
<td>0.171</td>
<td>32</td>
<td>0.303</td>
<td>14</td>
<td>0.396</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay payment to supplier/subcontractor</td>
<td>F5</td>
<td>0.197</td>
<td>29</td>
<td>0.299</td>
<td>15</td>
<td>0.299</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient site management and inspection</td>
<td>CPH1</td>
<td>0.234</td>
<td>26</td>
<td>0.360</td>
<td>7</td>
<td>0.309</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak coordination between project parties</td>
<td>C4</td>
<td>0.286</td>
<td>15</td>
<td>0.252</td>
<td>28</td>
<td>0.363</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errors in contract documents</td>
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<td>0.261</td>
<td>18</td>
<td>0.283</td>
<td>20</td>
<td>0.318</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak communication between project parties</td>
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<td>0.255</td>
<td>27</td>
<td>0.327</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deficient design and delays in design process</td>
<td>D4</td>
<td>0.252</td>
<td>22</td>
<td>0.268</td>
<td>25</td>
<td>0.316</td>
<td>22</td>
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<td></td>
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<tr>
<td>Lack of experience in handling construction projects</td>
<td>CPH5</td>
<td>0.257</td>
<td>19</td>
<td>0.290</td>
<td>17</td>
<td>0.279</td>
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<td></td>
</tr>
<tr>
<td>Errors during construction</td>
<td>CPH7</td>
<td>0.287</td>
<td>14</td>
<td>0.230</td>
<td>29</td>
<td>0.275</td>
<td>29</td>
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<td></td>
</tr>
<tr>
<td>Delay in inspection and approval of completed work</td>
<td>CPH6</td>
<td>0.247</td>
<td>23</td>
<td>0.223</td>
<td>31</td>
<td>0.256</td>
<td>31</td>
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<td>Poor financial control on site</td>
<td>F4</td>
<td>0.155</td>
<td>35</td>
<td>0.289</td>
<td>19</td>
<td>0.229</td>
<td>34</td>
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<td></td>
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<tr>
<td>Delay in approval</td>
<td>D5</td>
<td>0.166</td>
<td>33</td>
<td>0.258</td>
<td>26</td>
<td>0.302</td>
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<th>Issue</th>
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<th>35</th>
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<tr>
<td>Owner interference</td>
<td>PM7</td>
<td>0.254</td>
<td>0.190</td>
<td>0.349</td>
<td>0.261</td>
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<tr>
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<td>0.155</td>
<td>0.227</td>
<td>0.271</td>
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<td>Inflation in the cost of labors</td>
<td>L1</td>
<td>0.155</td>
<td>0.227</td>
<td>0.271</td>
<td>0.250</td>
<td>33</td>
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<tr>
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<td>M&amp;E3</td>
<td>0.215</td>
<td>0.199</td>
<td>0.244</td>
<td>0.236</td>
<td>34</td>
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<tr>
<td>Weak collaboration between management and labor</td>
<td>C2</td>
<td>0.193</td>
<td>0.219</td>
<td>0.214</td>
<td>0.223</td>
<td>35</td>
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</tr>
<tr>
<td>Accidents on site</td>
<td>CPH8</td>
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<td>0.188</td>
<td>0.183</td>
<td>0.214</td>
<td>36</td>
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<tr>
<td>Disputes on site</td>
<td>C1</td>
<td>0.131</td>
<td>0.167</td>
<td>0.161</td>
<td>0.188</td>
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<tr>
<td>Unforeseen ground conditions</td>
<td>CPH10</td>
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<td>0.101</td>
<td>0.155</td>
<td>0.136</td>
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<td>Effect of weather</td>
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<td>0.075</td>
<td>0.104</td>
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</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Factor</th>
<th>CM Rank</th>
<th>PE Rank</th>
<th>d</th>
<th>d^2</th>
</tr>
</thead>
<tbody>
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<td>0.186</td>
<td>0.139</td>
<td>0.064</td>
<td>1</td>
</tr>
<tr>
<td>C2</td>
<td>0.205</td>
<td>0.189</td>
<td>0.056</td>
<td>0</td>
</tr>
<tr>
<td>C3</td>
<td>0.276</td>
<td>0.249</td>
<td>0.063</td>
<td>16</td>
</tr>
<tr>
<td>C4</td>
<td>0.328</td>
<td>0.193</td>
<td>0.167</td>
<td>324</td>
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<td>0.299</td>
<td>0.309</td>
<td>0.010</td>
<td>144</td>
</tr>
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<td>CPH10</td>
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<td>0.091</td>
<td>0.062</td>
<td>12</td>
</tr>
<tr>
<td>CPH2</td>
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<td>0.247</td>
<td>81</td>
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<td>0.425</td>
<td>0.003</td>
<td>16</td>
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<td>CPH4</td>
<td>0.282</td>
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<td>0.091</td>
<td>484</td>
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<td>CPH5</td>
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<td>0.043</td>
<td>361</td>
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<tr>
<td>CPH6</td>
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<td>0.036</td>
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<td>CPH7</td>
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<td>0.257</td>
<td>0.006</td>
<td>121</td>
</tr>
<tr>
<td>CPH8</td>
<td>0.159</td>
<td>0.235</td>
<td>0.076</td>
<td>100</td>
</tr>
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<td>CPH9</td>
<td>0.083</td>
<td>0.078</td>
<td>0.005</td>
<td>0</td>
</tr>
<tr>
<td>D1</td>
<td>0.460</td>
<td>0.320</td>
<td>0.140</td>
<td>16</td>
</tr>
<tr>
<td>D2</td>
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<td>0.266</td>
<td>0.035</td>
<td>9</td>
</tr>
<tr>
<td>D3</td>
<td>0.334</td>
<td>0.279</td>
<td>0.057</td>
<td>1</td>
</tr>
<tr>
<td>D4</td>
<td>0.266</td>
<td>0.219</td>
<td>0.042</td>
<td>9</td>
</tr>
<tr>
<td>D5</td>
<td>0.259</td>
<td>0.232</td>
<td>0.026</td>
<td>9</td>
</tr>
<tr>
<td>F1</td>
<td>0.316</td>
<td>0.283</td>
<td>0.033</td>
<td>4</td>
</tr>
<tr>
<td>F2</td>
<td>0.307</td>
<td>0.249</td>
<td>0.057</td>
<td>25</td>
</tr>
<tr>
<td>F3</td>
<td>0.334</td>
<td>0.264</td>
<td>0.070</td>
<td>25</td>
</tr>
<tr>
<td>F4</td>
<td>0.333</td>
<td>0.272</td>
<td>0.061</td>
<td>1</td>
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<tr>
<td>F5</td>
<td>0.283</td>
<td>0.296</td>
<td>0.031</td>
<td>121</td>
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<td>L1</td>
<td>0.257</td>
<td>0.220</td>
<td>0.037</td>
<td>1</td>
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<td>Code</td>
<td>Issue Description</td>
<td>Value1</td>
<td>Value2</td>
<td>Value3</td>
</tr>
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<td>------</td>
<td>--------------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
<td>0.415</td>
<td>9</td>
<td>0.233</td>
</tr>
<tr>
<td>L3</td>
<td>Low labor productivity</td>
<td>0.403</td>
<td>10</td>
<td>0.230</td>
</tr>
<tr>
<td>M&amp;E1</td>
<td>Fluctuation in raw material prices</td>
<td>0.268</td>
<td>28</td>
<td>0.316</td>
</tr>
<tr>
<td>M&amp;E2</td>
<td>Late delivery of materials and equipment</td>
<td>0.307</td>
<td>19</td>
<td>0.254</td>
</tr>
<tr>
<td>M&amp;E3</td>
<td>Insufficient number of equipment</td>
<td>0.211</td>
<td>33</td>
<td>0.201</td>
</tr>
<tr>
<td>M&amp;E4</td>
<td>Changes in material specs and types</td>
<td>0.296</td>
<td>22</td>
<td>0.241</td>
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<td>PM1</td>
<td>Poor project management</td>
<td>0.424</td>
<td>8</td>
<td>0.340</td>
</tr>
<tr>
<td>PM2</td>
<td>Frequent changes to the scope of work</td>
<td>0.452</td>
<td>3</td>
<td>0.369</td>
</tr>
<tr>
<td>PM3</td>
<td>Delays in decisions making</td>
<td>0.424</td>
<td>7</td>
<td>0.236</td>
</tr>
<tr>
<td>PM4</td>
<td>Poor contract management</td>
<td>0.360</td>
<td>11</td>
<td>0.253</td>
</tr>
<tr>
<td>PM5</td>
<td>Errors in contract documents</td>
<td>0.337</td>
<td>12</td>
<td>0.287</td>
</tr>
<tr>
<td>PM6</td>
<td>Unrealistic contract duration and requirements imposed</td>
<td>0.436</td>
<td>4</td>
<td>0.298</td>
</tr>
<tr>
<td>PM7</td>
<td>Owner interference</td>
<td>0.278</td>
<td>25</td>
<td>0.180</td>
</tr>
<tr>
<td>PM8</td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.425</td>
<td>6</td>
<td>0.339</td>
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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

<table>
<thead>
<tr>
<th>Factor</th>
<th>More than 16 FCAII</th>
<th>Rank</th>
<th>Less than 16 FCAII</th>
<th>Rank</th>
<th>d</th>
<th>d^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Disputes on site</td>
<td>0.154</td>
<td>37</td>
<td>0.206</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>C2</td>
<td>Weak collaboration between management and labor</td>
<td>0.163</td>
<td>35</td>
<td>0.254</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>C3</td>
<td>Weak communication between project parties</td>
<td>0.302</td>
<td>22</td>
<td>0.298</td>
<td>26</td>
<td>4</td>
</tr>
<tr>
<td>C4</td>
<td>Weak coordination between project parties</td>
<td>0.323</td>
<td>18</td>
<td>0.284</td>
<td>28</td>
<td>10</td>
</tr>
<tr>
<td>CPH1</td>
<td>Insufficient site management and inspection</td>
<td>0.273</td>
<td>31</td>
<td>0.352</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>CPH10</td>
<td>Unforeseen ground conditions</td>
<td>0.154</td>
<td>36</td>
<td>0.112</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>CPH2</td>
<td>Schedule delay</td>
<td>0.581</td>
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<td>0.421</td>
<td>4</td>
<td>3</td>
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<tr>
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<td>Improper planning and scheduling</td>
<td>0.485</td>
<td>4</td>
<td>0.459</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>CPH4</td>
<td>Improper monitoring and control</td>
<td>0.330</td>
<td>16</td>
<td>0.368</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>CPH5</td>
<td>Lack of experience in handling construction projects</td>
<td>0.292</td>
<td>25</td>
<td>0.316</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>CPH6</td>
<td>Delay in inspection and approval of completed work</td>
<td>0.274</td>
<td>29</td>
<td>0.280</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>CPH7</td>
<td>Errors during construction</td>
<td>0.252</td>
<td>32</td>
<td>0.292</td>
<td>27</td>
<td>5</td>
</tr>
<tr>
<td>CPH8</td>
<td>Accidents on site</td>
<td>0.114</td>
<td>39</td>
<td>0.260</td>
<td>34</td>
<td>5</td>
</tr>
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<td>CPH9</td>
<td>Effect of weather</td>
<td>0.119</td>
<td>38</td>
<td>0.083</td>
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<td>Frequent Design changes</td>
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<td>0.405</td>
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<td>D2</td>
<td>Design errors and mistakes</td>
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<td>24</td>
<td>0.323</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>D3</td>
<td>Incomplete design at time of tender</td>
<td>0.360</td>
<td>11</td>
<td>0.339</td>
<td>14</td>
<td>3</td>
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<tr>
<td>D4</td>
<td>Deficient design and delays in design process</td>
<td>0.312</td>
<td>20</td>
<td>0.277</td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>D5</td>
<td>Delay in approval of drawings</td>
<td>0.323</td>
<td>17</td>
<td>0.265</td>
<td>32</td>
<td>15</td>
</tr>
<tr>
<td>F1</td>
<td>Delay in progress payment by owner for work completed</td>
<td>0.339</td>
<td>15</td>
<td>0.368</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>F2</td>
<td>Financial difficulties of owner</td>
<td>0.291</td>
<td>27</td>
<td>0.305</td>
<td>24</td>
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</tr>
<tr>
<td>F3</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.378</td>
<td>8</td>
<td>0.310</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>F4</td>
<td>Poor financial control on site</td>
<td>0.278</td>
<td>28</td>
<td>0.320</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
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<td>Value2</td>
<td>Value3</td>
<td>Value4</td>
<td>Value5</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>F5</td>
<td>Delay payment to supplier/subcontractor</td>
<td>0.345</td>
<td>14</td>
<td>0.314</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>L1</td>
<td>Inflation in the cost of labors</td>
<td>0.221</td>
<td>33</td>
<td>0.282</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
<td>0.351</td>
<td>13</td>
<td>0.365</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>L3</td>
<td>Low labor productivity</td>
<td>0.377</td>
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<td>0.306</td>
<td>23</td>
<td>14</td>
</tr>
<tr>
<td>M&amp;E1</td>
<td>Fluctuation in raw material prices</td>
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<td>0.347</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>M&amp;E2</td>
<td>Late delivery of materials and equipment</td>
<td>0.304</td>
<td>21</td>
<td>0.327</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>M&amp;E3</td>
<td>Insufficient number of equipment</td>
<td>0.182</td>
<td>34</td>
<td>0.261</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>M&amp;E4</td>
<td>Changes in material specs and types</td>
<td>0.320</td>
<td>19</td>
<td>0.304</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>PM1</td>
<td>Poor project management</td>
<td>0.369</td>
<td>10</td>
<td>0.436</td>
<td>2</td>
<td>8</td>
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<td>0.422</td>
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<td>3</td>
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<td>0.429</td>
<td>7</td>
<td>0.337</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>PM4</td>
<td>Poor contract management</td>
<td>0.358</td>
<td>12</td>
<td>0.311</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>PM5</td>
<td>Errors in contract documents</td>
<td>0.298</td>
<td>23</td>
<td>0.346</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>PM6</td>
<td>Unrealistic contract duration and requirements imposed</td>
<td>0.529</td>
<td>3</td>
<td>0.378</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>PM7</td>
<td>Owner interference</td>
<td>0.292</td>
<td>26</td>
<td>0.251</td>
<td>36</td>
<td>10</td>
</tr>
<tr>
<td>PM8</td>
<td>Inaccurate time and cost estimates of project</td>
<td>0.458</td>
<td>5</td>
<td>0.409</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Factor</th>
<th>Large Companies FCAII</th>
<th>Rank</th>
<th>Small Companies FCAII</th>
<th>Rank</th>
<th>d</th>
<th>d^2</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Disputes on site</td>
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<td>Insufficient site management and inspection</td>
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<td>Accidents on site</td>
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<td>Deficient design and delays in design process</td>
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<td>16</td>
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<td>Frequency</td>
<td>Cost 1</td>
<td>Cost 2</td>
<td>Cost 3</td>
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<td>Inflation in the cost of labors</td>
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<td>0.357</td>
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<td>Fluctuation in raw material prices</td>
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<td>26</td>
<td>0.416</td>
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<td>Late delivery of materials and equipment</td>
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<td>14</td>
<td>0.343</td>
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<tr>
<td>M&amp;E3</td>
<td>Insufficient number of equipment</td>
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<td>34</td>
<td>0.282</td>
<td>34</td>
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<td>Changes in material specs and types</td>
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<td>23</td>
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<td>Poor project management</td>
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<td>0.455</td>
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<td>0.435</td>
<td>10</td>
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<td>0.448</td>
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</table>
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

<table>
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<tr>
<th>Factor</th>
<th>Superstructure FCAII</th>
<th>Rank</th>
<th>Infrastructure FCAII</th>
<th>Rank</th>
<th>d</th>
<th>d^2</th>
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<tbody>
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<td>C1</td>
<td>Disputes on site</td>
<td>0.322</td>
<td>23</td>
<td>0.324</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>C2</td>
<td>Weak collaboration between management and labor</td>
<td>0.426</td>
<td>8</td>
<td>0.520</td>
<td>1</td>
<td>7</td>
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<tr>
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<td>0.473</td>
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<tr>
<td>C4</td>
<td>Weak coordination between project parties</td>
<td>0.366</td>
<td>14</td>
<td>0.335</td>
<td>9</td>
<td>5</td>
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<tr>
<td>CPH1</td>
<td>Insufficient site management and inspection</td>
<td>0.321</td>
<td>24</td>
<td>0.267</td>
<td>20</td>
<td>4</td>
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<tr>
<td>CPH10</td>
<td>Unforeseen ground conditions</td>
<td>0.271</td>
<td>32</td>
<td>0.267</td>
<td>21</td>
<td>11</td>
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<td>CPH2</td>
<td>Schedule delay</td>
<td>0.293</td>
<td>30</td>
<td>0.243</td>
<td>27</td>
<td>3</td>
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<td>CPH3</td>
<td>Improper planning and scheduling</td>
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<td>0.176</td>
<td>36</td>
<td>0</td>
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<td>0.089</td>
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<td>0</td>
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<td>0.160</td>
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<tr>
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<td>Delay in inspection and approval of completed work</td>
<td>0.499</td>
<td>1</td>
<td>0.379</td>
<td>5</td>
<td>4</td>
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<tr>
<td>CPH7</td>
<td>Errors during construction</td>
<td>0.338</td>
<td>17</td>
<td>0.235</td>
<td>30</td>
<td>13</td>
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<tr>
<td>CPH8</td>
<td>Accidents on site</td>
<td>0.338</td>
<td>18</td>
<td>0.309</td>
<td>15</td>
<td>3</td>
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<tr>
<td>CPH9</td>
<td>Effect of weather</td>
<td>0.294</td>
<td>29</td>
<td>0.249</td>
<td>24</td>
<td>5</td>
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<td>D1</td>
<td>Frequent Design changes</td>
<td>0.306</td>
<td>27</td>
<td>0.248</td>
<td>25</td>
<td>2</td>
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<tr>
<td>D2</td>
<td>Design errors and mistakes</td>
<td>0.431</td>
<td>7</td>
<td>0.286</td>
<td>16</td>
<td>9</td>
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<td>D3</td>
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<td>22</td>
<td>0.261</td>
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<td>Deficient design and delays in design process</td>
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<td>0.243</td>
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<td>17</td>
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<td>0.331</td>
<td>21</td>
<td>0.256</td>
<td>23</td>
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<td>Delay in progress payment by owner for work completed</td>
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<td>11</td>
<td>0.229</td>
<td>32</td>
<td>21</td>
</tr>
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<td>F2</td>
<td>Financial difficulties of owner</td>
<td>0.306</td>
<td>28</td>
<td>0.277</td>
<td>18</td>
<td>10</td>
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<tr>
<td>F3</td>
<td>Cash flow difficulties faced by contractor</td>
<td>0.334</td>
<td>19</td>
<td>0.239</td>
<td>28</td>
<td>9</td>
</tr>
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</tr>
<tr>
<td>F4</td>
<td>Poor financial control on site</td>
<td>0.230</td>
<td>33</td>
<td>0.198</td>
<td>34</td>
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<tr>
<td>F5</td>
<td>Delay payment to supplier/subcontractor</td>
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<td>35</td>
<td>0.157</td>
<td>38</td>
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<td>15</td>
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<td>25</td>
<td>0.407</td>
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<td>Low labor productivity</td>
<td>0.201</td>
<td>37</td>
<td>0.318</td>
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<td>M&amp;E1</td>
<td>Fluctuation in raw material prices</td>
<td>0.308</td>
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<td>0.319</td>
<td>12</td>
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<td>0.285</td>
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<td>0.381</td>
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**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

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<th>Factor</th>
<th>Superstructure Rank</th>
<th>All other industry types Rank</th>
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<th>d^2</th>
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<td></td>
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<td>Weak collaboration between management and labor</td>
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<td>Weak communication between project parties</td>
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<td>Weak coordination between project parties</td>
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<td>Unforeseen ground conditions</td>
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<td>Improper planning and scheduling</td>
<td>0.201 36 0.281 29 7 49</td>
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<td>0.090 39 0.089 38 1 1</td>
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<td>Errors during construction</td>
<td>0.338 17 0.358 12 5 25</td>
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<td>0.306 27 0.300 25 2 4</td>
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<tr>
<td>PM6</td>
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<td>PM7</td>
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</table>

**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>
<thead>
<tr>
<th>Code</th>
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<th>T-Test (p)</th>
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<tbody>
<tr>
<td>CPH8</td>
<td>Accidents on site Qatar VS GCC</td>
<td>0.0252</td>
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<tr>
<td>CPH9</td>
<td>Effect of weather</td>
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**Project Managers VS Project Engineers**

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<td>CPH2</td>
<td>Schedule delay</td>
<td>0.0338</td>
</tr>
<tr>
<td>CPH4</td>
<td>Improper monitoring and control</td>
<td>0.0061</td>
</tr>
<tr>
<td>CPH6</td>
<td>Delay in inspection and approval of completed work</td>
<td>0.0257</td>
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<tr>
<td>CPH8</td>
<td>Accidents on site</td>
<td>0.0627</td>
</tr>
<tr>
<td>C2</td>
<td>Weak coordination between project parties</td>
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<tr>
<td>L1</td>
<td>Low labor productivity</td>
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<tr>
<td>L2</td>
<td>Lack and shortage of skilled labors</td>
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<tr>
<td>PM3</td>
<td>Delays in decisions making</td>
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**Superstructure VS Infrastructure**

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**More than 16 years experience VS less than 16 years experience**

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<td>F2</td>
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<td><strong>GC VS Consultant</strong></td>
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<td><strong>PM8</strong></td>
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**GC VS Subcontractor**

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**Owner VS Consultant**

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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 \( R_{i1} \), and in group 2 is \( R_{i2} \). For any two groups, let the rank of the \( i^{th} \) item in group 1 be \( R_{i1} \) and in group 2 be \( R_{i2} \). Then the absolute difference \( D_i \) between any ranking of the, between any ranking of the \( i^{th} \) item by the groups would be

\[
D_i = |R_{i1} - R_{i2}|
\]

Where \( i = 1, 2, \ldots, N \)

And there are \( N \) items

\[
D_{\text{max}} = |R_{i1} - R_{j2}|
\]

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:

\[
PD = 100 \times \frac{\sum_{i=1}^{N} |R_{i1} - R_{i2}|}{\sum_{i=1}^{N} |R_{x1} - R_{x2}|}
\]

\[
PA = 100 - PD
\]

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

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

<table>
<thead>
<tr>
<th>Factor (Title of the point)</th>
<th>Importance Mean value (x-axis)</th>
<th>Frequency Mean value (y-axis)</th>
<th>Impact on Cost Mean value (Z-axis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient site management and inspection</td>
<td>3.73</td>
<td>2.99</td>
<td>3.62</td>
</tr>
<tr>
<td>Schedule delay</td>
<td>4.10</td>
<td>3.47</td>
<td>4.12</td>
</tr>
<tr>
<td>Improper planning and scheduling</td>
<td>4.33</td>
<td>3.27</td>
<td>4.13</td>
</tr>
<tr>
<td>Improper monitoring and control</td>
<td>3.84</td>
<td>3.01</td>
<td>3.84</td>
</tr>
<tr>
<td>Lack of experience in handling construction projects</td>
<td>3.65</td>
<td>2.92</td>
<td>3.64</td>
</tr>
<tr>
<td>Delay in inspection and approval of completed work</td>
<td>3.35</td>
<td>3.16</td>
<td>3.32</td>
</tr>
<tr>
<td>Errors during construction</td>
<td>3.53</td>
<td>2.86</td>
<td>3.47</td>
</tr>
<tr>
<td>Accidents on site</td>
<td>3.70</td>
<td>2.09</td>
<td>3.32</td>
</tr>
<tr>
<td>Effect of weather</td>
<td>2.49</td>
<td>2.15</td>
<td>2.23</td>
</tr>
<tr>
<td>Unforeseen ground conditions</td>
<td>2.89</td>
<td>2.00</td>
<td>2.73</td>
</tr>
<tr>
<td>Frequent Design changes</td>
<td>4.36</td>
<td>3.03</td>
<td>4.22</td>
</tr>
<tr>
<td>Design errors and mistakes</td>
<td>3.99</td>
<td>2.56</td>
<td>3.84</td>
</tr>
<tr>
<td>Incomplete design at time of tender</td>
<td>3.99</td>
<td>2.75</td>
<td>3.95</td>
</tr>
<tr>
<td>Deficient design and delays in design process</td>
<td>3.81</td>
<td>2.64</td>
<td>3.59</td>
</tr>
<tr>
<td>Delay in approval of drawings</td>
<td>3.63</td>
<td>2.93</td>
<td>3.34</td>
</tr>
<tr>
<td>Delay in progress payment by owner for work completed</td>
<td>4.13</td>
<td>3.06</td>
<td>3.55</td>
</tr>
<tr>
<td>Financial difficulties of owner</td>
<td>4.08</td>
<td>2.47</td>
<td>3.73</td>
</tr>
<tr>
<td>Cash flow difficulties faced by contractor</td>
<td>3.97</td>
<td>2.92</td>
<td>3.58</td>
</tr>
<tr>
<td>Poor financial control on site</td>
<td>3.76</td>
<td>2.79</td>
<td>3.62</td>
</tr>
<tr>
<td>Delay payment to supplier/subcontractor</td>
<td>3.81</td>
<td>3.03</td>
<td>3.50</td>
</tr>
<tr>
<td>Weak communication between project parties</td>
<td>3.78</td>
<td>2.88</td>
<td>3.42</td>
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<tr>
<td>Weak coordination between project parties</td>
<td>3.85</td>
<td>2.89</td>
<td>3.32</td>
</tr>
<tr>
<td>Weak collaboration between management and labour</td>
<td>3.39</td>
<td>2.74</td>
<td>2.98</td>
</tr>
<tr>
<td>Disputes on site</td>
<td>3.14</td>
<td>2.56</td>
<td>2.92</td>
</tr>
<tr>
<td>Low labour productivity</td>
<td>3.97</td>
<td>2.91</td>
<td>3.53</td>
</tr>
<tr>
<td>Lack and shortage of skilled labours</td>
<td>4.05</td>
<td>3.18</td>
<td>3.50</td>
</tr>
<tr>
<td>Inflation in the cost of labours</td>
<td>3.69</td>
<td>2.53</td>
<td>3.50</td>
</tr>
<tr>
<td>Disputes on site</td>
<td>3.14</td>
<td>2.56</td>
<td>2.92</td>
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<tr>
<td>Low labour productivity</td>
<td>3.97</td>
<td>2.91</td>
<td>3.53</td>
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<tr>
<td>Lack and shortage of skilled labours</td>
<td>4.05</td>
<td>3.18</td>
<td>3.50</td>
</tr>
<tr>
<td>Inflation in the cost of labours</td>
<td>3.69</td>
<td>2.53</td>
<td>3.50</td>
</tr>
<tr>
<td>Fluctuation in raw material prices</td>
<td>4.08</td>
<td>2.76</td>
<td>3.59</td>
</tr>
<tr>
<td>Late delivery of materials and equipment</td>
<td>3.92</td>
<td>2.98</td>
<td>3.41</td>
</tr>
<tr>
<td>Insufficient number of equipment</td>
<td>3.36</td>
<td>2.75</td>
<td>3.18</td>
</tr>
<tr>
<td>Changes in material specs and types</td>
<td>3.74</td>
<td>2.86</td>
<td>3.60</td>
</tr>
<tr>
<td>Poor project management</td>
<td>4.36</td>
<td>2.94</td>
<td>4.01</td>
</tr>
<tr>
<td>Frequent changes to the scope of work</td>
<td>4.22</td>
<td>3.04</td>
<td>4.18</td>
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<tr>
<td>Delays in decisions making</td>
<td>4.09</td>
<td>3.01</td>
<td>3.69</td>
</tr>
<tr>
<td>Poor contract management</td>
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<td>3.63</td>
</tr>
<tr>
<td>Errors in contract documents</td>
<td>4.04</td>
<td>2.65</td>
<td>3.85</td>
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<tr>
<td>Unrealistic contract duration and requirements imposed</td>
<td>4.35</td>
<td>2.93</td>
<td>4.15</td>
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<tr>
<td>Owner interference</td>
<td>3.60</td>
<td>2.83</td>
<td>3.23</td>
</tr>
<tr>
<td>Inaccurate time and cost estimates of project</td>
<td>4.27</td>
<td>3.07</td>
<td>4.04</td>
</tr>
</tbody>
</table>

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

**Construction Phase Factors**
- Insufficient site management
- Schedule delay
- Improper planning and scheduling
- Improper monitoring and control
- Lack of experience in handling construction projects
- Delay in inspection and approval of completed work
- Errors during construction

**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)

- Insufficient site management
- Schedule delay
- Improper planning and scheduling
- Improper monitoring and control
- Lack of experience in handling construction projects
- Delay in inspection and approval of completed work
- Errors during construction
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

![Risk Matrix Chart for Cost Overruns Related to Design (F vs I)](image)

**Design Factors**
- Frequent Design changes
- Design errors and mistakes
- Incomplete design at time of tender
- Deficient design and delays in design process
- Delay in approval of drawings

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

![Risk Matrix Chart for Cost Overruns Related to Design (CI vs I)](image)

**Design Factors**
- Frequent Design changes
- Design errors and mistakes
- Incomplete design at time of tender
- Deficient design and delays in design process
- Delay in approval of drawings

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)

**Financial Factors**
- Delay in progress payment by owner for work completed
- Financial difficulties of owner
- Cash flow difficulties faced by contractor
- Poor financial control on site
- Delay payment to supplier/subcontractor

**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 (Cl vs F)

- Delay in progress payment by owner for work completed
- Financial difficulties of owner
- Cash flow difficulties faced by contractor
- Poor financial control on site
- Delay payment to supplier/subcontractor
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)

- Weak communication between project parties
- Weak coordination between project parties
- Weak collaboration between management and labour
- Disputes on site
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 (Cl vs F)

**Labor Factors**
- Low labour productivity
- Lack and shortage of skilled labours
- Inflation in the cost of labours
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)

- Fluctuation in raw material prices
- Late delivery of materials and equipment
- Insufficient number of equipment
- Changes in material specs and types
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.

Table 28 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](image-url)

Figure 36 - Scale used to present factor’s risk related to importance, frequency and impact on cost
<table>
<thead>
<tr>
<th>Code</th>
<th>Factor (Title of the point)</th>
<th>Importance (I)</th>
<th>Frequency (F)</th>
<th>I*F</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean value</td>
<td>Mean value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPH</td>
<td>Insufficient site management and inspection</td>
<td>3.73</td>
<td>2.99</td>
<td>11.16</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Schedule delay</td>
<td>4.10</td>
<td>3.47</td>
<td>14.20</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Improper planning and scheduling</td>
<td>4.33</td>
<td>3.27</td>
<td>14.14</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Improper monitoring and control project parties</td>
<td>3.84</td>
<td>3.01</td>
<td>11.56</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Lack of experience in handling construction projects</td>
<td>3.65</td>
<td>2.92</td>
<td>10.67</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Delay in inspection and approval of completed work</td>
<td>3.35</td>
<td>3.16</td>
<td>10.57</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Errors during construction</td>
<td>3.53</td>
<td>2.86</td>
<td>10.11</td>
<td>Red</td>
</tr>
<tr>
<td>D</td>
<td>Frequent Design changes</td>
<td>4.36</td>
<td>3.03</td>
<td>13.20</td>
<td>Red</td>
</tr>
<tr>
<td>D</td>
<td>Design errors and mistakes</td>
<td>3.99</td>
<td>2.56</td>
<td>10.23</td>
<td>Red</td>
</tr>
<tr>
<td>D</td>
<td>Incomplete design at time of tender</td>
<td>3.99</td>
<td>2.75</td>
<td>10.98</td>
<td>Red</td>
</tr>
<tr>
<td>D</td>
<td>Deficient design and delays in design process</td>
<td>3.81</td>
<td>2.64</td>
<td>10.08</td>
<td>Red</td>
</tr>
<tr>
<td>D</td>
<td>Delay in approval of drawings</td>
<td>3.63</td>
<td>2.93</td>
<td>10.65</td>
<td>Red</td>
</tr>
<tr>
<td>F</td>
<td>Delay in progress payment by owner for work completed</td>
<td>4.13</td>
<td>3.06</td>
<td>12.63</td>
<td>Red</td>
</tr>
<tr>
<td>F</td>
<td>Financial difficulties of owner</td>
<td>4.08</td>
<td>2.47</td>
<td>10.06</td>
<td>Red</td>
</tr>
<tr>
<td>F</td>
<td>Cash flow difficulties faced by contractor</td>
<td>3.97</td>
<td>2.92</td>
<td>11.60</td>
<td>Red</td>
</tr>
<tr>
<td>F</td>
<td>Poor financial control on site</td>
<td>3.76</td>
<td>2.79</td>
<td>10.50</td>
<td>Red</td>
</tr>
<tr>
<td>F</td>
<td>Delay payment to supplier/subcontractor</td>
<td>3.81</td>
<td>3.03</td>
<td>11.55</td>
<td>Red</td>
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<tr>
<td></td>
<td>Issue</td>
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<td>Impact</td>
<td>Severity</td>
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<td>--------</td>
<td>----------</td>
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<tr>
<td>C</td>
<td>Weak communication between project parties</td>
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</tr>
<tr>
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</tr>
<tr>
<td>L</td>
<td>Low labour productivity</td>
<td>3.97</td>
<td>2.91</td>
<td>11.56</td>
<td>Red</td>
</tr>
<tr>
<td>L</td>
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<td>Impact on Cost</td>
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<td>(CI) Mean value</td>
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<td>3.62</td>
<td>13.53</td>
<td>Red</td>
</tr>
<tr>
<td>CPH</td>
<td>Schedule delay</td>
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<td>4.12</td>
<td>16.88</td>
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</tr>
<tr>
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<td>Improper planning and scheduling</td>
<td>4.33</td>
<td>4.13</td>
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<td>Red</td>
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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

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<td>CPH3</td>
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<tr>
<td>D1</td>
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<tr>
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<td>2</td>
</tr>
<tr>
<td>L2 Lack and shortage of skilled labours</td>
<td>0.407</td>
<td>3</td>
</tr>
<tr>
<td>PM1 Poor project management</td>
<td>0.381</td>
<td>4</td>
</tr>
<tr>
<td>CPH6 Delay in inspection and approval of completed work</td>
<td>0.379</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experts with Less than 16 years Experience</th>
<th>FCAII</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPH3 Improper planning and scheduling</td>
<td>0.459</td>
<td>1</td>
</tr>
<tr>
<td>PM1 Poor project management</td>
<td>0.436</td>
<td>2</td>
</tr>
<tr>
<td>PM2 Frequent changes to the scope of work</td>
<td>0.422</td>
<td>3</td>
</tr>
<tr>
<td>CPH2 Schedule delay</td>
<td>0.421</td>
<td>4</td>
</tr>
<tr>
<td>PM8 Inaccurate time and cost estimates of project</td>
<td>0.409</td>
<td>5</td>
</tr>
<tr>
<td>Large Companies Ranking</td>
<td>FCAII</td>
<td>Rank</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>C2   Weak collaboration between management and labour</td>
<td>0.459</td>
<td>1</td>
</tr>
<tr>
<td>C3   Weak communication between project parties</td>
<td>0.434</td>
<td>2</td>
</tr>
<tr>
<td>CPH6 Delay in inspection and approval of completed work</td>
<td>0.425</td>
<td>3</td>
</tr>
<tr>
<td>PM6  Unrealistic contract duration and requirements imposed</td>
<td>0.419</td>
<td>4</td>
</tr>
<tr>
<td>PM8  Inaccurate time and cost estimates of project</td>
<td>0.406</td>
<td>5</td>
</tr>
</tbody>
</table>

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


