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Evaluation of Delay's Causes and Effects on Sport Facilities

By

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Abstract

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Masters of Science in Engineering Management

Title: EVALUATION of DELAY'S CAUSES and EFFECTS on SPORT FACILITIES

Supervisor of Project: Prof. Murat Gunduz

The sports field has been expanded in drastic change during the last two decades in most countries who are hosting international tournaments like Olympic Games, World Cups or World Championship tournaments of different kind of sports and games. As example of these countries is the State of Qatar who hosted couple of GCC, Asian and International tournaments of many sports such as the 17th Arabian Gulf Cup - Doha 2004, The 15th Asian Game – Doha 2016, AFC Asian Cup 2011, 2015 World Men's Handball Championship and others.

Moreover, the magnitude of upcoming sport events for any country is playing a big role on the development of sports industry and the infrastructure of the whole country as these events are considered as investment and revenue generated for the country. Subsequently, fulfilling the requirements of International Federations to host these tournaments will impact the construction of infrastructure (transportation, drainage, power substations, treatment plants, etc.), accommodations (Hotels, sports village, etc.) and sports facilities (stadiums, training fields, etc.).

The resulting construction complexity, budget and time constraints and number of stakeholders affected by/from these development' projects increased the needs for the usage of proper project delivery system to achieve the scope of project, deliver on time

and proposed budget and prevented any major delay's causes which may affect the deliverable of such project. The aim and objective of this project is to identify and evaluate the most significant delay's causes and attributes which affecting the construction industry of sport projects worldwide.

The literature part includes the study of delay's causes related the scope of work, project duration, authorities' approval, end user interference, consultant and contractor capabilities, etc., in order to define the most affected group of attributes. A list of 44 delays attributes were distributed in 8 groups and presented through an online questionnaire portal in order to reach local and international participants. A total of 101 completed responses were collected and analyzed through different ranking approach and criteria decision-making method like Relative Importance Index (RII), Spearman's Rank Correlation, T-Test and Analytical Hierarchy Process (AHP).

As a result, the analysis of AHP concluded that "Low level of consultant experience" and "Delays related to Contractor Capabilities" were the most attribute factor and group which delay the construction of sports facility.

Acknowledgments

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Moreover, my deeply appreciation goes to Prof. Murat Gunduz for his continues support, inspiration comments, technical remarks and engagement through the learning process of this master project.

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1 Chapter (1): Introduction

1.1 Overview

The construction of sports facilities is becoming one of the most leading factors which evaluate the development of any country in case of hosting international tournaments and championships. The bidding also requests other infrastructure, transportation and tourism services, which will be available to the teams and spectators during the tournament.

Most of the previous researches identified the delay factors and attributes which affecting the normal construction project, but for sports facility, the number of these attributes and their ranking as a delay factor may differ due to the type of requested sports facility, construction complexity, local and international federations requirements or others.

Therefore, this study aimed to explore and identify the delay attributes and factors which adversely affect the duration of constructing a sport facility.

1.2 Problem Statement

As stated above, the bidding request of any international tournaments or championship should include all available or constructed facilities services which will be constructed and available during the time for tournament. This lead the bidding countries or cities to present the time schedule of constructing these facilities in order to be evaluated by the organizing committees and make sure that they achieve the requirements on the stated time as per their bidding request.

Furthermore, the construction industry in the awarded cities will be a great opportunity for international construction contractors, specialized sub-contractors, suppliers, supervision consultants and sports consultants who have experienced in this field as all projects must be completed on the stated time without any delays. The construction of sports facility may differ from normal superstructure project based on the type of sports, federations requirements and legacy mode of the facility after the tournament.

Therefore, a clear construction plan must be implemented and followed to complete the projects on their specified duration. This required from the project team to implement all their technical knowledge and attention to identify the influencing delay attributes which might adversely affect the duration of construction of sport facilities.

1.3 Objectives

The main objective of this study is to explore, identify and evaluate the most significant delay's causes and attributes which affect the construction industry of sport projects worldwide. Data were gathered through one-to-one meetings and online questionnaire which was sent to senior and upper level of management in which different attributes were identified based on experts and stakeholders from each field.

The analysis and results from this study could be used as lessons learned and starting point for all stakeholders who are involved in the sports facilities' construction in order to reduce the impact of delays on the construction schedule.

1.4 Methodology

The methodology which was used in this study could be summarized as following:

- Overview of previous literature and studies to identify a draft a list of delay causes and attributes affecting the construction of sports facilities.
- Confirming the draft list with technical expertise from project's stakeholders (clients, contractors, consultant, organizing committees, etc.) through one-to-one meetings.

- Gathering data through an online questionnaire (9-point Likert Scale) based on importance of each attribute.
- Analyzing the collected data through different ranking approach and criteria like Relative Importance Index (RII), Spearman's Rank Correlation, T-Test and Analytical Hierarchy Process (AHP).
- The results were then discussed, and final conclusions and recommendations have been highlighted.

1.5 Project Organization

This project comprises of five chapters:

A. Chapter 1: Presenting the introduction, study's overview, objectives, problem statement and methodology.
B. Chapter 2: Overviewing the literature review of previous relevant studies.
C. Chapter 3 Discussing the methodology used in this study.
D. Chapter 4: Analyzing the collected data from the online questionnaire and presenting the results.
E. Chapter 5 Discussing and summarizing the results, conclusions and recommendations to industry professionals.

2 Chapter (2): Literature review

The delay in construction projects was a debatable subject in most research papers accomplished earlier. Some researches defined the construction delay as “time overrun” in which the project either not completed as per on the specified completion date in contract, or as per the agreed date between project parties [10,11]. Other researches defined the delay as challenges, unexpected difficulties or unpredictable elements faced the project team during the construction execution [12].

The delay causes vary from one study to other based on projects’ type (governmental, sports, residential, commercial, high raised buildings, etc.), location, number of stakeholder involved and economic growth of the country in which the projects were studied. Thus, there was a continuous need in each developing country to explore, examine and evaluate the delay’s causes in order to reduce their effect and possibilities in the future projects.

In the state of Qatar, it was founded that 72% of public projects between 2000 and 2013 were delayed from their original completion date [3]. Moreover, 50% of the construction projects in United Arab Emirates (UAE) haven’t been completed on time [5], while 70% of different types of construction projects in Saudi Arabia (KSA) were delayed and experienced time overrun [10].

Concurrently, the delay of the project time led to project extension, cost overrun and loss of profit as the project overhead has been increased directly [3,5,8,10].

The majority of previous researches specified the delay causes based on previous literature reviews or interviews with technical experts in the field whenever the nature of the project is a bit different. The study of E. Abd El-Razek, M & Bassioni, H & Mobarak, A.M [1] outlined 32 delay causes of construction projects in Egypt. The list was derived from previous studies and 7 interviews with engineering experts who had a minimum of 15 years experienced in the construction field. These 32 delay causes were classified in 3 main groups (contractor, consultant and client) and the data were collected through a questionnaire survey based on 4 Likert scale using four options (very important, important, somewhat important, and not important) and then analyzed through relative importance index (RII) and Spearman rank correlation coefficient. The most top 5 factors were:

1. Financing by contractor during construction (Contractor)
2. Delays in contractor's payment by owner (Owner)
3. Design changes by owner or his agent during construction (Consultant)
4. Partial payments during construction (Owner)
5. Non-utilization of professional construction/contractual management (Common)

A research executed by Ayman H. Al-Momani [2] had concluded that 24.6% of the project were delayed because of "poor design". The other causes were change orders, weather condition, site condition, late delivery, economic conditions, and increase in quantities.

Another research was done by Abdalla M Odeh and Hussien T Battaineh [7] in which the 28 delay causes were categorized in 8 major groups which are; client, contractor, consultant, material, labor, contract, contractual relationships and external factors. The study concluded that the most significance causes were as following:

1- Owner interference

2- Inadequate contractor experience

3- Financing and payments

4- Labor productivity

5- Slow decision making

6- Improper planning

7- Subcontractors.

The study accomplished by Tsegay Gebrehiwet and Hanbin Luo [5] had concluded 52 delay causes and evaluated their importance based on construction stages (pre-construction stage, construction stage, and post-construction). The 5 most important causes were as following:

1- Corruption

2- Unavailability of utilities at site

3- Inflation or price increases in materials

4- Lack of quality materials

5- Late design and design documents

One of the most valuable study in the middle east was accomplished by Sadi A. Assaf, Sadiq Al-Hejji [10] in which they have studied the importance of delay cause in the construction project in Saudi Arabia (KSA). The research has identified 73 causes of delay which are classified in 9 groups according to the sources of delay (project, owner, contractor, consultant, design-team, materials, equipment, manpower (labor), and external factors). The most 4 important causes from owner, contractor and consultant were as following:

1- Owner: shortage of labors, unqualified work force, ineffective planning and scheduling of project by contractor and low productivity level of labors.

2- Contractor: delay in progress payments by owner, late in reviewing and approving design documents by owner, change orders by owner during construction and delays in producing design documents.

3- Consultant: type of project bidding and award, shortage of labors, ineffective planning and scheduling of project by contractor and delay in progress payments by owner.

For the sports project, the literature reviews were very limited. Therefore, 4 ono-to-one meetings with technical experts in the construction of sports facilities (more than 20 years experienced) were conducted. The main differences stated were related to the number of different stakeholders involved in this type of projects like local and international federations, tournaments organizing committees, investors and operation teams. Thus, consideration of the delay causes related for them were evaluated in the study.

3 Chapter (3): Research Methodology

3.1 Introduction

The methodology of this study is shown in Figure 1 to achieve the objectives about the evaluation of delay's causes and effects on construction of sport facilities.

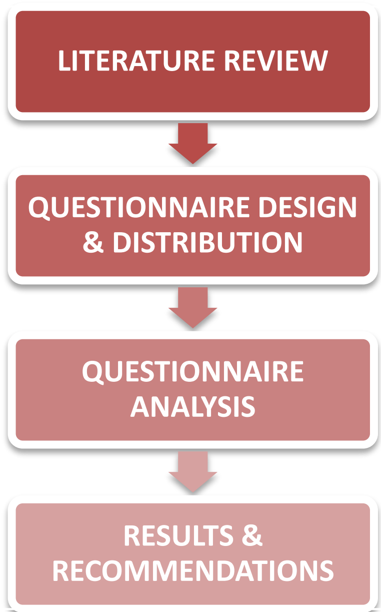

Figure 1 - Project's methodology

Firstly, the draft list which obtained from the literature review part consisted of 85 delay factors and attributes. The list has been further discussed and explored through 4 one-to-one meetings with senior level management from four entities who are the main controllers of any construction project (client, project management, contractor and supervision consultant) and 44 factors were taken into account in the study.

Secondly, a quantitative procedure was implemented by developing an online questionnaire which was distributed to the senior and upper level management for all stakeholders who play key roles in the construction industry of sports facilities as shown below:

- Client (Owner),
- Main Contractor,
- Sub-Contractor and suppliers,
- Supervision Consultant
- Design Consultant
- Sub-Consultant (Sports)
- Project Management Consultant
- Facility Management
- End- user (Organizing Committee of the tournament)
- Local and International Federations

Finally, the collected data were discussed further and analyzed by applying a multi-criteria decision-making method (Analytical Hierarchy Process) in which the final results and recommendations for future works will be shown.

3.2 Questionnaire Design and Structure

Because of the high number of stakeholders who are involved in the construction project of a sports facility, the environment and nature of the sports project are more challengeable rather than any other superstructure facilities. Therefore, the most productive approach to collect necessary data for the study and analysis was through developing an online questionnaire.

Moreover, this approach has assisted the study in exploring and observing different perceptions of responses based on the organization type and their involvement role in the project. The structure of the online questionnaire was composed of two main sections as following:

- Section (1): General information of the respondents including job designation, organization type, location and total number of construction experience which would assist the study in categorizing the respondents into different groups.
- Section (2): Evaluation of each of the 44 delay factors in which the respondents were requested to evaluate by their importance (how much does this factor affects the delay time in construction of sport facility) of each factor on the delay time of construction a sports facility based on their technical experience with a 9-Point Likert Scale (1=lowest, …., 9= the highest importance).

For example, the respondents were asked to evaluate the impact of "High level of design's complexity" on the delay time in construction of sport facility by selecting a number from 1 to 9 to rate the importance of this factor.

The questionnaire was distributed and sent to senior and upper level management of different organizations, and a total of 101 completed responses were received.

3.3 Ranking Approaches

3.3.1 Relative Importance Index (RII)

The first method used to rank the importance of delay factors and attributes (based on the collected responses) was the Relative Importance Index (RII). This method was used earlier in analyzing factors that delays the duration of construction projects in Egypt [1], Saudi Arabia (10) and Turkish (12). Below is the equation of the Relative Importance Index which was used in the study:

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

Equation 1 – Equation of Relative Importance Index (RII)

Where:

- W = Weight given to each attribute by the respondent (1 to 9).
- A = Highest weight (in this study is 9).
- N = Total number of respondents (in this study is 101).

Just to note that that the value of the RII ranges from 0 to 1, where the attribute with higher RII's value is more important compared to others.

3.3.2 Spearman's Rank Correlation

The second ranking approach used in this study was Spearman's Rank Correlation Factor which is a non-parametric test and statistical measure of the strength of a monotonic relationship between paired data. The most advantages of this method are:

1- Spearman's Rank Correlation doesn't assume any assumptions about the distribution of the data.

2- Spearman's Rank Correlation is the appropriate correlation analysis when the variables are measured on a scale that is at least ordinal.

In our study, this method was used to measure the correlation's strength between each type of respondents based on their category in order to find if there is a significant relationship between participants' responses.

The following formula is used to calculate the Spearman rank correlation

$$\boldsymbol{\rho = 1 - \left[\frac{6 \sum d_i^2}{n^3 - n}\right]}$$

Equation 2 - Equation of Spearman's Rank Correlation

Where,

- $\rho =$ Spearman rank correlation
- $d_i =$ Difference between the ranks of corresponding values Xi and Yi
- $n =$ Number of values in each data set (in our study, it is equal to the total number of delay factors and attributes (44)).

The strength of the relationship between the two set of variables take a value between -1 and 1 ($-1 \leq \rho \leq 1$) in which the positive values show (Agreement Relationship) while the negative values show the (Disagreement Relationship). The following guide could describe the strength of the relationship considering the absolute value of ρ:

- Very weak (0.0 - 0.19)
- Weak (0.20 – 0.39)

- Moderate (0.40 – 0.59)
- Strong (0.60 – 0.79)
- Very Strong (0.80 – 1.0)

3.3.3 T – Test

The third ranking method used in this study was the T-Test method which is a statistical method used to compare the differences between the means of two sets of data. The null hypothesis says that there is no significant difference between their means. In other words, it gives us an idea about the differences statistically.

The used formula for this method was as following:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Equation 3 - Equation of T - Test Method

Where;

- $\overline{X_1}$ represents the mean of first data group
- $\overline{X_2}$ represents the mean of second data group
- S_1 represents the standard deviation of first data group
- S_2 represents the standard deviation of second data group
- n_1 represents the number of responses in the first data group
- n_2 represents the number of responses in the second data group

Moreover, the study considered a significant level (alpha value) to be 0.05 (Two Tiled) and our case is considered as 2 independent samples with Separate variances. The t value was calculated under the assumption that there is no significant difference between the two groups to be compared when $t > t_{critical}\ OR\ P - Value\ > 0.05$, otherwise, a significant difference is existed.

3.3.4 Analytical Hierarchy Process (AHP)

The last method used in this study was Analytical Hierarchy Process (AHP) which is a process for developing a numerical score to rank each decision alternative based on how well the alternative meets the decision maker's criteria.

The algorithm of AHP is basically composed of three main steps:

- Step (1): Determine the vector of weights of delay factors,
- Step (2): Determine the matrix of rankings (priorities) of delay groups.
- Step (3): Ranking the delay groups.

3.3.4.1 AHP – Step (1)

In order to determine the weights for the different delay group, the AHP starts developing a pairwise comparison matrix A_m where m delay groups are considered and n delay factors to be evaluated. The matrix A_m is a $n \times n$ real matrix, where m is the number of delay groups considered. Each entry a_{jd} of the matrix A_m represents the importance of the *j*th delay factor relative to the *d*th delay factor within the same delay group as following:

- $a_{jd}\ > 1$: Importance of *j*th delay factor is <u>more</u> than *d*th delay factor
- $a_{jd}\ < 1$: Importance of *j*th delay factor is <u>less</u> than *d*th delay factor

- $a_{jd} = 1$: Two delay groups have the same importance
- $a_{jd}\ and\ a_{dj}$ must satisfy the constraint $a_{jd} . a_{dj} = 1$

The relative importance between two delay factors is measured according to a numerical scale from 1 to 9, as shown in Table 1, and all values of matrix A_m are by construction pairwise consistent.

Table 1

Table of Relative Scores

Value of a_{jd}	**Interpretation**
1	*j* and *d* are equally important
3	*j* is slightly more important than *d*
5	*j* is more important than *d*
7	*j* is strongly more important than *d*
9	*j* is absolutely more important than *d*
2, 4, 6, and 8	Intermediate numerical ratings

Then, matrix A_m should be normalized in order to have matrix A_{norm} as Equation 4:

$$\bar{a}_{jd} = \frac{a_{jd}}{\sum_{l=1}^{m} a_{ld}}$$

Equation 4 - Normalized matrix A_{norm}

Finally, the criteria weight vector *w* (that is an *m*-dimensional column vector) is computed by averaging the entries on each row of A_{norm} as Equation 5.

$$w_j = \frac{\sum_{l=1}^{m} \bar{a}_{jd}}{m}$$

Equation 5 - Weight vector *w*

3.3.4.2 AHP – Step (2)

The second matrix supposed to be computed in the AHP process is the matrix of rankings (priorities) of delay groups which is a $m \times m$ real matrix S. The process was similar to the one used to compute the *pairwise comparison matrix* A_m, but for delay groups in order to compute the preference vector *s* which contains the scores of the evaluated delay group with respect to the *j*th group.

$$S = \left[s^j \ldots s^m\right] \quad , \qquad j = 1, \ldots., m$$

3.3.4.3 AHP – Step (3)

Once the weight vector ***w*** and the preference vector ***s*** have been computed, the AHP obtains a ranking vector **v** of by multiplying **S** and **w** as following:

$$\boldsymbol{v} = \boldsymbol{S} \cdot \boldsymbol{w}$$

Equation 6 - Equation for ranking vector *v*

As the final step, the group's ranking is accomplished by ordering the score values in decreasing order.

4 Chapter (4): Data Analysis and Discussion

4.1 Introduction

The data collected from the 101 online responses will be summarized and analyzed in this chapter. The online questionnaire was developed through an online portal operated by Survey Monkey website. The portal allowed the user to customize the questionnaire based on the study needs and then exporting the collected the responses in various formats.

Moreover, the questionnaire web link was sent through email to a professional network of senior engineers, specialists, representatives and upper level management of all stakeholders who are relevant to the study. The data collection period took almost 2 months and the total number of completed responses was 101.

The questionnaire was developed from two main parts which are “Respondent Profile” and “Technical Evaluation of delay attributes and groups” which will be discussed deeply in this chapter.

4.2 Respondents Profile

The first part of the survey was concentrating on general information and profile of the respondent. It was designed from four questions which specified the job designation, organization type, location and total number of construction experience for each respondent. Thus, categorizing the respondents into different groups would be easier for the data analysis in later stage.

4.2.1 Respondents Location

As shown below in Figure 2, the participants were from the different locations which are Qatar, GCC and others. The majority of responses were from Qatar (74 responses) which represents 73.27%. The other two locations represented the remaining 26.73% with 7 participants from GCC Countries and other 20 participants from Others Countries (Spain, UK, US, South Korea and Switzerland).

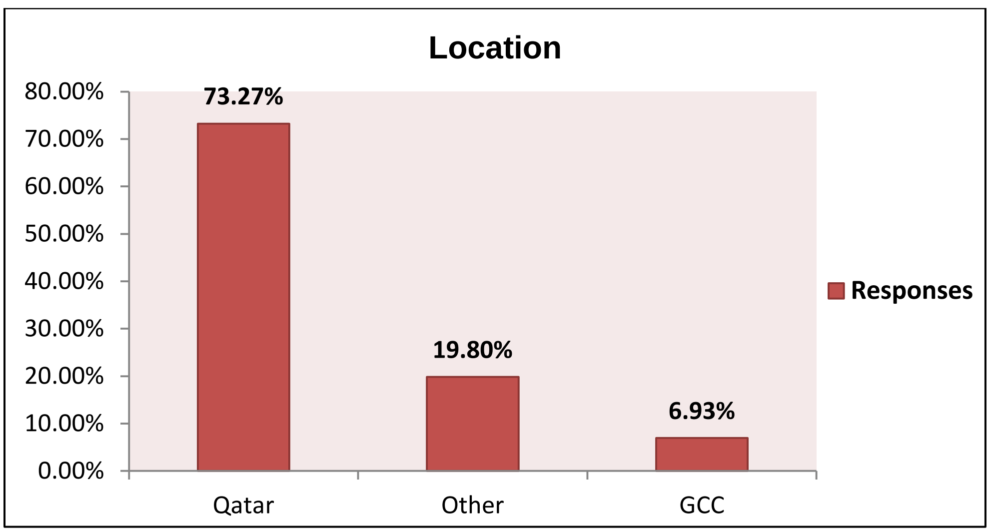

Figure 2 - Number of respondents based on Location

4.2.2 Respondents Organization Type

As the nature of the sports facility construction is a bit complicated than other projects, the organization type question was mandatory in order to assist the study with realistic data. The organization type options in the questionnaire were Owner (Client), Project Management (Client Representative), Consultant, Contractor, End User Representative, Local Federation Representative, International Federation Representative, Event Organizer / Operator, Facility Management or Other.

From Figure 3, the highest number of responses were from Project Management (Client Representative) with 30.69%, followed by Contractor (23.76%), Consultant (10.89%) Owner (8.91%) and International Federation Representative (8.91%). The remaining 16.83% was distribute among the other organizations.

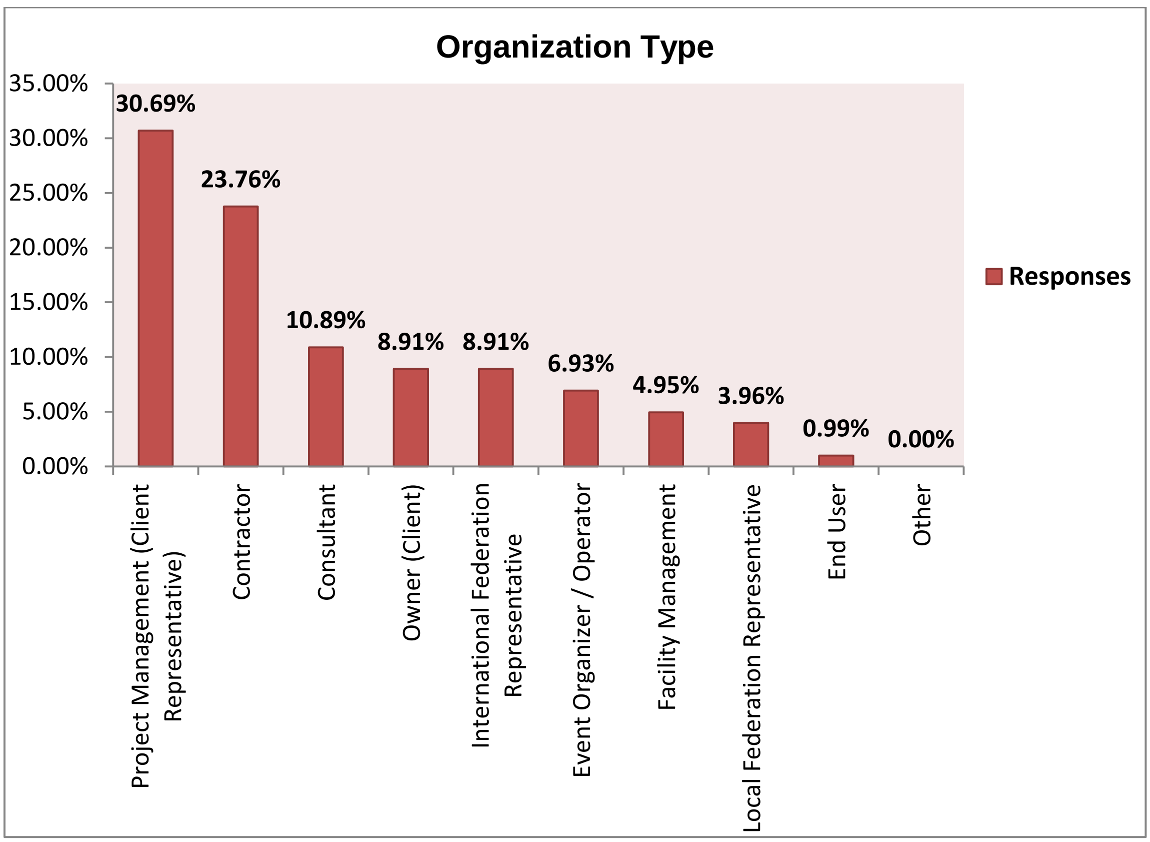

Figure 3 - Number of respondents based on Organization Type

4.2.3 Respondents Job Designation

Out of 101 complete responses for the study, the number of project manager was 1st ranking with 29.70% (30 responses) as showed in Figure 4. The second one was the construction manager with 14.85%. The rest of the participants were design engineer (13.86%), others (12.87%), project engineer (9.90%), facility engineer (6.93%), end-user representative (6.93%), owner (2,97%) and site superintendent (1.98%).

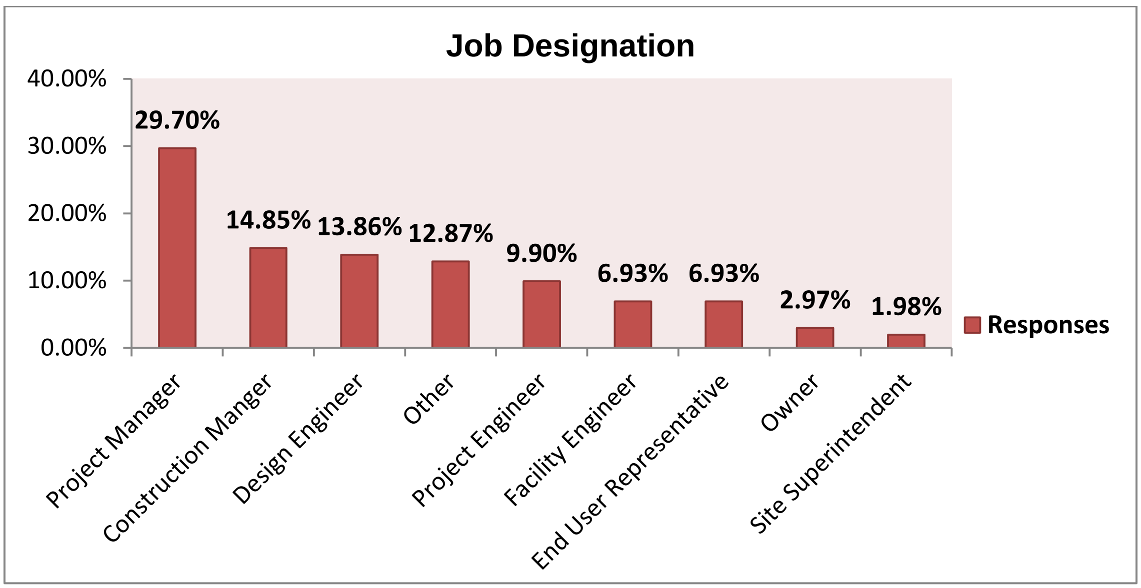

Figure 4 - Number of respondents based on Job Designation

4.2.4 Respondents Total Work Experience in Construction Field

From Figure 5, 31.68% of participants were having a level of experience between 11 and 15 years, while the second group was the expert level (More than 15 years) with 30.69%.

The other 37.62% are distributed along the remaining two groups, (5 - 10 years) with 29.70%, and (Less than 5 years) with 7.92%.

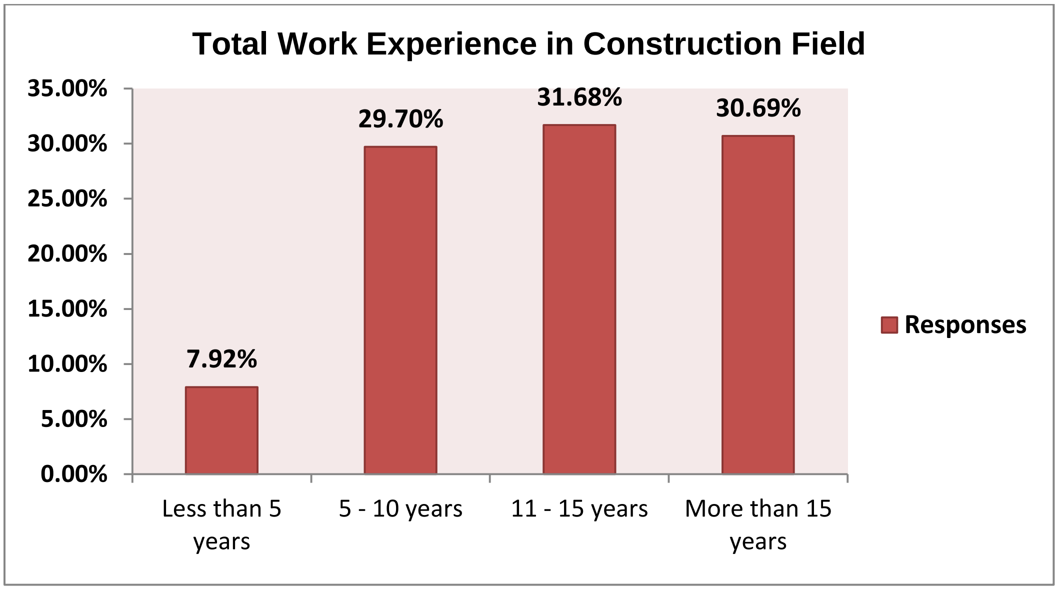

Figure 5 - Number of respondents based on Total Work Experience in Construction Field

4.3 Evaluation of construction delay attributes

The main objective of this study was to evaluate the delay's causes and effects on sports facilities by exploring the delay factors and attributes which delayed the construction time of a sports facility. This evaluation was based on realistic data which collected from different technical perceptions of the construction industry professionals through an online questionnaire as explained earlier.

Participants have been asked to rate the importance of each delay factor and attributes (9 - point Likert Scale) based on their technical experience in the construction and operation of a sports facility. Moreover, they were asked to evaluate the importance of each delay group as a second part of the process in order to analyze the study through the four ranking approaches specified earlier.

The following sections of this chapter will present the raw data, coding system, mean, median and data analysis, calculations and results of each ranking approaches.

4.3.1 Raw Data

The first step in the analysis was to organize the raw data exported from the questionnaire which used later to develop all required data for the four ranking approaches in order to reach project results.

4.3.2 Coding System

In order to have a simple and professional data presentation, a coding system was used in the study as shown below:

- "DG*k*" for delay groups, where:
    - "DG" is the abbreviation of "Delay Group"
    - "*k*" represents the delay group number (*k* value is from 1 to 7 as the questionnaire categorized in 7 delay groups).
- "DG*k*F*i*" for delay factors/attributes, where:
    - "DG*k*" represents the delay group number
    - "F" is the abbreviation of "Delay Factors/Attributes"
    - "*i*" represents the delay factors/attributes number (*i* value is from 1 to n where "n" is the total number of factors/attributes in each delay group).

The below table (Table 2) is showing the full coding system:

Table 2

Coding System Used to Organize the Collected Data

Codes of Delay Group and Factors		Code
#	**Delays related to scope of work (SOW)**	**DG1**
1	Increased number of design's errors	DG1F1
2	Increased number of scope changes	DG1F2
3	Additional requirements between the Event and Legacy mode of the facility	DG1F3
4	Enforcement of using specialized items, suppliers and vendors	DG1F4
5	High level of design's complexity	DG1F5
6	Increased number of requirements based on type of sports facility	DG1F6
	Delays related to project duration	**DG2**

7	Unrealistic enforced contract duration	DG2F1
8	Delay in approvals by the authorities	DG2F2
9	Delay in delivering infrastructure services to the facility	DG2F3
	Delays related to client or client representative (project management)	**DG3**
10	Increased number of bidding requirements	DG3F1
11	Low level of client's project team experience	DG3F2
12	Delay in revising and approving documents	DG3F3
13	Delay in decision making	DG3F4
14	Delay in payments	DG3F5
15	Increased investors' interference	DG3F6
16	Delay in final acceptance of the facility	DG3F7
	Delays related to consultant	**DG4**
17	Low level of consultant experience	DG4F1
18	Delay in inspecting, revising and approving documents	DG4F2
19	Discrepancies in documents issued by consultant	DG4F3
20	Poor communication and coordination	DG4F4
	Delays related to contractor	**DG5**
21	Low level of contractor experience	DG5F1
22	Late delivery of appropriate construction equipment	DG5F2
23	Poor site management and supervision	DG5F3
24	Loss of efficiency due to rework activities	DG5F4
25	Difficulties in financing the project by contractor	DG5F5
26	Deficiencies in planning and scheduling of project	DG5F6
27	Changes in material specifications during construction	DG5F7
28	Shortage of construction materials	DG5F8
29	Unforeseen site conditions	DG5F9
30	Lack of permanent site utilities	DG5F10
31	Unforeseen weather conditions	DG5F11
	Delays related to international federation	**DG6**
32	Changes in International Federation's regulation	DG6F1
33	Additional requirements by the International Federation	DG6F2
34	Enforcement of selected sponsors for certain sports equipment and systems	DG6F3
	Delays related to local authorities	**DG7**
35	Changes in regulations and laws	DG7F1
36	Additional requirements during inspection.	DG7F2

37	Delay in inspections procedures	DG7F3
	Most significant delay's attribute group	**DG8**
38	Delays related to scope of work	DG1
39	Delays related to project duration	DG2
40	Delays related to client or client representative (project management)	DG3
41	Delays related to consultant	DG4
42	Delays related to contractor	DG5
43	Delays related to international federation	DG6
44	Delays related to local authorities	DG7

4.3.3 Mean of Delay Groups / Factors

As the questionnaire was based on technical experience and judgment of participants, the study has used the mean of each delay groups and factors. Table 3 shows the calculated mean of each delay groups and factors:

Table 3

Mean of Each Delay Groups and Factors

Code	Delay Group/ Factors	Mean
DG1	**Delays related to scope of work (SOW):**	
DG1F1	Increased number of design's errors	5.96
DG1F2	Increased number of scope changes	7.50
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.67
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.43
DG1F5	High level of design's complexity	6.46
DG1F6	Increased number of requirements based on type of sports facility	5.90
DG2	**Delays related to project duration:**	
DG2F1	Unrealistic enforced contract duration	6.70
DG2F2	Delay in approvals by the authorities	6.48
DG2F3	Delay in delivering infrastructure services to the facility	5.37
DG3	**Delays related to client or client representative (project management):**	
DG3F1	Increased number of bidding requirements	4.66
DG3F2	Low level of client's project team experience	6.34
DG3F3	Delay in revising and approving documents	5.82
DG3F4	Delay in decision making	7.33
DG3F5	Delay in payments	6.87
DG3F6	Increased investors' interference	5.42
DG3F7	Delay in final acceptance of the facility	6.12
DG4	**Delays related to consultant:**	
DG4F1	Low level of consultant experience	6.63
DG4F2	Delay in inspecting, revising and approving documents	6.08

DG4F3	Discrepancies in documents issued by consultant	5.84
DG4F4	Poor communication and coordination	5.96
DG5	**Delays related to contractor:**	
DG5F1	Low level of contractor experience	7.15
DG5F2	Late delivery of appropriate construction equipment	6.89
DG5F3	Poor site management and supervision	6.25
DG5F4	Loss of efficiency due to rework activities	6.40
DG5F5	Difficulties in financing the project by contractor	6.76
DG5F6	Deficiencies in planning and scheduling of project	6.30
DG5F7	Changes in material specifications during construction	6.15
DG5F8	Shortage of construction materials	6.98
DG5F9	Unforeseen site conditions	5.64
DG5F10	Lack of permanent site utilities	4.80
DG5F11	Unforeseen weather conditions	4.63
DG6	**Delays related to international federation:**	
DG6F1	Changes in International Federation’s regulation	4.38
DG6F2	Additional requirements by the International Federation	5.43
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.80
DG7	**Delays related to local authorities:**	
DG7F1	Changes in regulations and laws	5.35
DG7F2	Additional requirements during inspection.	6.09
DG7F3	Delay in inspections procedures	5.80
DG8	**Most significant delay's attribute group:**	
DG1	Delays related to scope of work	6.11
DG2	Delays related to project duration	5.70
DG3	Delays related to client or client representative (project management)	6.14
DG4	Delays related to consultant	6.62
DG5	Delays related to contractor	7.75
DG6	Delays related to international federation	4.66
DG7	Delays related to local authorities	5.80

4.3.4 Ranking by Relative Importance Index (RII)

Table 4 and Table 5 are showing the calculated RII values and ranking of each delay groups and factors based on Equation 1 as explained earlier in Chapter 3 (3.3.1 Page 11).

Table 4

RII Values and Ranking (Sorted Based on Code).

Code	Delay Groups/ Factors	W	RII %	RII Rank
DG1F1	Increased number of design's errors	602	66.23%	18
DG1F2	Increased number of scope changes	757	83.28%	43
DG1F3	Additional requirements between the Event and Legacy mode of the facility	674	74.15%	35
DG1F4	Enforcement of using specialized items, suppliers and vendors	649	71.40%	30
DG1F5	High level of design's complexity	652	71.73%	31
DG1F6	Increased number of requirements based on type of sports facility	596	65.57%	17
DG2F1	Unrealistic enforced contract duration	677	74.48%	36
DG2F2	Delay in approvals by the authorities	654	71.95%	32
DG2F3	Delay in delivering infrastructure services to the facility	542	59.63%	7
DG3F1	Increased number of bidding requirements	471	51.82%	3
DG3F2	Low level of client’s project team experience	640	70.41%	28
DG3F3	Delay in revising and approving documents	588	64.69%	15
DG3F4	Delay in decision making	740	81.41%	42
DG3F5	Delay in payments	694	76.35%	38
DG3F6	Increased investors’ interference	547	60.18%	8
DG3F7	Delay in final acceptance of the facility	618	67.99%	23
DG4F1	Low level of consultant experience	670	73.71%	34
DG4F2	Delay in inspecting, revising and approving documents	614	67.55%	20
DG4F3	Discrepancies in documents issued by consultant	590	64.91%	16
DG4F4	Poor communication and coordination	602	66.23%	19
DG5F1	Low level of contractor experience	722	79.43%	41
DG5F2	Late delivery of appropriate construction equipment	696	76.57%	39
DG5F3	Poor site management and supervision	631	69.42%	26

DG5F4	Loss of efficiency due to rework activities	646	71.07%	29
DG5F5	Difficulties in financing the project by contractor	683	75.14%	37
DG5F6	Deficiencies in planning and scheduling of project	636	69.97%	27
DG5F7	Changes in material specifications during construction	621	68.32%	25
DG5F8	Shortage of construction materials	705	77.56%	40
DG5F9	Unforeseen site conditions	570	62.71%	10
DG5F10	Lack of permanent site utilities	485	53.36%	5
DG5F11	Unforeseen weather conditions	468	51.49%	2
DG6F1	Changes in International Federation’s regulation	442	48.62%	1
DG6F2	Additional requirements by the International Federation	548	60.29%	9
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	586	64.47%	12
DG7F1	Changes in regulations and laws	540	59.41%	6
DG7F2	Additional requirements during inspection.	615	67.66%	21
DG7F3	Delay in inspections procedures	586	64.47%	13
DG1	Delays related to scope of work	617	67.88%	22
DG2	Delays related to project duration	576	63.37%	11
DG3	Delays related to client or client representative (project management)	620	68.21%	24
DG4	Delays related to consultant	669	73.60%	33
DG5	Delays related to contractor	783	86.14%	44
DG6	Delays related to international federation	471	51.82%	4
DG7	Delays related to local authorities	586	64.47%	14

Table 5

RII Values and Ranking (Sorted Based on RII Rank)

Code	Delay Groups/ Factors	W	RII %	RII Rank
DG6F1	Changes in International Federation’s regulation	442	48.62%	1
DG5F11	Unforeseen weather conditions	468	51.49%	2
DG3F1	Increased number of bidding requirements	471	51.82%	3
DG6	Delays related to international federation	471	51.82%	4
DG5F10	Lack of permanent site utilities	485	53.36%	5
DG7F1	Changes in regulations and laws	540	59.41%	6
DG2F3	Delay in delivering infrastructure services to the facility	542	59.63%	7

DG3F6	Increased investors' interference	547	60.18%	8
DG6F2	Additional requirements by the International Federation	548	60.29%	9
DG5F9	Unforeseen site conditions	570	62.71%	10
DG2	Delays related to project duration	576	63.37%	11
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	586	64.47%	12
DG7F3	Delay in inspections procedures	586	64.47%	13
DG7	Delays related to local authorities	586	64.47%	14
DG3F3	Delay in revising and approving documents	588	64.69%	15
DG4F3	Discrepancies in documents issued by consultant	590	64.91%	16
DG1F6	Increased number of requirements based on type of sports facility	596	65.57%	17
DG1F1	Increased number of design's errors	602	66.23%	18
DG4F4	Poor communication and coordination	602	66.23%	19
DG4F2	Delay in inspecting, revising and approving documents	614	67.55%	20
DG7F2	Additional requirements during inspection.	615	67.66%	21
DG1	Delays related to scope of work	617	67.88%	22
DG3F7	Delay in final acceptance of the facility	618	67.99%	23
DG3	Delays related to client or client representative (project management)	620	68.21%	24
DG5F7	Changes in material specifications during construction	621	68.32%	25
DG5F3	Poor site management and supervision	631	69.42%	26
DG5F6	Deficiencies in planning and scheduling of project	636	69.97%	27
DG3F2	Low level of client's project team experience	640	70.41%	28
DG5F4	Loss of efficiency due to rework activities	646	71.07%	29
DG1F4	Enforcement of using specialized items, suppliers and vendors	649	71.40%	30
DG1F5	High level of design's complexity	652	71.73%	31
DG2F2	Delay in approvals by the authorities	654	71.95%	32
DG4	Delays related to consultant	669	73.60%	33
DG4F1	Low level of consultant experience	670	73.71%	34
DG1F3	Additional requirements between the Event and Legacy mode of the facility	674	74.15%	35
DG2F1	Unrealistic enforced contract duration	677	74.48%	36
DG5F5	Difficulties in financing the project by contractor	683	75.14%	37
DG3F5	Delay in payments	694	76.35%	38
DG5F2	Late delivery of appropriate construction equipment	696	76.57%	39
DG5F8	Shortage of construction materials	705	77.56%	40
DG5F1	Low level of contractor experience	722	79.43%	41
DG3F4	Delay in decision making	740	81.41%	42

DG1F2	Increased number of scope changes	757	83.28%	43
DG5	Delays related to contractor	783	86.14%	44

From the above table, the top 2 delay groups and 10 delay factors were exported in Table 6 and Table 7 where 4 delay factors were relevant to contractor, 2 to scope of work, 2 to client or client representative (project management), 1 to project duration and 1 to consultant groups respectively.

Table 6

Top 2 Delay Groups by RII Ranking

Code	**Delay Groups**	**W**	**RII %**	**RII Rank**
DG5	Delays related to contractor	783	86.14%	44
DG4	Delays related to consultant	669	73.60%	33

Table 7

Top 10 Delay Factors by RII Ranking

Code	**Delay Factors**	**W**	**RII %**	**RII Rank**
DG1F2	Increased number of scope changes	757	83.28%	43
DG3F4	Delay in decision making	740	81.41%	42
DG5F1	Low level of contractor experience	722	79.43%	41
DG5F8	Shortage of construction materials	705	77.56%	40
DG5F2	Late delivery of appropriate construction equipment	696	76.57%	39
DG3F5	Delay in payments	694	76.35%	38
DG5F5	Difficulties in financing the project by contractor	683	75.14%	37

DG2F1	Unrealistic enforced contract duration	677	74.48%	36
DG1F3	Additional requirements between the Event and Legacy mode of the facility	674	74.15%	35
DG4F1	Low level of consultant experience	670	73.71%	34

4.3.5 Ranking by Spearman's Rank Correlation

The calculation of the second ranking approach was achieved through Equation 2 which explained earlier. The aim of using the Spearman's Rank Correlation was to observe the relationship between the two selected sets of data, based on their category, in order to evaluate the strength of the relationship between participants' responses. The strength was evaluated in two approaches as following:

- Comparing the value of Spearman Rank Correlation (ρ) in which the strength of the relationship between the two set of variables take a value between -1 and 1 ($-1 \leq \rho \leq 1$) in which the positive values show (Agreement Relationship) while the negative values show the (Disagreement Relationship). The following guide could describe the strength of the relationship considering the absolute value of ρ:
  - Very weak (0.0 - 0.19)
  - Weak (0.20 – 0.39)
  - Moderate (0.40 – 0.59)
  - Strong (0.60 – 0.79)
  - Very Strong (0.80 – 1.0)
- Comparing the value of Spearman Rank Correlation (ρ) to the Critical Values (r_s) of Spearman's Rank Order Correlation from the statistic tables where;
  - Level of Significance of a Two-Tailed is 95% (α = 0.05)

- $\rho > r_s$ ➔ No significant difference between the two sets of data
- $\rho < r_s$ ➔ There is a significant difference between the two sets of data.

The major 9 comparative data categories were as following:

4.3.5.1 Qatar vs World (GCC and Others)

The computed value of Spearman rank correlation (ρ) for this comparison, as shown below in Table 8, was 0.678 which indicate:

- "Strong" relationship between the two groups as (0.60 > ρ > 0.79).
- r_s = 0.305 ➔ No significant difference between the two sets of data.

Table 8

Spearman Rank Correlation for Qatar vs World (GCC and Others)

Code	**Delay Group/ Factors**	**Qatar Mean (M1)**	**Qatar Rank (R1)**	**Others Mean (M2)**	**Others Rank (R2)**	**d (R1-R2)**	**d^2**
DG1F1	Increased number of design's errors	5.73	30	6.59	20.5	9.5	90.3
DG1F2	Increased number of scope changes	7.50	1	7.48	10	-9.0	81.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.49	8.5	7.19	13	-4.5	20.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.11	19	7.30	12	7.0	49.0
DG1F5	High level of design's complexity	6.04	21.5	7.59	9	12.5	156.3
DG1F6	Increased number of requirements based on type of sports facility	5.55	35	6.85	16	19.0	361.0
DG2F1	Unrealistic enforced contract duration	6.73	4	6.63	19	-15.0	225.0
DG2F2	Delay in approvals by the authorities	6.70	5	5.85	32	-27.0	729.0
DG2F3	Delay in delivering infrastructure services to the facility	5.57	34	4.81	40	-6.0	36.0
DG3F1	Increased number of bidding	4.80	41	4.30	44	-3.0	9.0

	requirements						
DG3F2	Low level of client's project team experience	6.04	21.5	7.15	14	7.5	56.3
DG3F3	Delay in revising and approving documents	5.69	32	6.19	29	3.0	9.0
DG3F4	Delay in decision making	7.11	3	7.93	6	-3.0	9.0
DG3F5	Delay in payments	6.57	7	7.70	8	-1.0	1.0
DG3F6	Increased investors' interference	5.14	38	6.19	29	9.0	81.0
DG3F7	Delay in final acceptance of the facility	6.01	23	6.41	25	-2.0	4.0
DG4F1	Low level of consultant experience	6.19	16.5	7.85	7	9.5	90.3
DG4F2	Delay in inspecting, revising and approving documents	5.84	29	6.74	17	12.0	144.0
DG4F3	Discrepancies in documents issued by consultant	5.72	31	6.19	29	2.0	4.0
DG4F4	Poor communication and coordination	5.96	26	5.96	31	-5.0	25.0
DG5F1	Low level of contractor experience	6.65	6	8.52	2	4.0	16.0
DG5F2	Late delivery of appropriate construction equipment	6.31	11.5	8.48	3	8.5	72.3
DG5F3	Poor site management and supervision	6.16	18	6.48	23	-5.0	25.0
DG5F4	Loss of efficiency due to rework activities	6.19	16.5	6.96	15	1.5	2.3
DG5F5	Difficulties in financing the project by contractor	6.31	11.5	8.00	5	6.5	42.3
DG5F6	Deficiencies in planning and scheduling of project	6.26	13	6.41	25	-12.0	144.0
DG5F7	Changes in material specifications during construction	5.99	25	6.59	20.5	4.5	20.3
DG5F8	Shortage of construction materials	6.49	8.5	8.33	4	4.5	20.3
DG5F9	Unforeseen site conditions	5.58	33	5.81	33.5	-0.5	0.3
DG5F10	Lack of permanent site utilities	4.85	40	4.67	41.5	-1.5	2.3
DG5F11	Unforeseen weather conditions	4.35	43	5.41	36	7.0	49.0
DG6F1	Changes in International Federation's regulation	4.18	44	4.93	38	6.0	36.0
DG6F2	Additional requirements by the International Federation	5.07	39	6.41	25	14.0	196.0
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.49	36	6.67	18	18.0	324.0

DG7F1	Changes in regulations and laws	5.42	37	5.15	37	0.0	0.0
DG7F2	Additional requirements during inspection.	5.92	27	6.56	22	5.0	25.0
DG7F3	Delay in inspections procedures	5.89	28	5.56	35	-7.0	49.0
DG1	Delays related to scope of work	6.22	14.5	5.81	33.5	-19.0	361.0
DG2	Delays related to project duration	6.00	24	4.89	39	-15.0	225.0
DG3	Delays related to client or client representative (project management)	6.05	20	6.37	27	-7.0	49.0
DG4	Delays related to consultant	6.32	10	7.44	11	-1.0	1.0
DG5	Delays related to contractor	7.38	2	8.78	1	1.0	1.0
DG6	Delays related to international federation	4.70	42	4.56	43	-1.0	1.0
DG7	Delays related to local authorities	6.22	14.5	4.67	41.5	-27.0	729.0
				Σd^2			**4571.0**
				Spearman Rank Correlation (*ρ*)			**0.678**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.2 Client vs Contractor

The second comparison was based on the organization type of the respondents. The computed value of ρ was 0.271, as shown below in Table 9, which indicates a "Weak" relationship between the two groups. Moreover, a significant difference between the two sets of data is existed as $\rho < r_s$.

Table 9

Spearman Rank Correlation for Client vs Contractor

Code	**Delay Group/ Factors**	**Client Mean (M1)**	**Client Rank (R1)**	**Cont. Mean (M2)**	**Cont. Rank (R2)**	**d (R1-R2)**	**d^2**
DG1F1	Increased number of design's errors	6.11	14.5	5.88	29.5	-15.0	225.0
DG1F2	Increased number of scope changes	6.67	7	7.54	3	4.0	16.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.22	12.5	6.13	24	-11.5	132.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	5.00	39.5	7.04	7	32.5	1056.3
DG1F5	High level of design's complexity	5.22	38	6.17	22.5	15.5	240.3
DG1F6	Increased number of requirements based on type of sports facility	5.44	35.5	5.71	34	1.5	2.3
DG2F1	Unrealistic enforced contract duration	5.56	31.5	6.92	9	22.5	506.3
DG2F2	Delay in approvals by the authorities	7.00	2	5.96	27	-25.0	625.0
DG2F3	Delay in delivering infrastructure services to the facility	6.11	14.5	4.79	39	-24.5	600.3
DG3F1	Increased number of bidding requirements	4.56	43.5	4.67	41	2.5	6.3
DG3F2	Low level of client's project team experience	5.56	31.5	6.79	12.5	19.0	361.0
DG3F3	Delay in revising and approving documents	5.67	27	6.17	22.5	4.5	20.3
DG3F4	Delay in decision making	6.56	8	7.88	1	7.0	49.0
DG3F5	Delay in payments	5.89	21	7.42	5	16.0	256.0
DG3F6	Increased investors' interference	5.00	39.5	6.04	25	14.5	210.3

DG3F7	Delay in final acceptance of the facility	5.44	35.5	6.75	14.5	21.0	441.0
DG4F1	Low level of consultant experience	6.44	9	6.83	11	-2.0	4.0
DG4F2	Delay in inspecting, revising and approving documents	5.56	31.5	6.88	10	21.5	462.3
DG4F3	Discrepancies in documents issued by consultant	5.56	31.5	5.83	31	0.5	0.3
DG4F4	Poor communication and coordination	6.78	4.5	6.00	26	-21.5	462.3
DG5F1	Low level of contractor experience	6.78	4.5	6.79	12.5	-8.0	64.0
DG5F2	Late delivery of appropriate construction equipment	6.22	12.5	6.75	14.5	-2.0	4.0
DG5F3	Poor site management and supervision	6.00	16.5	5.75	32.5	-16.0	256.0
DG5F4	Loss of efficiency due to rework activities	5.89	21	6.71	16	5.0	25.0
DG5F5	Difficulties in financing the project by contractor	5.89	21	6.96	8	13.0	169.0
DG5F6	Deficiencies in planning and scheduling of project	6.78	4.5	5.67	35.5	-31.0	961.0
DG5F7	Changes in material specifications during construction	5.67	27	6.33	21	6.0	36.0
DG5F8	Shortage of construction materials	6.33	10.5	7.79	2	8.5	72.3
DG5F9	Unforeseen site conditions	5.89	21	5.88	29.5	-8.5	72.3
DG5F10	Lack of permanent site utilities	5.67	27	4.58	43	-16.0	256.0
DG5F11	Unforeseen weather conditions	4.56	43.5	4.71	40	3.5	12.3
DG6F1	Changes in International Federation’s regulation	4.67	42	4.42	44	-2.0	4.0
DG6F2	Additional requirements by the International Federation	5.56	31.5	5.46	38	-6.5	42.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	4.89	41	5.92	28	13.0	169.0
DG7F1	Changes in regulations and laws	5.89	21	5.50	37	-16.0	256.0
DG7F2	Additional requirements during inspection.	5.89	21	6.46	19	2.0	4.0
DG7F3	Delay in inspections procedures	5.33	37	6.58	18	19.0	361.0
DG1	Delays related to scope of work	5.56	31.5	6.67	17	14.5	210.3
DG2	Delays related to project duration	5.78	25	5.75	32.5	-7.5	56.3
DG3	Delays related to client or client representative (project management)	5.89	21	6.42	20	1.0	1.0
DG4	Delays related to consultant	6.33	10.5	7.29	6	4.5	20.3
DG5	Delays related to contractor	7.33	1	7.50	4	-3.0	9.0
DG6	Delays related to international federation	6.00	16.5	4.63	42	-25.5	650.3

DG7	Delays related to local authorities	6.78	4.5	5.67	35.5	-31.0	961.0
				Σd^2			**10348.0**
				Spearman Rank Correlation (*ρ)*			**0.271**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.3 Client vs Consultant

The third comparison sets were also based on the organization type of the respondents. The computed value of ρ was 0.406, as shown below in Table 10, which is also indicates a "Moderate" relationship between the two groups. Furthermore, No significant difference between the two sets of data as $\rho > r_s$.

Table 10

Spearman Rank Correlation for Client vs Consultant

Code	Delay Group/ Factors	Client Mean (M1)	Client Rank (R1)	Cons. Mean (M2)	Cons. Rank (R2)	d (R1-R2)	d^2
DG1F1	Increased number of design's errors	6.11	14.5	5.36	31	-16.5	272.3
DG1F2	Increased number of scope changes	6.67	7	7.36	6	1.0	1.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.22	12.5	6.91	10	2.5	6.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	5.00	39.5	7.09	7	32.5	1056.3
DG1F5	High level of design's complexity	5.22	38	6.36	13	25.0	625.0
DG1F6	Increased number of requirements based on type of sports facility	5.44	35.5	6.27	14.5	21.0	441.0
DG2F1	Unrealistic enforced contract duration	5.56	31.5	6.73	11.5	20.0	400.0
DG2F2	Delay in approvals by the authorities	7.00	2	6.00	18	-16.0	256.0
DG2F3	Delay in delivering infrastructure services to the facility	6.11	14.5	5.00	34	-19.5	380.3
DG3F1	Increased number of bidding requirements	4.56	43.5	3.82	43.5	0.0	0.0
DG3F2	Low level of client's project team experience	5.56	31.5	5.64	24	7.5	56.3
DG3F3	Delay in revising and approving documents	5.67	27	5.45	29.5	-2.5	6.3
DG3F4	Delay in decision making	6.56	8	7.55	5	3.0	9.0

DG3F5	Delay in payments	5.89	21	7.00	8.5	12.5	156.3
DG3F6	Increased investors' interference	5.00	39.5	5.64	24	15.5	240.3
DG3F7	Delay in final acceptance of the facility	5.44	35.5	5.55	27	8.5	72.3
DG4F1	Low level of consultant experience	6.44	9	6.18	16	-7.0	49.0
DG4F2	Delay in inspecting, revising and approving documents	5.56	31.5	5.45	29.5	2.0	4.0
DG4F3	Discrepancies in documents issued by consultant	5.56	31.5	5.55	27	4.5	20.3
DG4F4	Poor communication and coordination	6.78	4.5	4.55	39	-34.5	1190.3
DG5F1	Low level of contractor experience	6.78	4.5	7.91	2	2.5	6.3
DG5F2	Late delivery of appropriate construction equipment	6.22	12.5	7.82	3	9.5	90.3
DG5F3	Poor site management and supervision	6.00	16.5	6.09	17	-0.5	0.3
DG5F4	Loss of efficiency due to rework activities	5.89	21	6.73	11.5	9.5	90.3
DG5F5	Difficulties in financing the project by contractor	5.89	21	7.00	8.5	12.5	156.3
DG5F6	Deficiencies in planning and scheduling of project	6.78	4.5	5.82	20.5	-16.0	256.0
DG5F7	Changes in material specifications during construction	5.67	27	5.64	24	3.0	9.0
DG5F8	Shortage of construction materials	6.33	10.5	7.73	4	6.5	42.3
DG5F9	Unforeseen site conditions	5.89	21	4.91	35.5	-14.5	210.3
DG5F10	Lack of permanent site utilities	5.67	27	4.18	42	-15.0	225.0
DG5F11	Unforeseen weather conditions	4.56	43.5	4.45	40	3.5	12.3
DG6F1	Changes in International Federation's regulation	4.67	42	3.82	43.5	-1.5	2.3
DG6F2	Additional requirements by the International Federation	5.56	31.5	4.82	37	-5.5	30.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	4.89	41	5.18	32	9.0	81.0
DG7F1	Changes in regulations and laws	5.89	21	4.64	38	-17.0	289.0
DG7F2	Additional requirements during inspection.	5.89	21	5.91	19	2.0	4.0
DG7F3	Delay in inspections procedures	5.33	37	5.09	33	4.0	16.0
DG1	Delays related to scope of work	5.56	31.5	5.73	22	9.5	90.3

DG2	Delays related to project duration	5.78	25	5.55	27	-2.0	4.0
DG3	Delays related to client or client representative (project management)	5.89	21	5.82	20.5	0.5	0.3
DG4	Delays related to consultant	6.33	10.5	6.27	14.5	-4.0	16.0
DG5	Delays related to contractor	7.33	1	8.64	1	0.0	0.0
DG6	Delays related to international federation	6.00	16.5	4.36	41	-24.5	600.3
DG7	Delays related to local authorities	6.78	4.5	4.91	35.5	-31.0	961.0
				Σd^2			**8434.0**
				Spearman Rank Correlation (*ρ*)			**0.406**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.4 Project Management (Client Representative) vs Contractor

A "Weak" relationship between the two groups was also existed in this relationship where the computed value of ρ was 0.359 as shown below in Table 11. On the other hand, no significant difference between the two sets of data was existed as $\rho > r_s$.

Table 11

Spearman Rank Correlation for Project Management (Client Representative) vs Contractor

Code	Delay Group/ Factors	PM Mean (M1)	PM Rank (R1)	Cont. Mean (M2)	Cont. Rank (R2)	d (R1-R2)	d^2
DG1F1	Increased number of design's errors	6.00	20	5.88	29.5	-9.5	90.3
DG1F2	Increased number of scope changes	7.65	1	7.54	3	-2.0	4.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.23	11.5	6.13	24	-12.5	156.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	5.42	35.5	7.04	7	28.5	812.3
DG1F5	High level of design's complexity	6.23	11.5	6.17	22.5	-11.0	121.0
DG1F6	Increased number of requirements based on type of sports facility	5.58	30	5.71	34	-4.0	16.0
DG2F1	Unrealistic enforced contract duration	6.61	7.5	6.92	9	-1.5	2.3
DG2F2	Delay in approvals by the authorities	7.29	2.5	5.96	27	-24.5	600.3
DG2F3	Delay in delivering infrastructure services to the facility	5.71	26	4.79	39	-13.0	169.0
DG3F1	Increased number of bidding requirements	4.74	40	4.67	41	-1.0	1.0
DG3F2	Low level of client's project team experience	5.32	37	6.79	12.5	24.5	600.3
DG3F3	Delay in revising and approving documents	5.03	39	6.17	22.5	16.5	272.3
DG3F4	Delay in decision making	6.45	9	7.88	1	8.0	64.0
DG3F5	Delay in payments	6.10	16	7.42	5	11.0	121.0
DG3F6	Increased investors' interference	4.16	44	6.04	25	19.0	361.0
DG3F7	Delay in final acceptance of the facility	5.58	30	6.75	14.5	15.5	240.3

DG4F1	Low level of consultant experience	5.68	27	6.83	11	16.0	256.0
DG4F2	Delay in inspecting, revising and approving documents	5.58	30	6.88	10	20.0	400.0
DG4F3	Discrepancies in documents issued by consultant	5.81	24.5	5.83	31	-6.5	42.3
DG4F4	Poor communication and coordination	5.81	24.5	6.00	26	-1.5	2.3
DG5F1	Low level of contractor experience	6.71	6	6.79	12.5	-6.5	42.3
DG5F2	Late delivery of appropriate construction equipment	6.10	16	6.75	14.5	1.5	2.3
DG5F3	Poor site management and supervision	6.61	7.5	5.75	32.5	-25.0	625.0
DG5F4	Loss of efficiency due to rework activities	6.10	16	6.71	16	0.0	0.0
DG5F5	Difficulties in financing the project by contractor	6.13	14	6.96	8	6.0	36.0
DG5F6	Deficiencies in planning and scheduling of project	6.81	4	5.67	35.5	-31.5	992.3
DG5F7	Changes in material specifications during construction	6.03	18.5	6.33	21	-2.5	6.3
DG5F8	Shortage of construction materials	5.48	34	7.79	2	32.0	1024.0
DG5F9	Unforeseen site conditions	6.03	18.5	5.88	29.5	-11.0	121.0
DG5F10	Lack of permanent site utilities	5.19	38	4.58	43	-5.0	25.0
DG5F11	Unforeseen weather conditions	4.52	42	4.71	40	2.0	4.0
DG6F1	Changes in International Federation’s regulation	4.48	43	4.42	44	-1.0	1.0
DG6F2	Additional requirements by the International Federation	5.42	35.5	5.46	38	-2.5	6.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.58	30	5.92	28	2.0	4.0
DG7F1	Changes in regulations and laws	5.55	33	5.50	37	-4.0	16.0
DG7F2	Additional requirements during inspection.	5.94	22	6.46	19	3.0	9.0
DG7F3	Delay in inspections procedures	5.97	21	6.58	18	3.0	9.0
DG1	Delays related to scope of work	6.19	13	6.67	17	-4.0	16.0
DG2	Delays related to project duration	6.39	10	5.75	32.5	-22.5	506.3
DG3	Delays related to client or client representative (project management)	5.58	30	6.42	20	10.0	100.0
DG4	Delays related to consultant	5.84	23	7.29	6	17.0	289.0
DG5	Delays related to contractor	7.29	2.5	7.50	4	-1.5	2.3
DG6	Delays related to international	4.58	41	4.63	42	-1.0	1.0

	federation						
DG7	Delays related to local authorities	6.74	5	5.67	35.5	-30.5	930.3
				Σd^2			**9099.5**
				Spearman Rank Correlation (*ρ*)			**0.359**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.5 Project Management (Client Representative) vs Consultant

The ρ value for this comparison was 0.570 which indicate:

- "Moderate" relationship between the two groups as (0.40 > ρ > 0.59).
- $\rho > r_s$ = 0.305 ➔ No significant difference between the two sets of data.

Table 12

Spearman Rank Correlation for Project Management (Client Representative) vs Consultant

Code	Delay Group/ Factors	PM Mean (M1)	PM Rank (R1)	Cons. Mean (M2)	Cons. Rank (R2)	d (R1-R2)	d^2
DG1F1	Increased number of design's errors	6.00	20	5.36	31	-11.0	121.0
DG1F2	Increased number of scope changes	7.65	1	7.36	6	-5.0	25.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.23	11.5	6.91	10	1.5	2.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	5.42	35.5	7.09	7	28.5	812.3
DG1F5	High level of design's complexity	6.23	11.5	6.36	13	-1.5	2.3
DG1F6	Increased number of requirements based on type of sports facility	5.58	30	6.27	14.5	15.5	240.3
DG2F1	Unrealistic enforced contract duration	6.61	7.5	6.73	11.5	-4.0	16.0
DG2F2	Delay in approvals by the authorities	7.29	2.5	6.00	18	-15.5	240.3
DG2F3	Delay in delivering infrastructure services to the facility	5.71	26	5.00	34	-8.0	64.0
DG3F1	Increased number of bidding requirements	4.74	40	3.82	43.5	-3.5	12.3
DG3F2	Low level of client's project team experience	5.32	37	5.64	24	13.0	169.0
DG3F3	Delay in revising and approving documents	5.03	39	5.45	29.5	9.5	90.3
DG3F4	Delay in decision making	6.45	9	7.55	5	4.0	16.0
DG3F5	Delay in payments	6.10	16	7.00	8.5	7.5	56.3
DG3F6	Increased investors' interference	4.16	44	5.64	24	20.0	400.0
DG3F7	Delay in final acceptance of the	5.58	30	5.55	27	3.0	9.0

	facility						
DG4F1	Low level of consultant experience	5.68	27	6.18	16	11.0	121.0
DG4F2	Delay in inspecting, revising and approving documents	5.58	30	5.45	29.5	0.5	0.3
DG4F3	Discrepancies in documents issued by consultant	5.81	24.5	5.55	27	-2.5	6.3
DG4F4	Poor communication and coordination	5.81	24.5	4.55	39	-14.5	210.3
DG5F1	Low level of contractor experience	6.71	6	7.91	2	4.0	16.0
DG5F2	Late delivery of appropriate construction equipment	6.10	16	7.82	3	13.0	169.0
DG5F3	Poor site management and supervision	6.61	7.5	6.09	17	-9.5	90.3
DG5F4	Loss of efficiency due to rework activities	6.10	16	6.73	11.5	4.5	20.3
DG5F5	Difficulties in financing the project by contractor	6.13	14	7.00	8.5	5.5	30.3
DG5F6	Deficiencies in planning and scheduling of project	6.81	4	5.82	20.5	-16.5	272.3
DG5F7	Changes in material specifications during construction	6.03	18.5	5.64	24	-5.5	30.3
DG5F8	Shortage of construction materials	5.48	34	7.73	4	30.0	900.0
DG5F9	Unforeseen site conditions	6.03	18.5	4.91	35.5	-17.0	289.0
DG5F10	Lack of permanent site utilities	5.19	38	4.18	42	-4.0	16.0
DG5F11	Unforeseen weather conditions	4.52	42	4.45	40	2.0	4.0
DG6F1	Changes in International Federation’s regulation	4.48	43	3.82	43.5	-0.5	0.3
DG6F2	Additional requirements by the International Federation	5.42	35.5	4.82	37	-1.5	2.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.58	30	5.18	32	-2.0	4.0
DG7F1	Changes in regulations and laws	5.55	33	4.64	38	-5.0	25.0
DG7F2	Additional requirements during inspection.	5.94	22	5.91	19	3.0	9.0
DG7F3	Delay in inspections procedures	5.97	21	5.09	33	-12.0	144.0
DG1	Delays related to scope of work	6.19	13	5.73	22	-9.0	81.0
DG2	Delays related to project duration	6.39	10	5.55	27	-17.0	289.0
DG3	Delays related to client or client representative (project management)	5.58	30	5.82	20.5	9.5	90.3
DG4	Delays related to consultant	5.84	23	6.27	14.5	8.5	72.3
DG5	Delays related to contractor	7.29	2.5	8.64	1	1.5	2.3

DG6	Delays related to international federation	4.58	41	4.36	41	0.0	0.0
DG7	Delays related to local authorities	6.74	5	4.91	35.5	-30.5	930.3
				Σd^2			**6100.5**
				Spearman Rank Correlation (*ρ*)			**0.570**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.6 Project Manager vs Construction Manger

The comparison of these sets of data we based on the "Job Designation" of the respondents. The computed value of ρ was 0.519, as shown below in Table 13 which indicates a "Moderate" relationship between the two groups. Moreover, no significant difference between the two sets of data as $\rho > r_s$ = 0.305

Table 13

Spearman Rank Correlation for Project Manager vs Construction Manger

Code	Delay Group/ Factors	PM Mean (M1)	PM Rank (R1)	CM Mean (M2)	CM Rank (R2)	d (R1-R2)	d^2
DG1F1	Increased number of design's errors	5.90	26.5	5.40	34	-7.5	56.3
DG1F2	Increased number of scope changes	7.87	1	7.07	1.5	-0.5	0.3
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.67	9	5.60	25.5	-16.5	272.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.27	18	6.40	10.5	7.5	56.3
DG1F5	High level of design's complexity	5.27	36.5	6.40	10.5	26.0	676.0
DG1F6	Increased number of requirements based on type of sports facility	5.83	29.5	5.47	31.5	-2.0	4.0
DG2F1	Unrealistic enforced contract duration	6.83	6	6.47	8	-2.0	4.0
DG2F2	Delay in approvals by the authorities	7.53	2	5.53	28.5	-26.5	702.3
DG2F3	Delay in delivering infrastructure services to the facility	6.50	12.5	3.87	43	-30.5	930.3
DG3F1	Increased number of bidding requirements	5.20	38	3.73	44	-6.0	36.0
DG3F2	Low level of client's project team experience	6.33	16.5	5.60	25.5	-9.0	81.0
DG3F3	Delay in revising and approving documents	5.63	33	5.33	35.5	-2.5	6.3
DG3F4	Delay in decision making	7.37	3	6.33	13	-10.0	100.0
DG3F5	Delay in payments	6.37	15	7.07	1.5	13.5	182.3

DG3F6	Increased investors’ interference	4.73	41	5.07	38	3.0	9.0
DG3F7	Delay in final acceptance of the facility	5.40	35	5.53	28.5	6.5	42.3
DG4F1	Low level of consultant experience	5.90	26.5	6.20	14.5	12.0	144.0
DG4F2	Delay in inspecting, revising and approving documents	5.60	34	5.73	21.5	12.5	156.3
DG4F3	Discrepancies in documents issued by consultant	5.80	31	5.60	25.5	5.5	30.3
DG4F4	Poor communication and coordination	5.83	29.5	5.47	31.5	-2.0	4.0
DG5F1	Low level of contractor experience	6.67	9	6.60	7	2.0	4.0
DG5F2	Late delivery of appropriate construction equipment	6.20	19	6.87	4	15.0	225.0
DG5F3	Poor site management and supervision	6.67	9	5.67	23	-14.0	196.0
DG5F4	Loss of efficiency due to rework activities	6.50	12.5	5.73	21.5	-9.0	81.0
DG5F5	Difficulties in financing the project by contractor	6.70	7	6.80	5.5	1.5	2.3
DG5F6	Deficiencies in planning and scheduling of project	6.97	5	5.80	19.5	-14.5	210.3
DG5F7	Changes in material specifications during construction	5.73	32	5.47	31.5	0.5	0.3
DG5F8	Shortage of construction materials	6.47	14	6.40	10.5	3.5	12.3
DG5F9	Unforeseen site conditions	5.97	25	5.80	19.5	5.5	30.3
DG5F10	Lack of permanent site utilities	4.87	40	4.67	41	-1.0	1.0
DG5F11	Unforeseen weather conditions	4.33	44	4.80	40	4.0	16.0
DG6F1	Changes in International Federation’s regulation	4.50	42	4.47	42	0.0	0.0
DG6F2	Additional requirements by the International Federation	5.07	39	5.93	17	22.0	484.0
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.27	36.5	6.07	16	20.5	420.3
DG7F1	Changes in regulations and laws	6.03	22.5	5.33	35.5	-13.0	169.0
DG7F2	Additional requirements during inspection.	6.00	24	6.80	5.5	18.5	342.3
DG7F3	Delay in inspections procedures	6.13	20	6.20	14.5	5.5	30.3
DG1	Delays related to scope of work	5.87	28	5.87	18	10.0	100.0
DG2	Delays related to project duration	6.10	21	5.00	39	-18.0	324.0
DG3	Delays related to client or client representative (project management)	6.33	16.5	5.60	25.5	-9.0	81.0
DG4	Delays related to consultant	6.03	22.5	6.40	10.5	12.0	144.0

DG5	Delays related to contractor	7.30	4	7.00	3	1.0	1.0
DG6	Delays related to international federation	4.43	43	5.27	37	6.0	36.0
DG7	Delays related to local authorities	6.60	11	5.47	31.5	-20.5	420.3
				Σd^2			**6823.0**
				Spearman Rank Correlation (*ρ*)			**0.519**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.7 Project Manager vs Project Engineer & Facility Engineer

The computed value of these two sets was ρ was 0.554, as shown below in Table 14 which indicates a “Moderate” relationship between the two groups. Moreover, no significant difference between the two sets of data as $\rho > r_s$ = 0.305

Table 14

Spearman Rank Correlation for Project Manager vs Project Engineer & Facility Engineer

Code	**Delay Group/ Factors**	**PM Mean (M1)**	**PM Rank (R1)**	**PE & FE Mean (M2)**	**PE & FE Rank (R2)**	**d (R1-R2)**	**d^2**
DG1F1	Increased number of design's errors	5.90	26.5	5.59	31	-4.5	20.3
DG1F2	Increased number of scope changes	7.87	1	6.59	17	-16.0	256.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.67	9	6.65	14.5	-5.5	30.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.27	18	7.00	8	10.0	100.0
DG1F5	High level of design's complexity	5.27	36.5	6.88	9.5	27.0	729.0
DG1F6	Increased number of requirements based on type of sports facility	5.83	29.5	6.24	22.5	7.0	49.0
DG2F1	Unrealistic enforced contract duration	6.83	6	6.88	9.5	-3.5	12.3
DG2F2	Delay in approvals by the authorities	7.53	2	5.82	28	-26.0	676.0
DG2F3	Delay in delivering infrastructure services to the facility	6.50	12.5	5.29	36	-23.5	552.3
DG3F1	Increased number of bidding requirements	5.20	38	5.18	37.5	0.5	0.3

DG3F2	Low level of client's project team experience	6.33	16.5	6.65	14.5	2.0	4.0
DG3F3	Delay in revising and approving documents	5.63	33	6.24	22.5	10.5	110.3
DG3F4	Delay in decision making	7.37	3	7.12	7	-4.0	16.0
DG3F5	Delay in payments	6.37	15	7.53	4	11.0	121.0
DG3F6	Increased investors' interference	4.73	41	5.94	26	15.0	225.0
DG3F7	Delay in final acceptance of the facility	5.40	35	6.65	14.5	20.5	420.3
DG4F1	Low level of consultant experience	5.90	26.5	6.82	11	15.5	240.3
DG4F2	Delay in inspecting, revising and approving documents	5.60	34	5.59	31	3.0	9.0
DG4F3	Discrepancies in documents issued by consultant	5.80	31	5.35	35	-4.0	16.0
DG4F4	Poor communication and coordination	5.83	29.5	6.29	20	9.5	90.3
DG5F1	Low level of contractor experience	6.67	9	7.59	3	6.0	36.0
DG5F2	Late delivery of appropriate construction equipment	6.20	19	7.94	2	17.0	289.0
DG5F3	Poor site management and supervision	6.67	9	6.71	12	-3.0	9.0
DG5F4	Loss of efficiency due to rework activities	6.50	12.5	6.65	14.5	-2.0	4.0
DG5F5	Difficulties in financing the project by contractor	6.70	7	7.29	6	1.0	1.0
DG5F6	Deficiencies in planning and scheduling of project	6.97	5	6.41	19	-14.0	196.0
DG5F7	Changes in material specifications during construction	5.73	32	6.24	22.5	9.5	90.3
DG5F8	Shortage of construction materials	6.47	14	7.35	5	9.0	81.0
DG5F9	Unforeseen site conditions	5.97	25	5.59	31	-6.0	36.0
DG5F10	Lack of permanent site utilities	4.87	40	4.82	40.5	-0.5	0.3
DG5F11	Unforeseen weather conditions	4.33	44	4.71	42	2.0	4.0
DG6F1	Changes in International Federation's regulation	4.50	42	4.41	44	-2.0	4.0

DG6F2	Additional requirements by the International Federation	5.07	39	5.76	29	10.0	100.0
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.27	36.5	6.06	25	11.5	132.3
DG7F1	Changes in regulations and laws	6.03	22.5	4.53	43	-20.5	420.3
DG7F2	Additional requirements during inspection.	6.00	24	6.24	22.5	1.5	2.3
DG7F3	Delay in inspections procedures	6.13	20	5.47	34	-14.0	196.0
DG1	Delays related to scope of work	5.87	28	5.18	37.5	-9.5	90.3
DG2	Delays related to project duration	6.10	21	4.88	39	-18.0	324.0
DG3	Delays related to client or client representative (project management)	6.33	16.5	5.88	27	-10.5	110.3
DG4	Delays related to consultant	6.03	22.5	6.47	18	4.5	20.3
DG5	Delays related to contractor	7.30	4	8.06	1	3.0	9.0
DG6	Delays related to international federation	4.43	43	4.82	40.5	2.5	6.3
DG7	Delays related to local authorities	6.60	11	5.53	33	-22.0	484.0
				Σd^2			**6322.5**
				Spearman Rank Correlation (*ρ*)			**0.554**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.8 Project Manager vs Owner & End User Representative

The computed value of these two sets was ρ was 0.483, as shown below in Table 15 which indicates a "Moderate" relationship between the two groups. Additionally, no significant difference between the two sets of data as $\rho > r_s = 0.305$

Table 15

Spearman Rank Correlation for Project Manager vs Owner & End User Representative

Code	Delay Group/ Factors	PM Mean (M1)	PM Rank (R1)	Owner & EU Mean (M2)	Owner & EU Rank (R2)	d (R1-R2)	d^2
DG1F1	Increased number of design's errors	5.90	26.5	6.30	24.5	2.0	4.0
DG1F2	Increased number of scope changes	7.87	1	7.80	5	-4.0	16.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.67	9	8.10	2	7.0	49.0
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.27	18	6.10	27	-9.0	81.0
DG1F5	High level of design's complexity	5.27	36.5	7.30	6.5	30.0	900.0
DG1F6	Increased number of requirements based on type of sports facility	5.83	29.5	6.90	17	12.5	156.3
DG2F1	Unrealistic enforced contract duration	6.83	6	6.70	20.5	-14.5	210.3
DG2F2	Delay in approvals by the authorities	7.53	2	6.70	20.5	-18.5	342.3
DG2F3	Delay in delivering infrastructure services to the facility	6.50	12.5	5.20	34.5	-22.0	484.0
DG3F1	Increased number of bidding requirements	5.20	38	4.60	40	-2.0	4.0
DG3F2	Low level of client's project team experience	6.33	16.5	7.30	6.5	10.0	100.0
DG3F3	Delay in revising and approving documents	5.63	33	6.90	17	16.0	256.0
DG3F4	Delay in decision making	7.37	3	8.10	2	1.0	1.0

DG3F5	Delay in payments	6.37	15	7.20	9.5	5.5	30.3
DG3F6	Increased investors' interference	4.73	41	5.80	30	11.0	121.0
DG3F7	Delay in final acceptance of the facility	5.40	35	5.70	31	4.0	16.0
DG4F1	Low level of consultant experience	5.90	26.5	7.90	4	22.5	506.3
DG4F2	Delay in inspecting, revising and approving documents	5.60	34	7.00	13.5	20.5	420.3
DG4F3	Discrepancies in documents issued by consultant	5.80	31	7.00	13.5	17.5	306.3
DG4F4	Poor communication and coordination	5.83	29.5	7.10	12	17.5	306.3
DG5F1	Low level of contractor experience	6.67	9	7.20	9.5	-0.5	0.3
DG5F2	Late delivery of appropriate construction equipment	6.20	19	6.90	17	2.0	4.0
DG5F3	Poor site management and supervision	6.67	9	6.10	27	-18.0	324.0
DG5F4	Loss of efficiency due to rework activities	6.50	12.5	5.50	32	-19.5	380.3
DG5F5	Difficulties in financing the project by contractor	6.70	7	7.20	9.5	-2.5	6.3
DG5F6	Deficiencies in planning and scheduling of project	6.97	5	6.30	24.5	-19.5	380.3
DG5F7	Changes in material specifications during construction	5.73	32	6.10	27	5.0	25.0
DG5F8	Shortage of construction materials	6.47	14	7.20	9.5	4.5	20.3
DG5F9	Unforeseen site conditions	5.97	25	5.00	36	-11.0	121.0
DG5F10	Lack of permanent site utilities	4.87	40	4.20	43	-3.0	9.0
DG5F11	Unforeseen weather conditions	4.33	44	4.40	42	2.0	4.0
DG6F1	Changes in International Federation's regulation	4.50	42	3.70	44	-2.0	4.0
DG6F2	Additional requirements by the International Federation	5.07	39	5.30	33	6.0	36.0
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.27	36.5	6.50	22.5	14.0	196.0
DG7F1	Changes in regulations and laws	6.03	22.5	4.70	38.5	-16.0	256.0
DG7F2	Additional requirements during inspection.	6.00	24	5.20	34.5	-10.5	110.3
DG7F3	Delay in inspections procedures	6.13	20	4.70	38.5	-18.5	342.3

DG1	Delays related to scope of work	5.87	28	6.50	22.5	5.5	30.3
DG2	Delays related to project duration	6.10	21	6.00	29	-8.0	64.0
DG3	Delays related to client or client representative (project management)	6.33	16.5	6.90	17	-0.5	0.3
DG4	Delays related to consultant	6.03	22.5	6.90	17	5.5	30.3
DG5	Delays related to contractor	7.30	4	8.10	2	2.0	4.0
DG6	Delays related to international federation	4.43	43	4.50	41	2.0	4.0
DG7	Delays related to local authorities	6.60	11	4.90	37	-26.0	676.0
				Σd^2			**7337.5**
				Spearman Rank Correlation (*ρ*)			**0.483**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.9 Design Engineer vs Construction Manager

The last comparison sets based on the "Job Designation" of the respondents was between Design Engineer vs Construction Manager. The computed value of ρ was 0.727, as shown below in Table 16, which indicates a "Strong" relationship between the two groups. Likewise, no significant difference between the two sets of data as $\rho > r_s$ = 0.305

Table 16

Spearman Rank Correlation for Design Engineer vs Construction Manager

Code	**Delay Group/ Factors**	**DE Mean (M1)**	**DE Rank (R1)**	**CM Mean (M2)**	**CM Rank (R2)**	**d (R1-R2)**	**d^2**
DG1F1	Increased number of design's errors	5.79	33	5.40	34	-1.0	1.0
DG1F2	Increased number of scope changes	7.64	8	7.07	1.5	6.5	42.3
DG1F3	Additional requirements between the Event and Legacy mode of the facility	7.00	12	5.60	25.5	-13.5	182.3
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.00	27	6.40	10.5	16.5	272.3
DG1F5	High level of design's complexity	7.79	4.5	6.40	10.5	-6.0	36.0
DG1F6	Increased number of requirements based on type of sports facility	5.86	30.5	5.47	31.5	-1.0	1.0
DG2F1	Unrealistic enforced contract duration	6.86	15	6.47	8	7.0	49.0
DG2F2	Delay in approvals by the authorities	6.21	21.5	5.53	28.5	-7.0	49.0
DG2F3	Delay in delivering infrastructure services to the facility	5.43	37.5	3.87	43	-5.5	30.3
DG3F1	Increased number of bidding requirements	4.57	44	3.73	44	0.0	0.0
DG3F2	Low level of client's project team experience	5.86	30.5	5.60	25.5	5.0	25.0
DG3F3	Delay in revising and approving documents	5.57	35	5.33	35.5	-0.5	0.3
DG3F4	Delay in decision making	8.21	3	6.33	13	-10.0	100.0
DG3F5	Delay in payments	7.71	6.5	7.07	1.5	5.0	25.0

DG3F6	Increased investors’ interference	6.29	20	5.07	38	-18.0	324.0
DG3F7	Delay in final acceptance of the facility	6.93	13.5	5.53	28.5	-15.0	225.0
DG4F1	Low level of consultant experience	7.57	10	6.20	14.5	-4.5	20.3
DG4F2	Delay in inspecting, revising and approving documents	6.14	24	5.73	21.5	2.5	6.3
DG4F3	Discrepancies in documents issued by consultant	6.14	24	5.60	25.5	-1.5	2.3
DG4F4	Poor communication and coordination	5.50	36	5.47	31.5	4.5	20.3
DG5F1	Low level of contractor experience	8.43	2	6.60	7	-5.0	25.0
DG5F2	Late delivery of appropriate construction equipment	7.71	6.5	6.87	4	2.5	6.3
DG5F3	Poor site management and supervision	6.14	24	5.67	23	1.0	1.0
DG5F4	Loss of efficiency due to rework activities	6.79	16	5.73	21.5	-5.5	30.3
DG5F5	Difficulties in financing the project by contractor	7.57	10	6.80	5.5	4.5	20.3
DG5F6	Deficiencies in planning and scheduling of project	6.07	26	5.80	19.5	6.5	42.3
DG5F7	Changes in material specifications during construction	6.57	17.5	5.47	31.5	-14.0	196.0
DG5F8	Shortage of construction materials	7.79	4.5	6.40	10.5	-6.0	36.0
DG5F9	Unforeseen site conditions	5.93	28	5.80	19.5	8.5	72.3
DG5F10	Lack of permanent site utilities	5.43	37.5	4.67	41	-3.5	12.3
DG5F11	Unforeseen weather conditions	5.64	34	4.80	40	-6.0	36.0
DG6F1	Changes in International Federation’s regulation	4.79	42.5	4.47	42	0.5	0.3
DG6F2	Additional requirements by the International Federation	5.86	30.5	5.93	17	13.5	182.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	6.36	19	6.07	16	3.0	9.0
DG7F1	Changes in regulations and laws	5.00	41	5.33	35.5	5.5	30.3
DG7F2	Additional requirements during inspection.	5.86	30.5	6.80	5.5	25.0	625.0
DG7F3	Delay in inspections procedures	5.29	40	6.20	14.5	25.5	650.3
DG1	Delays related to scope of work	6.93	13.5	5.87	18	-4.5	20.3
DG2	Delays related to project duration	6.21	21.5	5.00	39	-17.5	306.3
DG3	Delays related to client or client representative (project management)	6.57	17.5	5.60	25.5	-8.0	64.0

DG4	Delays related to consultant	7.57	10	6.40	10.5	-0.5	0.3
DG5	Delays related to contractor	8.79	1	7.00	3	-2.0	4.0
DG6	Delays related to international federation	4.79	42.5	5.27	37	5.5	30.3
DG7	Delays related to local authorities	5.36	39	5.47	31.5	7.5	56.3
				Σd^2			**3867.0**
				Spearman Rank Correlation (*ρ*)			**0.727**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.5.10 Less than 10 Years vs More than 10 years

The 10th comparison sets of Spearman Rank Correlation were based on the “Total Work Experience in Construction Field”. The two sets were “Less than 10 Years” versus “More than 10 years”. The computed value of ρ was 0.773 which indicates a “Strong” relationship and no significant difference between them as $\rho > r_s$ = 0.305

Table 17

Spearman Rank Correlation for Less Than 10 Years vs More Than 10 Years

Code	**Delay Group/ Factors**	**Less than 10 Years Mean (M1)**	**Less than 10 Years Rank (R1)**	**More than 10 years Mean (M2)**	**More than 10 years Rank (R2)**	**d (R1-R2)**	**d^2**
DG1F1	Increased number of design's errors	6.11	2	5.78	1	1.0	1.0
DG1F2	Increased number of scope changes	7.29	7	7.50	2	5.0	25.0
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.42	3	6.72	3	0.0	0.0
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.55	1	6.25	4.5	-3.5	12.3
DG1F5	High level of design's complexity	6.84	4	6.13	4.5	-0.5	0.3
DG1F6	Increased number of requirements based on type of sports facility	6.39	13	5.52	6	7.0	49.0
DG2F1	Unrealistic enforced contract duration	6.37	12	6.80	7	5.0	25.0
DG2F2	Delay in approvals by the authorities	6.05	30	6.63	8	22.0	484.0
DG2F3	Delay in delivering infrastructure services to the facility	4.87	5.5	5.58	9	-3.5	12.3
DG3F1	Increased number of bidding requirements	4.39	5.5	4.75	10	-4.5	20.3
DG3F2	Low level of client’s project team experience	6.82	20.5	5.95	11	9.5	90.3
DG3F3	Delay in revising and approving	6.05	11	5.59	12	-1.0	1.0

	documents						
DG3F4	Delay in decision making	7.24	15.5	7.27	13	2.5	6.3
DG3F5	Delay in payments	7.13	18	6.61	14	4.0	16.0
DG3F6	Increased investors' interference	5.55	24	5.25	15	9.0	81.0
DG3F7	Delay in final acceptance of the facility	6.37	23	5.88	16	7.0	49.0
DG4F1	Low level of consultant experience	7.13	28	6.23	17	11.0	121.0
DG4F2	Delay in inspecting, revising and approving documents	5.97	28	6.05	18	10.0	100.0
DG4F3	Discrepancies in documents issued by consultant	5.87	33.5	5.73	19	14.5	210.3
DG4F4	Poor communication and coordination	6.16	10	5.75	20	-10.0	100.0
DG5F1	Low level of contractor experience	7.26	9	6.97	21	-12.0	144.0
DG5F2	Late delivery of appropriate construction equipment	7.34	8	6.52	22	-14.0	196.0
DG5F3	Poor site management and supervision	5.79	22	6.42	23	-1.0	1.0
DG5F4	Loss of efficiency due to rework activities	6.26	19	6.38	24	-5.0	25.0
DG5F5	Difficulties in financing the project by contractor	6.87	35	6.59	25	10.0	100.0
DG5F6	Deficiencies in planning and scheduling of project	6.32	26	6.19	26	0.0	0.0
DG5F7	Changes in material specifications during construction	5.82	14	6.25	27.5	-13.5	182.3
DG5F8	Shortage of construction materials	6.89	38.5	6.92	27.5	11.0	121.0
DG5F9	Unforeseen site conditions	5.45	17	5.67	29.5	-12.5	156.3
DG5F10	Lack of permanent site utilities	4.76	32	4.75	29.5	2.5	6.3
DG5F11	Unforeseen weather conditions	4.89	25	4.41	31	-6.0	36.0
DG6F1	Changes in International Federation's regulation	4.50	33.5	4.23	32	1.5	2.3
DG6F2	Additional requirements by the International Federation	5.50	15.5	5.30	33	-17.5	306.3
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	5.79	43	5.72	34	9.0	81.0
DG7F1	Changes in regulations and laws	4.87	36	5.55	35	1.0	1.0
DG7F2	Additional requirements during	5.68	38.5	6.23	36	2.5	6.3

	inspection.						
DG7F3	Delay in inspections procedures	5.34	20.5	5.98	37	-16.5	272.3
DG1	Delays related to scope of work	6.08	31	6.03	38	-7.0	49.0
DG2	Delays related to project duration	5.05	28	6.00	39	-11.0	121.0
DG3	Delays related to client or client representative (project management)	6.37	37	5.91	40	-3.0	9.0
DG4	Delays related to consultant	6.82	41	6.41	41	0.0	0.0
DG5	Delays related to contractor	7.82	40	7.59	42	-2.0	4.0
DG6	Delays related to international federation	4.71	42	4.56	43	-1.0	1.0
DG7	Delays related to local authorities	5.37	44	5.97	44	0.0	0.0
				Σd^2			**3224.5**
				Spearman Rank Correlation (*ρ*)			**0.773**
				Degree of Freedom			**42**
				Critical Value			**0.305**
				Confidence Level			**95%**

4.3.6 Ranking by T – Test Method

The *t* value of T-Test Ranking Method was calculated as per the formula specified and explained earlier (Equation 3) for the same sets of data like Spearman Rank Correlation (Page 32) in which categorization was based on the respondent profile (location, organization type, job designation and total work experience in construction field).

As mentioned in section 3.3.3, the study has considered the significant level (alpha value) to be 0.05 (Two-tailed t-test) and our case is considered as 2 independent samples with separate variances. The research hypotheses were as following:

- Null Hypothesis (H_0): No statistically significant relationship between the two data sets.

  H_0: $\Delta = \mu_1 - \mu_2 = 0$

- Alternative Hypothesis (H_1): There is a statistically significant relationship between the two data sets.

  H_1: $\Delta = \mu_1 - \mu_2 \neq 0$ "Two-tailed"

The "Null Hypothesis" would be rejected when probability (P) is less than α value ($P < 0.05$). Therefore, the following tables have presented the delay groups and factors in which a significant difference existed between the two compared sets.

Table 18

T – Test Results for Qatar vs World (GCC and Others)

Qatar vs World (GCC and Others)		
Code	**Delay Factors**	***P-Value***
DG1F1	Increased number of design's errors	0.0046577
DG1F3	Additional requirements between the Event and Legacy mode of the facility	0.0254762
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.0001420
DG1F5	High level of design's complexity	0.0000030
DG1F6	Increased number of requirements based on type of sports facility	0.0002699
DG2F2	Delay in approvals by the authorities	0.0219790
DG2F3	Delay in delivering infrastructure services to the facility	0.0288752
DG3F2	Low level of client's project team experience	0.0026178
DG3F4	Delay in decision making	0.0113546
DG3F5	Delay in payments	0.0027726
DG3F6	Increased investors' interference	0.0099897
DG4F1	Low level of consultant experience	0.0000002
DG5F1	Low level of contractor experience	0.0000000
DG5F2	Late delivery of appropriate construction equipment	0.0000000
DG5F4	Loss of efficiency due to rework activities	0.0113937
DG5F5	Difficulties in financing the project by contractor	0.0000002
DG5F7	Changes in material specifications during construction	0.0397967
DG5F8	Shortage of construction materials	0.0000000
DG5F11	Unforeseen weather conditions	0.0030900
DG6F1	Changes in International Federation's regulation	0.0338867
DG6F2	Additional requirements by the International Federation	0.0003585
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	0.0041807
Code	**Delay Groups**	
DG2	Delays related to project duration	0.0011855
DG4	Delays related to consultant	0.0000530
DG5	Delays related to contractor	0.0000000
DG7	Delays related to local authorities	0.0004282

Table 19

T – Test Results for Client vs Contractor

Client vs Contractor		
Code	**Delay Factors**	***P-Value***
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.0170
DG2F1	Unrealistic enforced contract duration	0.0467
DG3F5	Delay in payments	0.0406
DG4F2	Delay in inspecting, revising and approving documents	0.0162
DG7F3	Delay in inspections procedures	0.0159
Code	**Delay Groups**	
DG4	Delays related to consultant	0.0381
DG6	Delays related to international federation	0.0412

Table 20

T – Test Results for Client vs Consultant

Client vs Consultant		
Code	**Delay Factors**	***P-Value***
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.0145
DG4F4	Poor communication and coordination	0.0085
Code	**Delay Groups**	
DG5	Delays related to contractor	0.0406
DG6	Delays related to international federation	0.0371
DG7	Delays related to local authorities	0.0446

Table 21

T – Test Results for Project Management (Client Representative) vs Contractor

Project Management (Client Representative) vs Contractor		
Code	**Delay Factors**	***P-Value***
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.0018
DG2F2	Delay in approvals by the authorities	0.0065
DG3F2	Low level of client's project team experience	0.0166
DG3F3	Delay in revising and approving documents	0.0423
DG3F4	Delay in decision making	0.0073
DG3F5	Delay in payments	0.0129
DG3F6	Increased investors' interference	0.0005
DG3F7	Delay in final acceptance of the facility	0.0416
DG4F2	Delay in inspecting, revising and approving documents	0.0232
DG5F6	Deficiencies in planning and scheduling of project	0.0481
DG5F8	Shortage of construction materials	0.0003
Code	**Delay Groups**	
DG4	Delays related to consultant	0.0010

Table 22

T – Test Results for Project Management (Client Representative) vs Consultant

Project Management (Client Representative) vs Consultant		
Code	**Delay Factors**	***P-Value***
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.0009
DG2F2	Delay in approvals by the authorities	0.0488
DG5F1	Low level of contractor experience	0.0192
DG5F2	Late delivery of appropriate construction equipment	0.0085
DG5F6	Deficiencies in planning and scheduling of project	0.0420
DG5F8	Shortage of construction materials	0.0006
Code	**Delay Groups**	
DG5	Delays related to contractor	0.0002
DG7	Delays related to local authorities	0.0378

Table 23

T – Test Results for Project Manager vs Construction Manger

Project Manager vs Construction Manager		
Code	**Delay Factors**	***P-Value***
DG1F5	High level of design's complexity	0.0240
DG2F2	Delay in approvals by the authorities	0.0086
DG2F3	Delay in delivering infrastructure services to the facility	0.0003
DG3F1	Increased number of bidding requirements	0.0284

Table 24

T – Test Results for Project Manager vs Project Engineer & Facility Engineer

Project Manager vs Project Engineer & Facility Engineer		
Code	**Delay Factors**	***P-Value***
DG1F2	Increased number of scope changes	0.0011
DG1F5	High level of design's complexity	0.0085
DG2F2	Delay in approvals by the authorities	0.0003
DG2F3	Delay in delivering infrastructure services to the facility	0.0294
DG3F5	Delay in payments	0.0246
DG3F6	Increased investors' interference	0.0342
DG3F7	Delay in final acceptance of the facility	0.0491
DG5F2	Late delivery of appropriate construction equipment	0.0004
DG7F1	Changes in regulations and laws	0.0208

Table 25

T – Test Results for Project Manager vs Owner & End User Representative

Project Manager vs Owner & End User Representative		
Code	**Delay Factors**	***P-Value***
DG1F3	Additional requirements between the Event and Legacy mode of the facility	0.0097
DG1F5	High level of design's complexity	0.0036
DG2F3	Delay in delivering infrastructure services to the facility	0.0151
DG3F3	Delay in revising and approving documents	0.0319
DG3F4	Delay in decision making	0.0470
DG4F1	Low level of consultant experience	0.0001
DG4F2	Delay in inspecting, revising and approving documents	0.0060
DG4F3	Discrepancies in documents issued by consultant	0.0175
DG4F4	Poor communication and coordination	0.0228
DG7F1	Changes in regulations and laws	0.0348
DG7F3	Delay in inspections procedures	0.0232
Code	**Delay Groups**	
DG7	Delays related to local authorities	0.0224

Table 26

T – Test Results for Design Engineer vs Construction Manger

Design Engineer vs Construction Manger		
Code	**Delay Factors**	***P-Value***
DG1F5	High level of design's complexity	0.0019
DG2F3	Delay in delivering infrastructure services to the facility	0.0291
DG3F4	Delay in decision making	0.0226
DG3F6	Increased investors' interference	0.0434
DG3F7	Delay in final acceptance of the facility	0.0354
Code	**Delay Groups**	
DG3	Delays related to client or client representative (project management)	0.0472
DG4	Delays related to consultant	0.0218
DG5	Delays related to contractor	0.0098

Table 27

T – Test Results for Less Than 10 Years vs More Than 10 Years

Less than 10 Years vs More than 10 years		
Code	**Delay Factors**	***P-Value***
DG2F2	Delay in approvals by the authorities	0.0403
DG2F3	Delay in delivering infrastructure services to the facility	0.0246
DG4F1	Low level of consultant experience	0.0370
DG5F3	Poor site management and supervision	0.0369
DG7F1	Changes in regulations and laws	0.0488
DG7F3	Delay in inspections procedures	0.0403
Code	**Delay Groups**	
DG2	Delays related to project duration	0.0074

4.3.7 Ranking by Analytical Hierarchy Process (AHP)

The last ranking method used in the analysis was Analytical Hierarchy Process (AHP) in which the weighted vector for delay factors and matrix of rankings (priorities) for delay groups were calculated as explained earlier in chapter 3 in order to rank the top affected delay factors and groups. The following parts will explain the calculation process used to get the final ranking of the 44 delay factors and groups.

- Step (1): Determine the vector of weights of delay factors,
- Step (2): Determine the matrix of rankings (priorities) of delay groups.
- Step (3): Ranking the delay groups.

4.3.7.1 Step (1): Determine the vector of weights of delay factors

The first step was to develop the 7 Pairwise Comparison Matrixes $A_1, A_2, \ldots, A_m$ which are $n \times n$ real matrix considering the following:

1- n delay factors to be evaluated in each m delay group (n=1,2,…., i)

2- m delay groups to be considered (m= 1,2, …., 7)

The study has used the mean value $\overline{X_{DGkFi}}$ of the summation of given importance values related to every delay factor as per the following equation:

$$\overline{X_{DGkFi}} = \frac{\sum R_{DGkFi}}{Total\ number\ of\ study\ respondents} = \frac{\sum R_{DGkFi}}{101}$$

Equation 7 – Equation for mean value of given respondent’s importance values

Where:

- $\overline{X_{DGkFi}}$ represents the mean value of the summation of given importance for each delay factor (*DGkFi*)
- R_{DGkFi} represents the importance value given from every respondent to each delay factor

The second step was to calculate the relative importance score (a_{jd}) of every delay factor in respect to other factors within the same delay group. As the same process would be repeated for the seven delay groups, this section has shown the mathematical equations and calculation formulas of delay group (DG_1) which consist of 6 delay factors (*DG1F1, DG1F2, ….., DG1F6).*

The process started by sorting the 6 delay factors in ascending order (A to Z) in order to find (M_{diff}) which represents the difference between the highest and lowest mean values ($M_h=7.495$ and $M_l=5.901$). Then, the M_{diff} was divided by the highest score value of a_{jd} in relative importance scores table (Table 1) subtracted by 1, in order to obtain the M_{com} as shown in Equation 8.

$$M_{com} = \frac{M_{diff}}{Highest\ value\ of\ a_{jd} - 1} = \frac{M_h - M_l}{9 - 1} = \frac{7.495 - 5.901}{8} = 0.199$$

Equation 8 - Equation for cumulative mean value of delay group DG_1

The computed value of M_{com} (0.199) was added cumulatively to the lowest mean value (M_l) to find the mean values correspond to each relative importance score (1 to 9) as following:

Table 28

Mean Values Correspond to Each Relative Importance Score A_{jd}

Value of a_{jd}	Mean Values of a_{jd}	
1	$M1 = M_l$	5.901
2	$M2 = M_1 + M_{com}$	6.100
3	$M3 = M_2 + M_{com}$	6.300
4	$M4 = M_3 + M_{com}$	6.499
5	$M5 = M_4 + M_{com}$	6.698
6	$M6 = M_5 + M_{com}$	6.897
7	$M7 = M_6 + M_{com}$	7.097
8	$M8 = M_7 + M_{com}$	7.296
9	$M9 = M_8 + M_{com} = M_h$	7.495

Subsequently, the relative importance scores (1 to 9) were assigned to the sorted delay factors based on the matched mean value of relative importance score (Approximately) as shown in Table 29.

Table 29

Relative Importance Score Of DG_1

Code	Delay Group/ Factors	Mean	Relative Scores
DG1	**Delays related to scope of work (SOW)**		
DG1F6	Increased number of requirements based on type of sports facility	5.901	1
DG1F1	Increased number of design's errors	5.960	2
DG1F4	Enforcement of using specialized items, suppliers and vendors	6.426	4
DG1F5	High level of design's complexity	6.455	4
DG1F3	Additional requirements between the Event and Legacy mode of the facility	6.673	5
DG1F2	Increased number of scope changes	7.495	9

Next, the pairwise comparison matrix A_1 need to be computed. As we have 6 delay factors, the A_1 matrix will be a 6 X 6 in which;

- The relative importance score of each delay factor to itself is equal to one ($a_{jj} = 1$ for all j=1, …, 6)
- The relative importance score of jth delay factor in respect to dth delay factor is equal to P ($a_{jd} = P$)
- The relative importance score of the same dth delay factor in respect to the same jth delay factor stated previously is equal to the inverse of t a_{jd} ($a_{dj} = {}^{1}/_{a_{jd}} = {}^{1}/_{P}$)

Table 30

Pairwise Comparison Matrix A_1 of DG_1

	DG1F6	DG1F1	DG1F4	DG1F5	DG1F3	DG1F2
DG1F6	1	1/2	1/4	1/4	1/5	1/9
DG1F1	2	1	1/3	1/3	1/4	1/8
DG1F4	4	3	1	1	1/2	1/6
DG1F5	4	3	1	1	1/2	1/6
DG1F3	5	4	2	2	1	1/5
DG1F2	9	8	6	6	5	1

Then, matrix A_1 should be normalized in order to have matrix A_{1norm} as stated in Equation 4. The matrix A_{1norm} is computed by dividing each a_{jd} by the summation of all a_{jd} of the same column which appears in Table 31.

Table 31

Matrix A_{1norm}

	DG1F6	DG1F1	DG1F4	DG1F5	DG1F3	DG1F2
DG1F6	0.040	0.026	0.024	0.024	0.027	0.063
DG1F1	0.080	0.051	0.031	0.031	0.034	0.071
DG1F4	0.160	0.154	0.094	0.094	0.067	0.094
DG1F5	0.160	0.154	0.094	0.094	0.067	0.094
DG1F3	0.200	0.205	0.189	0.189	0.134	0.113
DG1F2	0.360	0.410	0.567	0.567	0.671	0.565

Finally, the criteria weight vector *w* is computed by averaging the entries on each row of A_{1norm} as shown previously in Equation 5.

Table 32

Weight Vector (w) of Matrix A_1

	(Weight Vector *w*)
DG1F6	0.034
DG1F1	0.050
DG1F4	0.111
DG1F5	0.111
DG1F3	0.172
DG1F2	0.523

4.3.7.2 AHP – Step (2)

The second matrix supposed to be computed in the AHP process is the matrix of rankings (priorities) of delay groups which is a $m \times m$ real matrix *s*. The process was similar to the one used to compute the *pairwise comparison matrix* A_m, but for delay groups (DG_1, DG_2, …., DG_7) in order to obtain the preference vector *s* which represents the computed weight of *jth* delay groups.

$$S = \left[s^j \ldots s^m\right] \quad , \qquad j = 1, \ldots., m$$

Table 33

Relative Importance Score of DG8

Code	Delay Group/ Factors	Mean	Relative Scores
DG8	**Most significant delay's attribute group**		
DG6	Delays related to international federation	4.663	1
DG2	Delays related to project duration	5.703	3
DG7	Delays related to local authorities	5.802	3
DG1	Delays related to scope of work	6.109	4
DG3	Delays related to client or client representative (project management)	6.139	4
DG4	Delays related to consultant	6.624	6
DG5	Delays related to contractor	7.752	9

Table 34

Pairwise Comparison Matrix of DG8

	DG6	DG2	DG7	DG1	DG3	DG4	DG5
DG6	1	1/3	1/3	1/4	1/4	1/6	1/9
DG2	3	1	1	1/2	1/2	1/4	1/7
DG7	3	1	1	1/2	1/2	1/4	1/7
DG1	4	2	2	1	1	1/3	1/6
DG3	4	2	2	1	1	1/3	1/6
DG4	6	4	4	3	3	1	1/4
DG5	9	7	7	6	6	4	1

Table 35

Normalized Matrix

	DG6	DG2	DG7	DG1	DG3	DG4	DG5
DG6	0.033	0.019	0.019	0.020	0.020	0.026	0.056
DG2	0.100	0.058	0.058	0.041	0.041	0.039	0.072
DG7	0.100	0.058	0.058	0.041	0.041	0.039	0.072
DG1	0.133	0.115	0.115	0.082	0.082	0.053	0.084
DG3	0.133	0.115	0.115	0.082	0.082	0.053	0.084
DG4	0.200	0.231	0.231	0.245	0.245	0.158	0.126
DG5	0.300	0.404	0.404	0.490	0.490	0.632	0.505

Table 36

Preference Vector S

Delay Groups	Preference Vector *s*
DG6	0.033
DG2	0.100
DG7	0.100
DG1	0.133
DG3	0.133
DG4	0.200
DG5	0.300

4.3.7.3 AHP – Step (3)

Once the weight vector *w* and preference vector *s* have been computed, the AHP obtains a ranking vector *v* of by multiplying *s* and *w* as stated in Equation 6 (w_1 is multiplied by s_1, w_2 is multiplied by s_2, ……, w_7 is multiplied by s_7). As the final step, the overall ranking is accomplished by ordering the score values in decreasing order.

Table 37

AHP Overall Rankin of Delay Factors

Code	**Delay Group/ Factors**	**Weighted Vector (*w*)**	**Weighted Vector X Preference Weight (*w* X *s*)**	**Overall Rank**
DG4F1	Low level of consultant experience	0.6712	0.1376	1
DG5F1	Low level of contractor experience	0.2524	0.1162	2
DG5F8	Shortage of construction materials	0.1761	0.0811	3
DG5F5	Difficulties in financing the project by contractor	0.1164	0.0536	4
DG5F2	Late delivery of appropriate construction equipment	0.1164	0.0536	5
DG1F2	Increased number of scope changes	0.5234	0.0497	6
DG2F1	Unrealistic enforced contract duration	0.6486	0.0379	7
DG7F2	Additional requirements during inspection.	0.6486	0.0379	8
DG3F4	Delay in decision making	0.3738	0.0355	9
DG4F2	Delay in inspecting, revising and approving documents	0.1688	0.0346	10
DG5F3	Poor site management and supervision	0.0739	0.0340	11
DG5F6	Deficiencies in planning and scheduling of project	0.0739	0.0340	12
DG5F4	Loss of efficiency due to rework activities	0.0739	0.0340	13
DG3F5	Delay in payments	0.2641	0.0251	14
DG5F7	Changes in material specifications during construction	0.0489	0.0225	15
DG4F4	Poor communication and coordination	0.1096	0.0225	16
DG6F3	Enforcement of selected sponsors for certain sports equipment and systems	0.6486	0.0181	17

DG2F2	Delay in approvals by the authorities	0.2946	0.0172	18
DG7F3	Delay in inspections procedures	0.2946	0.0172	19
DG1F6	Additional requirements between the Event and Legacy mode of the facility	0.1717	0.0163	20
DG5F9	Unforeseen site conditions	0.0345	0.0159	21
DG3F2	Low level of client's project team experience	0.1366	0.0130	22
DG1F4	Enforcement of using specialized items, suppliers and vendors	0.1107	0.0105	23
DG1F5	High level of design's complexity	0.1107	0.0105	24
DG4F3	Discrepancies in documents issued by consultant	0.0504	0.0103	25
DG3F7	Delay in final acceptance of the facility	0.0938	0.0089	26
DG5F10	Lack of permanent site utilities	0.0190	0.0088	27
DG6F2	Additional requirements by the International Federation	0.2946	0.0082	28
DG5F11	Unforeseen weather conditions	0.0145	0.0067	29
DG3F3	Delay in revising and approving documents	0.0638	0.0061	30
DG1F1	Increased number of design's errors	0.0497	0.0047	31
DG3F6	Increased investors' interference	0.0440	0.0042	32
DG2F3	Delay in delivering infrastructure services to the facility	0.0567	0.0033	33
DG7F1	Changes in regulations and laws	0.0567	0.0033	34
DG1F3	Increased number of requirements based on type of sports facility	0.0338	0.0032	35
DG3F1	Increased number of bidding requirements	0.0239	0.0023	36
DG6F1	Changes in International Federation's regulation	0.0567	0.0016	37

5 Chapter (5): Discussion, Recommendations, Conclusions and Future Works

5.1 Discussion

As stated previously, the aim of the study was to evaluate delay's causes and effects on the construction of sport facilities in the world, in general, and Qatar specifically. In order to come up with valuable results, the first task was to study and review past literatures and articles which wrote about this subject.

In general, most studies in the literature focused on the delay attributes affecting the construction of infrastructure, superstructure, residential compounds and army facilities. Therefore, it was a bit difficult to relate our study to most literatures as the environment of the construction of sport facility is more complicated compared to other type of constructions.

The structure of the online questionnaire was built through online portal in two sections which are respondent's profile and respondent's technical evaluation of importance of each delay factor and group (how much does this factor affects the delay time in construction of sport facility). This structure was very useful in distributing the data as per the needs of each ranking approach methods used in the study.

A total of 44 delay factors and groups were selected and the questionnaire was sent to senior and upper level management of different organizations specialized in the sports industry, and a total of 101 completed responses were collected and analyzed thought 4 different ranking approaches which are Relative Importance Index (RII), Spearman's Rank Correlation, T-Test and Analytical Hierarchy Process (AHP).

In accordance to the results of the are Relative Importance Index (Table 4 and Table 5), the most significant factor was "Increased number of scope changes (DG1F2)" with an

RII % value of 83.28% and categorized under the delay group related to scope of work (DG1). In the sports industry, there is a possibility to add or remove a part of the scope of work based on the stakeholders' requirements. The nature of the sports industry imposed the contractor to comply continuously with updated local and international federations, sponsors and authorities' regulations and requirements.

The second factor was "Delay in decision making (DG3F4)" with 81.41% RII %. This factor is adversely affecting the completion time of any construction project in the world. The main challenge in the sport constructions is the number of stakeholders who have the right to control the decision. The decision might be in hand of the client, investor, local authorities, local or international federation. Therefore, there should be a clear communication and decision approval plan with a specific time manner in case of any decision needed.

The third, fourth and fifth factors were "Low level of contractor experience (DG5F1)", "Shortage of construction materials (DG5F8)" and "Late delivery of appropriate construction equipment (DG5F2)" with RII% values of 79.43%, 77.56% and 76.57% respectively. These factors were obviously related to the main contractor capabilities in handling this type of projects. Most of the sports industry required long lead construction materials which sponsored or procured from certain manufactures and suppliers. Therefore, the procurement team of the contractor should focus on these three factors specifically as they might have also a cost impact on the contractor in case of change the delivery schedule and methods.

The second set of results were from the Spearman's Rank Correlation. This method observed the relationship between the two selected sets of data in order to evaluate the strength of the relationship between participants' responses. based on their category. In this method, the data were distributed among nine comparatives sets of data in respect to the respondent profile, and the results are shown below:

Table 38

Summary of Results of Spearman's Rank Correlation Method

#	Comparative sets of data		Respondents Profile	Spearman Rank Correlation (*ρ)*	Type of relationship
1	Qatar	World (GCC and Others)	Location	0.678	Strong
2	Client	Contractor	Organization Type	0.271	Weak
3	Client	Consultant	Organization Type	0.406	Moderate
4	Project Management (Client Representative)	Contractor	Organization Type	0.359	Weak
5	Project Management (Client Representative)	Consultant	Organization Type	0.570	Moderate
6	Project Manager	Construction Manger	Job Designation	0.519	Moderate
7	Project Manager	Project Engineer & Facility Engineer	Job Designation	0.554	Moderate
8	Project Manager	Owner & End User Representative	Job Designation	0.483	Moderate
9	Design Engineer	Construction Manager	Job Designation	0.727	Strong
10	Less than 10 Years	More than 10 years	Total Work Experience in Construction Field	0.773	Strong

In general, the values of "Spearman Rank Correlation" were close to each other in the four categories of the respondent's profile, which represents a moderate and strong agreement between the two sets of data of each comparative sets of data. The disagreement relationship was observed in (Client vs Contractor) and (Project Management vs Contractor) which represent the reality of site condition in which there are different perspectives between the management side and contractor side.

The third ranking approach “T-Test” was also analyzed through the same nine comparatives sets of data as “Spearman Rank Correlation” in which *t value and Probability (P)* were computed separately to each comparative set based on the number of respondents. The number of critical factors vary from one set to other, but the mutual factors in at least four comparative sets were as following:

Table 39

The Mutual Factors of The T-Test Results

#	Code	Delay Factors / Attributes
1	DG2F2	Delay in approvals by the authorities
2	DG2F3	Delay in delivering infrastructure services to the facility
3	DG1F4	Enforcement of using specialized items, suppliers and vendors
4	DG1F5	High level of design's complexity
5	DG3F4	Delay in decision making
6	DG3F5	Delay in payments
7	DG3F6	Increased investors’ interference

The delay factors were related to scope of work (2), project duration (2) and client or client representative (project management) (3). Most of these factors could be controlled easily by client, consultant and contractor by implementing the lesson of learned from previous projects executed in the same area in order to overcome any challenges from the available site utilities, site condition, weather condition or authorities' requirements.

The rest factors are under the client, local and international federation control in which a clear bidding and stakeholder management plans should be organized and well implemented and followed by all parties.

The last ranking approach used to analyze the collected data was Analytical Hierarchy Process (AHP) in which a numerical score is developed to each factor based on the importance of this factor to the respondents. The process was straight forward to implement as the data were organized in easily manner.

Form the study, it was observed that the highest weighted value in the delay groups were found in contractor (0.461), consultant (0.205) and client (0.095), which mean that the 3 parties are the main parties who hold the responsibilities if any delay is occurred.

Moving to the second part of the study, the weights of the top 5 delay factors out of 34 were calculated and presented in Table 40 where 4 factors are related to contractor and 1 factor to consultant. This result supports the general practice of construction projects in which the contractor is always the main responsible of most delays in the project.

The contractors are fully responsible to assure the availability of construction material, appropriate construction equipment, deployment of experienced technical team and reserving a separate capital for the project in order to overcome any financing difficulties during the construction stage.

In addition, consultants and clients are part of the delay as they need to be experienced in managing this type of projects because of their special nature and squeezed times.

Table 40

Top 5 Delay Factors as per AHP Method

Code	**Delay Factors / Attributes**	**Weighted Vector (*w*)**	**Weighted Vector X Preference Weight (*w* X *s*)**	**Overall Rank**
DG4F1	Low level of consultant experience	0.6712	0.1376	1
DG5F1	Low level of contractor experience	0.2524	0.1162	2
DG5F8	Shortage of construction materials	0.1761	0.0811	3
DG5F5	Difficulties in financing the project by contractor	0.1164	0.0536	4
DG5F2	Late delivery of appropriate construction equipment	0.1164	0.0536	5

5.2 Recommendations

The recommendations of the study will be focused on the 3 main parts of the organization structure in the construction of sports facilities who are client or client representative, consultant and Contractor.

5.2.1 Client and Client Representative

The client could be the one who derive the project to success or failure. Most of sports facilities are constructed by government sector in which the technical experience of the client team might not reach the technical standards required for this type of projects. Therefore, the client (government or organizing committee of the event or tournament) should deploy a project management firm who have experienced in sports facilities.

Moreover, the client team should have a clear systematic system to award the consultant and contractor of the project. This system should include a comprehensive technical and commercial evaluation as failing in this point will lead the project to huge loss and failure.

Additionally, the client team should make sure of including strict clauses in the contract regarding awarding client's right to award or reject any subcontractors, responsibility of 3rd party delays, delay of payments, delay in material procurement and obtaining the authorities approval as these items are the most disputed items experienced in the construction.

Finally, the client should involve his operation and facility management teams in the construction stage in order to reduce any snags or comments which delay the operation and handing over procedures.

5.2.2 Consultant

The second part in the successful cycle of the project is the consultant who could be named as the technical eyes of the client. They should have the appropriate technical team who are specialized in the constructability of sports facilities in terms of equipment, material and local or international federations requirements.

Moreover, they should have a professional management system to track all documents related to site inspection, material submittal, request for information, …, etc. in order to reduce the possibility of any delay might exist from reviewing or approving these documents and works.

5.2.3 Contractor

The contractor is the last and most important part in the pyramids of success. The contractor should deploy an experienced technical team up to the site engineers level as any failure in complying with project specifications will be the fully responsibility of the main contractor.

Additionally, the contractor will bear the responsibility of the work of his subcontractors. This might include the rework of their activity which is a cost and time impact of the main contractor specifically, and on the whole completion time of the project in case these activities are on the critical path of the project schedule. Therefore, a high skilled subcontractor need to be selected in this type of project in order to reduce the chances of this risk.

The third element which the contractor needs to be aware is the authorities and stakeholders' approval which might adversely affect the completion time of the project in case of additional requirement or inspection procedure. Thus, the contractor should have a separate team of engineers whose called “stakeholder engineers” and their responsibility is to obtain the required approval from those stakeholders.

The last element is the financial capabilities of the contractor. Most of construction contractors sponsored more than 80% of their project through banks and financing companies which is a huge risk in case of any financial crises. Therefore, the contractor should maintain a financial satiability of the project all in all construction periods.

5.3 Conclusions

As stated earlier, the available studies and literatures concerning the delay in construction of sports facilities were limited, however, the interview with technical experienced engineers and sports specialist was valuable to overcome this challenge as the most different parts in the environment of the sports facilities was the number of stakeholders involved.

A total number of 44 delays attributes were selected in the study and distributed among 8 groups for proper organization of data. This has been developed further in an online questionnaire portal which aimed to collect data from local and international participants. A total of 101 completed responses were collected and analyzed through four ranking approaches and criteria decision-making methods.

Each of those ranking approach (Relative Importance Index (RII), Spearman's Rank Correlation, T-Test and Analytical Hierarchy Process (AHP)) has different outcome in respect to the process of developing the data, however, most of them specified the contractor, consultant and client as the top three factors of delay related to construction of sports facilities.

In conclusion, the construction of sports facilities needs to have more concentration on these factors as most of these projects have a limited budget and fixed duration to complete in order to host a local or international tournament based on the need. Moreover, the client should focus more in including all requirements of legacy mood investors and end users in the construction stage. This will reduce the time and cost related to reworks needed to convert the venue from tournament mood to legacy mood.

5.4 Future Works

As any other study, there are many chances, techniques and study areas in which the study data could be enhanced and improved further. The following point are some suggested points to be studied in future work:

1- Expanding the area of study to include the type of Contract and Project Delivery Method as this will assist the client in selecting the most appropriate contract type and PDM for the sports projects.

2- Evaluation of the frequency of delay attributes which might change the ranking of these delay as the importance is only showing one side of these challenges.

3- Expanding the ranking methods to include multi objectives (cost, risk, etc.) instead of single objective which will export more valuable results for the clients in the future projects.

4- Including the blockade impact in the study as this factor becomes more critical and challengeable for contractors and clients.

5- Including of risk mapping techniques to the future work as this might change the whole results based on the risks faced by each project.

6- Increasing the number of respondents by conducting one-to-one interviews, site visits to construction projects and exploring more reports about previous sports projects completed recently.

7- Validation of the study by collecting more data and respondents.

8- Analyzing the collected data through different ranking software in order to compare the results easily.

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Appendix – Questionnaire Survey

كلية الهندسة
College of Engineering
QATAR UNIVERSITY جامعة قطر

Evaluation of Delay's Causes and Effects in Construction of Sport Facilities

1. Introduction

Qatar University
College of Engineering
Engineering Management Master Program

Evaluation of Delay's Causes and Effects in Construction of Sport Facilities

Dear Sir/Madam,

Thanks for your valuable time and effort in assisting us in our master graduate research which is about "Evaluation of Delay's Causes and Effects in Construction of Sport Facilities"

The objective of the research is to study and evaluate various delay's causes and attributes which affecting the construction of sports facilities in order to identify the top 10 factors.

We would kindly request your assistance to provide the required information in the questionnaire which will require approximately 10 min to complete, and the information provided will be only used for research purposes.

If you have any questions or would like us to email another person for your institution, please contact me directly on the below contact details.

Yours Sincerely,

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Evaluation of Delay's Causes and Effects in Construction of Sport Facilities

2. General Information

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

*** 1. Location**

- ◯ Qatar
- ◯ GCC
- ◯ Other (please specify)

*** 2. Organization Type**

- ◯ Owner (Client)
- ◯ Project Management (Client Representative)
- ◯ Consultant
- ◯ Contractor
- ◯ End User
- ◯ Local Federation Representative
- ◯ International Federation Representative
- ◯ Event Organizer / Operator
- ◯ Facility Management
- ◯ Other (please specify)

*** 3. Job Designation**

- Owner
- Project Manager
- Construction Manger
- Project Engineer
- Site Superintendent
- Design Engineer
- Facility Engineer
- End User Representative
- Other (please specify)

4. Total Work Experience in Construction Field

- Less than 5 years
- 5 - 10 years
- 11 - 15 years
- More than 15 years
- Other (please specify)

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3. Evaluation of Delay's Causes and Attributes

Please evaluate the following delay's causes and attributes based on the importance (how much does it affect the delay time in construction of sport facility) on a rating scale of 1 - 9 ("9" is the highest importance) as shown below.

Example:

The respondent is asked to evaluate the delay of "High level of design's complexity" and select a number from 1 to 9 to rate the importance.

Importance: What is the impact of " High level of design's complexity" on the delay time in construction of sport facility?

*** 5. Delays related to scope of work (SOW):**

	Importance
Increased number of design's errors	
Increased number of scope changes	
Additional requirements between the Event and Legacy mode of the facility	
Enforcement of using specialized items, suppliers and vendors	
High level of design's complexity	
Increased number of requirements based on type of sports facility	

*** 6. Delays related to project duration:**

	Importance
Unrealistic enforced contract duration	
Delay in approvals by the authorities	
Delay in delivering infrastructure services to the facility	

*** 7. Delays related to client or client representative (project management):**

	Importance
Increased number of bidding requirements	
Low level of client's project team experience	
Delay in revising and approving documents	
Delay in decision making	
Delay in payments	
Increased investors' interference	
Delay in final acceptance of the facility	

*** 8. Delays related to consultant:**

	Importance
Low level of consultant experience	
Delay in inspecting, revising and approving documents	
Discrepancies in documents issued by consultant	
Poor communication and coordination	

*** 9. Delays related to contractor:**

	Importance
Low level of contractor experience	
Late delivery of appropriate construction equipment	
Poor site management and supervision	
Loss of efficiency due to rework activities	
Difficulties in financing the project by contractor	
Deficiencies in planning and scheduling of project	
Unforeseen site conditions	
Lack of permanent site utilities	
Unforeseen weather conditions	

*** 10. Delays related to International Federation:**

	Importance
Changes in International Federation’s regulation	
Additional requirements by the International Federation	
Enforcement of selected sponsors for certain sports equipment and systems	

*** 11. Delays related to local authorities:**

	Importance
Changes in regulations and laws	
Additional requirements during inspection.	
Delay in inspections procedures	

*** 12. Most significant delay's attribute group:**

	Importance
Delays related to scope of work	
Delays related to project duration	
Delays related to client or client representative (project management)	
Delays related to consultant	
Delays related to contractor	
Delays related to international federation	
Delays related to local authorities	

Thanks for your valuable time and effort to complete the questionnaire