Post Contract Design Changes in the UAE Construction Industry

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Entitled

Investigation of the factors causing post contract design changes in the UAE construction industry: Analysis of the reasons, Impact on time, cost and quality and recommendations

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We hereby certify that this Dissertation submitted by Joseph Salameh conforms to acceptable standards, and as such is fully adequate in scope and quality. It is therefore approved as the fulfillment of the Dissertation requirements for the degree of Master of Science in Project Management (Construction and Infrastructure).

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2013

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

Signed

Joseph Salameh

TABLE OF CONTENTS

ABSTRACT

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The construction industry in the UAE has been suffering regularly from time and capital losses due to the incurred delays to completion in projects. Faridi and El-Sayegh (2007) identified 44 factors causing delays to the construction projects in the UAE, where several factors are correlated to post contract design changes. Few authors concentrated on investigating the reasons for those changes and attempted reducing them.

This study aims to determine the factors causing post contract design changes in the UAE construction industry, reveal the impact of the changes on the projects' time, cost and quality, then highlight the knowledge areas requiring more attention from the project management professionals working in the UAE.

The researcher developed a questionnaire that was addressed to 200 construction professionals in the UAE construction industry, from different businesses (clients, developers, project management companies, consultants, contractors and subcontractors) and held interviews with few of them.

The researcher identified 26 factors causing post contract design changes and studied the impact of the caused changes on the time, cost and quality in the studied projects, from different perspectives, in different projects' types and several contracts' types. It has been identified "changes in the client's requirements" ranked as the top factor causing design changes with medium impact on time and cost while "Utilities requirements", "changes requested by other stakeholders" and "changes in Government policies/regulations" ranked second, third and fourth respectively with similar impact on time and cost. Emerging factors in the UAE construction industry were also identified "Design changes to reduce project duration", "Design changes due to value engineering", "Design changes due to budget constraints (omissions due to lack of funds)", "Design changes due to incompetent contractor's technical team" and "Design changes due to sustainability requirements (LEED/Estidama)". The study shows that the design changes caused by the majority of the identified factors are causing minor to medium delays and cost overrun (10% to 20%) and minor decline to the quality. The root causes of the identified factors are studied and recommendations to project management professionals are drafted, to prevent/reduce design changes and/or reduce their impact on the time, cost and quality.

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Chapter 1 . AIMS OF THE DISSERTATION

The construction industry in the UAE has been suffering frequently from time and capital losses due to the incurred delays to completion of the projects. Clients, consultants and contractors are often blaming each other for being the cause of the delays as explained by Al-Kharashi and Skitmore (2009, p. 13).

Few studies have been done for identifying the factors causing delays to the construction projects in the UAE. One of the few, Faridi and El-Sayegh (2007) uncovered 44 factors, ranked among various categories. The exploration of those factors in detail reveals that some causes are correlated to changes to the design, especially during the construction stage while other factors are associated to the poor performance of the contractors, consultants or clients in accomplishing their duties.

While some authors have concentrated on creating a framework for handling the post contract changes in projects, from initiation till successful implementation, in line with the Project Management Institute (2008, pp. 71-102)'s recommendation to create a change management system for each project, few have concentrated on investigating the reasons for those changes and attempting to reduce them.

Traditionally, the design-bid-build approach has been used for decades in the UAE, particularly by the government and developers, for building residential, commercial and infrastructure projects, by allowing enough time for the design, prior to the award and the beginning of any construction works. However, changes were occurring and were handled in different ways.

In 2009, the oil rich Emirate of Abu Dhabi has established its master plan "Abu Dhabi 2030" (Abu Dhabi Urban Planning Council, 2009), which redefines old areas and defines new

areas to be developed in the Emirate, and the different infrastructure networks required for serving the old and new areas as declared by Abu Dhabi Urban Planning Council (2009). The new plan which became the baseline for all the new projects, had a significant impact on projects under construction, especially those in proximity of the new networks, where new requirements were established.

Since 2006, Abu Dhabi has launched its multibillion infrastructure projects in aviation, ports, rail, bridges, water, sewerage, power, communications etc. (The General Secretariat of the Executive Council - Abu Dhabi, 2012) with tight (unrealistic) schedules in order to better serve the property developers for building the country and ensure the finest living standards for the UAE nationals. Consequently, many items were overlooked in the original design and some projects were awarded on the design-build basis considering only the concept design. The design changes during the construction were inevitable, causing losses and delays.

On the other hand, the government authorities went into restructuring, privatization and updating the regulations (Hindley, 2005, p.40), in line with the new growth in technologies and the government's commitment to sustainability and renewable energy. New authoritative bodies were founded to control the compliance with the new or updated regulations. Some of the new regulations overlooked the conditions of the existing buildings or those that are under construction; in consequence, design changes in projects during the construction phase were inevitable in order to comply with the regulations.

After the recession, the government has changed some priorities in its projects, either in shortening or extending the time to completion, and even in making design changes deemed necessary to comply with the revised budgets (Anon, 2009, p.20), (Roscoe, 2011, pp.13-14),

Foreman (2011, p.16) and (Anon, 2011, p.10). The same philosophy has been adopted by property developers and investors.

Dubai, the second largest Emirate has launched its ambitious projects in transforming the desert to residential, commercial and industrial zones (Foreman, 2007, p.10), (Deulgaonkar, 2007), (Foreman, 2008, p.9) and (Shutz, 2009, p.14); the UAE government and the property developers have invested more than 400 billion dollars in infrastructure and construction projects (UAE, 2011, p.23). The common denominator among all these ambitious projects was the tight schedule for design and implementation. The projects were sold based on the concept design plans, ahead of starting the works on site. The designers were facing various difficulties in coping with the investors' increasing demands, especially when asking for taller skyscrapers, even after progress in substructure, superstructure and electro-mechanical works.

The developers were extremely demanding and asked for the highest standards, specifically for constructing sustainable buildings. Due to the unrealistic projects' constraints set by the developers, materials procured to international standards were not always suited for the harsh weather conditions of the Gulf; consequently, design changes have been remarkably popular after the failure of such materials.

The large amount of investments all over the UAE has created a shortage of qualified subcontractors (Egbert, 2007); hence, mistakes were recurring and design changes were occurring recurrently.

The fast growing economy, coupled with new regulations for owning a property in the UAE, has attracted more investors to the construction industry as it was published in the UAE media prior to the recession (Anon, 2008). The increasing demand of residential and

commercial properties had urged the developers to shorten the durations to completion of their projects, for facilitating the utilization of their properties.

The traditional method initially adopted has been replaced by the new fast-track approach dominating the industry such as in the Motor City Project (Sell, 2007), where work in the construction has been ongoing (24 hours a day / 7 days a week) for successful deliveries. The projects were generally starting before completion of the final design; hence, several design changes were occurring to the projects during their construction; thus, making the delivery harder.

Despite the slowdown in the construction industry, starting with the recession hitting the UAE construction sector by the end of 2008, changes to the designs in projects during their construction phase are still dominant in the UAE construction industry, causing rework (Burati et al., 1992 cited in (Love and Li, 2000, p. 483)), delays and losses.

The design changes during the construction phase had got little importance on its own in the available literature, but they remain considered as one component of delay to projects under construction as identified by Faridi and El-Sayegh (2007, p.1171) and Assaf and Al-Hejji (2005, p. 352).

Construction Professionals from around the globe are working in the UAE construction industry which still an emerging but rapidly growing market; the construction professionals thirst for a better understanding of the construction industry as to recognize how to better serve this industry.

This study aims to assess the factors causing post contract design changes in the UAE's construction industry, against best practices of applying the tools & techniques of project

management, reveal their implications on the project's time, cost and quality and highlight the knowledge areas requiring more attention from construction professionals.

Considering the projects executed/ being executed in the UAE, this project intends to answer the following questions:

- ✓ What factors are causing post contract design changes to projects in the UAE construction industry?
- ✓ How can these factors be ranked and prioritized among various categories and from different perspectives?
- ✓ What can be learned from this case as applied against the project management body of knowledge? What are the benefits to clients, consultants and contractors?

This study shall notify the construction professionals and clients in the UAE, on the utmost significant causes and consequences of such changes; as to conclude recommendations on the preventive actions for avoiding / reducing such changes, in order to minimize the implications on future projects.

Chapter 2 . LITERATURE REVIEW

2.1 INTRODUCTION

“Design changes”, a general term used in the construction industry, has been appearing in several studies as part of the changes in projects and/or a factor of delays and cost overrun in the construction projects. None of these studies has focused on identifying the causes of these design changes, especially during the construction stage.

The present chapter starts by defining the “design changes” in construction projects, provides an overview on the existing literature who quoted the design changes as a key factor for delays and cost overrun, then explores the available literature on the design changes and the causing factors in different construction markets, identifying common factors and emerging factors for each market. A separate section is dedicated to the available literature on the design changes in the Gulf region and especially in the UAE construction industry while another section briefly recognizes some consequences of design changes,

This chapter ends with a conclusion, listing all the identified factors causing post-contract design change that were drafted into a questionnaire to be addressed to the construction professionals in the UAE construction industry.

2.2 DEFINITION OF “DESIGN CHANGES”

Oxford Dictionaries (2012) define “design” as being “a plan or drawing produced to show the look and function or workings of a building, garment or other object before it is made” while it defines “specification” as “a detailed description of the design and materials used to make something”. In construction, the design includes the drawings and the specifications; hence, any changes to the design, means alterations to the drawings and/or to the specifications.

2.3 DESIGN CHANGES: KEY FACTOR FOR DELAYS AND COST OVERRUN

Several studies across different countries (Faridi and El-Sayegh, 2007), (Assaf and Al Hejji, 2005), (Abd El-Razek et al., 2008) and many others have concentrated on the reasons causing delays to projects, and uncovered several factors that can be grouped under design changes. One of the few, Kaming et al. (1996) reveal that design changes are considered to be the leading cause of delays to construction projects in Indonesia construction industry. However, Kaming et al. (1996, p. 83) suggests that his results "reflect construction management problems common to developing countries".

Similarly, other studies have concentrated on the cost overrun to projects and the reasons behind and concluded that post contract design changes were one of the main factors increasing the projects' cost; one of the few (Cox et. Al, 1997) has estimated a cost overrun of 5.10 to 7.6% of the total project cost caused by post-contract design changes. These findings were in line with the findings of a recent study of Chang, Shih and Choo (2011) who confirmed that, redesign costs range between 2.1% and 21.5%, with an 8.5% average of the construction change cost, which is enough for designing a new project.

Wu et al. (2004) has studied the reasons for construction changes in Taiwan public works and its impact, and concluded "design changes have contributed to the main cause of construction delay and cost overrun". This conclusion is in line with the findings of Al-Momani (2000) who recognized that, designer changes and errors in design have negatively contributed to the completion durations and budgets of the construction projects in Jordan. Likewise, Mansfield, Ugwu & Doran (1994) and Dlakwa (1990) found that, post contract design changes were a significant contributing factor incurring delays to construction projects, in the Nigerian construction industry.

Le-Hoai, Lee & Lee (2008) studied the overruns in large construction projects in Vietnam and compared their findings to results from other developing countries; their conclusion was that design changes caused cost and time overruns. They ranked high in Jordan and Kuwait while they ranked low in Vietnam.

2.4 DESIGN CHANGES IN DIFFERENT CONSTRUCTION MARKETS

In Vietnam, Large construction projects had suffered from cost and time overruns due to design changes as concluded by Le-Hoai, Lee & Lee (2008) who recognized that unforeseen site condition, mistakes in design, poor design, incompetent designer and unrealistic design were the main factors causing design changes in Vietnam. Le-Hoai, Lee & Lee (2008) argued that their results were comparable to results from other developing countries.

Wu et al. (2004) in his study on the causes for construction changes in the Taiwan public work sector, believes that a perfect design is impractical, due to various constraints; in consequence, design changes are unavoidable.

In an attempt to understand the difficulties facing the project management practitioners, when controlling the time and cost of their projects during the construction stage, Olawale & Sun (2010) have studied 250 construction projects in UK, and recognized that, post-contract design changes were “one of the leading factors, inhibiting cost and time controls”, during the construction stage. Olawale & Sun (2010) found other factors that would cause design changes, ranked extremely high in inhibiting an appropriate control of the time and cost during the construction stage; among those factors, they cited: complexity of works, disagreement in interpreting the contract and specification, discrepancies in contract documentation and, the change in government policies. The latter two factors were previously cited by Sambasivan and Yau (2006) in their study on the reasons and effects of

delays to construction projects in Malaysia, who also identified that unforeseen site conditions is another factor causing design changes and delays to projects.

In a study on the delays to construction projects in the Nigerian construction industry, Mansfield, Ugwu & Doran (1994) identified that, changes in the site conditions, mistakes and discrepancies in the contract documents are the two main reasons of post-contract design changes.

Ming & Xianhai (2008) compared the results from three studies (Hsieh et al., 2004), (Chan and Kumaraswamy, 1997) and (Wu et al., 2004) on factors causing post-contract variations in the construction projects and classified them in different groups: client-related factors, project related factors, contractor related factors, design related factors and external factors.

The first study was on the time overrun to construction projects in Hong Kong, where Chan and Kumaraswamy (1997) unveiled several causes of design changes. Ming & Xianhai (2008) classified these causes as project related (complexity of the project), Client-related (changes requested by the client, unrealistic projects' durations enforced by clients), design-related (essential variations of the works, delays in providing the design information, discrepancies and errors in the design documents, poor design team skills) and external factors (unforeseen ground conditions).

The second article of Hsieh et al. (2004) was in Taipei, Taiwan on 90 metropolitan public work projects completed before 2000, where they identified the causes for change orders, including changes to the design. Similarly to the first study, Ming & Xianhai (2008) classified these factors as project related (complexity of the project), design-related (defects in design, inconsistency between drawings and site conditions, citation of inadequate

specification) and external factors (unforeseen ground conditions and amendment of regulations).

In the third study, Wu et al. (2004) investigated the causes for changes in the second national highway project of “Taiwan”, and classified them according to the initiating party: Client, consultant, contractor or external party. Likewise, the identified factors causing the design changes were classified by Ming & Xianhai (2008), as project related (site restrictions), client related (requirement changes) design-related (design alterations in response to the site conditions, inaccurate or incomplete design information, incomplete site survey preceding the design), contractor related (changes to the construction method), and external factors (legislative or policy changes).

The above three studies reveal a consensus among the authors that, the complexity of the project, the mistakes and discrepancies in the tender documents, unforeseen underground conditions and changes to the regulations are the commonest factors causing post-contract design changes, and are eventually, delaying the projects. This is in line with the findings of Cox et al. (1999) who also identified that the changes in the Client’s requirements is another factor causing post-contract design changes.

Chang, Shih & Choo (2011) studied seven construction projects to understand the reasons for changes, the construction cost overrun and the redesign costs. They identified 10 reasons of design changes: client request, unclear design, inadequate design, unreliable design and site, utilities, construction conflict, facility increase, contractor recommendation, stakeholders’ request and actual needs. Chang, Shih & Choo (2011) classified the above reasons in three categories: under the designer’s control, under the client’s control and beyond control.

By comparing results from previous studies from KSA, UAE, Kuwait, Jordan and Lebanon, Sweis et al. (2007, p.666) concluded that, design change during construction is one of the reasons behind delays to projects, caused by poor design, mistakes in design, changes by owners during construction. While Motawa et al. (2007, pp. 368-377) opinion was to include change reasons, in change classification, as an ingredient plan for construction change management, Alnuaimi et al. (2010) identified that design changes were a primary source of variation orders, leading typically to project delays, cost overrun and disputes.

In his study on the causes of changes in public construction projects in Oman, Alnuaimi et al. (2010) unveils various factors related to design changes, namely Client direct requests, unrealistic design periods, less experienced designers, design errors, unclear tender documents, unclear or not well-defined client needs during tender stage, outdated design criteria, and finally consultant not aware of the current regulations.

By aiming to compare the reasons for change and the change practices in contractual relationships in construction and information technology, Brochner & Badenfelt (2011) identified several common factors, causing changes to projects, where the errors in the original documentation, the better understanding of the client needs and the change in provider/subcontractor technology ranked highest in causing design changes while the change in the client's core activity and the lack of communication ranked less in causing design changes.

Abd El-Razek et al. (2008, p. 834) revealed in his analysis of the Egyptian construction industry that changes to the design by owners during the construction period were a substantial cause of delay in projects. They also identified other factors causing design changes such as inadequate design by designers, changes to materials and specifications, unexpected underground conditions and design errors. This is in line with the findings of

Han et al. (2011) who recognized that design errors found during construction lead to rework and/or design changes, constituting a significant cause of delays and cost overruns in construction projects.

Burati et al. (1992) studied the causes of quality deviations in design and construction, and concluded that the majority of deviations (78%) were design deviations. He cited several factors causing design alterations such as errors or omissions during design, fabrication, transportation or construction phase, field conditions and operability requirement.

Osmani et al. (2007, p. 1149) revealed that design changes resulting from poor design practices such as design errors, design complexity, unclear specifications, poor communication and coordination, are a significant source of waste generation in the UK construction industry. This is in line with the findings of El-Sayegh (2008, p.435) who has assessed the risks surrounding the UAE construction industry, and identified that inadequate design & design changes ranked among the highest risks.

2.5 DESIGN CHANGES IN THE UAE CONSTRUCTION INDUSTRY

Design changes during the construction stage in the UAE are becoming a significant factor of delays to projects while in rare cases would be an opportunity to save time and cost. Divakar and Subramanian (2009, p. 1563) concluded that it is particularly beneficial to monitor the frequent changes to plans, designs and drawings during the construction phase, for a successful delivery of Construction Projects.

Faridi and El-Sayegh (2007) identified 44 factors causing delays to projects in the UAE, where several causes are related to changes to the design (drawings, specifications and materials) and are attributed to consultants and owners (Faridi and El-Sayegh, 2007, p. 1169) who identified other causes that would be grouped under this category such as

contract modifications and unforeseen conditions (subsurface soil condition, water table); this is in line with the findings of Assaf and Al Hejji (2005, pp. 352-356) who also identified that changes requested by owners during construction incurring design changes, being one major factor of delays and cost overrun in large construction projects.

The study of Assaf and Al Hejji (2005, pp. 352-353) reveals several causes of design changes during the construction stage that all negatively impact the project's time and cost. Among those causes: errors and inconsistencies in the design documents, vague and incomplete details in the drawings, complexity of the design, deficiency in collecting information preceding the design stage, misinterpretation of owner's design requirements, incompetent design team and most importantly, the changes in the government laws and regulations.

In recognizing the causes of design changes during the construction stage, identified by previous authors in different countries, and their consequences on the projects, those causes and consequences shall be drawn into a questionnaire to be addressed to professionals in the UAE construction industry, to justify their applicability in the UAE construction industry, and identify any emerging causes and consequences in this market. A summary of the identified factors causing post contract design changes is shown in Table 1.

Table 1 - Summary of identified factors causing post contract design changes across countries

S/N	Factors causing post contract design changes	References
1	Unforeseen site/underground condition	Le-Hoai, Lee & Lee (2008), Sambasivan and Yau (2006), Chan and Kumaraswamy (1997), Hsieh et al. (2004), Cox et al. (1999), Abd El-Razek et al. (2008), Han et al. (2011), Assaf and Al Hejji (2005).
2	Design changes due to Errors or Deficiencies made during Design Phase; example: Unclear/ Incomplete/ Inadequate/ Inconsistent/ Poor/ Unrealistic Design, Conflicting Specifications, Outdated Design Criteria…	Le-Hoai, Lee & Lee (2008), Chan and Kumaraswamy (1997), Hsieh et al. (2004), Wu et al. (2004), Chang, Shih & Choo (2011), Sweis et al. (2007), Alnuaimi et al. (2010), Abd El-Razek et al. (2008), Han et al. (2011), Burati et al. (1992), Abd El-Razek et al. (2008), El-Sayegh (2008), Assaf and Al Hejji (2005).
3	Incompetent designer or design team	Le-Hoai, Lee & Lee (2008), Chan and Kumaraswamy (1997), Alnuaimi et al. (2010), Assaf and Al Hejji (2005).
4	Consultant not aware of the current regulations.	Alnuaimi et al. (2010).
5	Complexity of design/project	Olawale & Sun (2010), Chan and Kumaraswamy (1997), Hsieh et al. (2004), Cox et al. (1999), Abd El-Razek et al. (2008), El-Sayegh (2008), Assaf and Al Hejji (2005).
6	Mistakes/discrepancies in	Olawale & Sun (2010), Sambasivan and Yau (2006), Mansfield, Ugwu & Doran (1994), Chan and

S/N	Factors causing post contract design changes	References
	design/contract documents	Kumaraswamy (1997), Cox et al. (1999), Alnuaimi et al. (2010), Brochner & Badenfelt (2011), Assaf and Al Hejji (2005).
7	Unclear or misinterpretation of client needs	Alnuaimi et al. (2010), Brochner & Badenfelt (2011), Assaf and Al Hejji (2005).
8	Change in government policies/regulations	Olawale & Sun (2010), Sambasivan and Yau (2006), Hsieh et al. (2004), Wu et al. (2004), Cox et al. (1999), Assaf and Al Hejji (2005).
9	Changes in the Client's requirements	Chan and Kumaraswamy (1997), Wu et al. (2004), Cox et al. (1999), Chang, Shih & Choo (2011), Sweis et al. (2007), Alnuaimi et al. (2010), Brochner & Badenfelt (2011), Assaf and Al Hejji (2005).
10	Changes recommended by the contractor	Chang, Shih & Choo (2011).
11	Changes requested by other stakeholders	Chang, Shih & Choo (2011), Burati et al. (1992).
12	Unrealistic design/project's periods	Chan and Kumaraswamy (1997), Alnuaimi et al. (2010).
13	Poor communication	Brochner & Badenfelt (2011), Abd El-Razek et al. (2008), El-Sayegh (2008).
14	Poor coordination	Abd El-Razek et al. (2008), El-Sayegh (2008).

S/N	Factors causing post contract design changes	References
15	Field Conditions or Change in Site Conditions	Mansfield, Ugwu & Doran (1994), Chan and Kumaraswamy (1997), Hsieh et al. (2004), Wu et al. (2004), Chang, Shih & Choo (2011), Burati et al. (1992), Assaf and Al Hejji (2005).
16	Changes in construction method/technology	Chan and Kumaraswamy (1997), Wu et al. (2004).
17	Changes to materials and specifications	Abd El-Razek et al. (2008), Han et al. (2011), Faridi and El-Sayegh (2007), Assaf and Al Hejji (2005).
18	Change in Market Conditions (Outdated design criteria)	Alnuaimi et al. (2010).
19	Utilities requirements	Chang, Shih & Choo (2011).
20	Construction conflict	Chang, Shih & Choo (2011).
21	Design changes due to Errors/Omissions during Construction/ Fabrication/Transportation Phase	Burati et al. (1992).

2.6 IMPACT OF POST CONTRACT DESIGN CHANGES

The review of the precedent studies clearly unveils that post contract design changes cause overruns in time and cost, sometimes to a substantial amount of the original price/duration while in rare situations would reduce the time and/or cost.

Burati (1992) unveiled that; design changes would produce quality deviations in design and construction. However, design changes may have more negative consequences such as low morale (Wu et al., 2004) among team members and workers, an impact on productivity as argued by Revay (2003) and Hanna et al. (1999).

2.7 CONCLUSION

The literature review has led the author to identify 21 factors causing post contract design changes and the relevant references as shown in Table 1.

The analysis of the identified factors reveals that some factors are remarkably common across the studied countries while others are emerging in some other countries. The Figure 1 uncovers “errors or deficiencies made during design phase” rank highest, “changes in Client’s requirements”, “unforeseen site / underground condition” and “mistakes/discrepancies/omissions in tender/contract documents” rank second, “complexity of design/project” and “Field conditions or change in site conditions” rank third, “change in government policies/regulations” rank fourth, “incompetent designer or design team” and “changes to materials and/or specifications” rank fourth, while the other factors rank fewer.

The Figure 2 classifies the identified factors under the project management knowledge areas, where it uncovers “scope management” ranks highest (26.09%), “quality management” and “Integration management” rank second (17.39%), “risk management” and “procurement management” rank third (13.04%), while “time management”, “human resources

management" and "communication management" rank fourth (4.35%), with "cost management" rank (0%).

Figure 1- Frequency of recurrence of the factors causing post contract design changes across countries as identified in the literature review

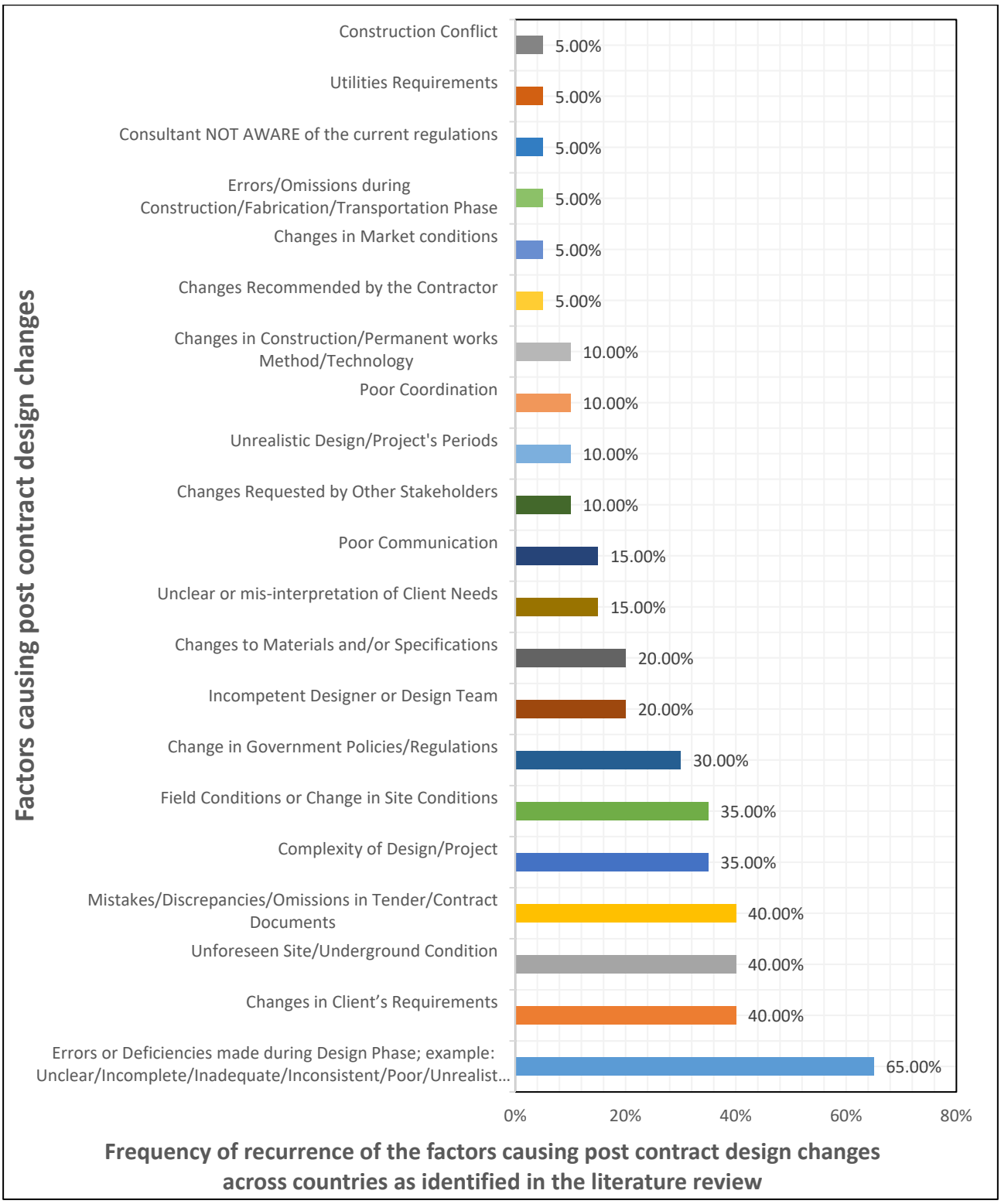
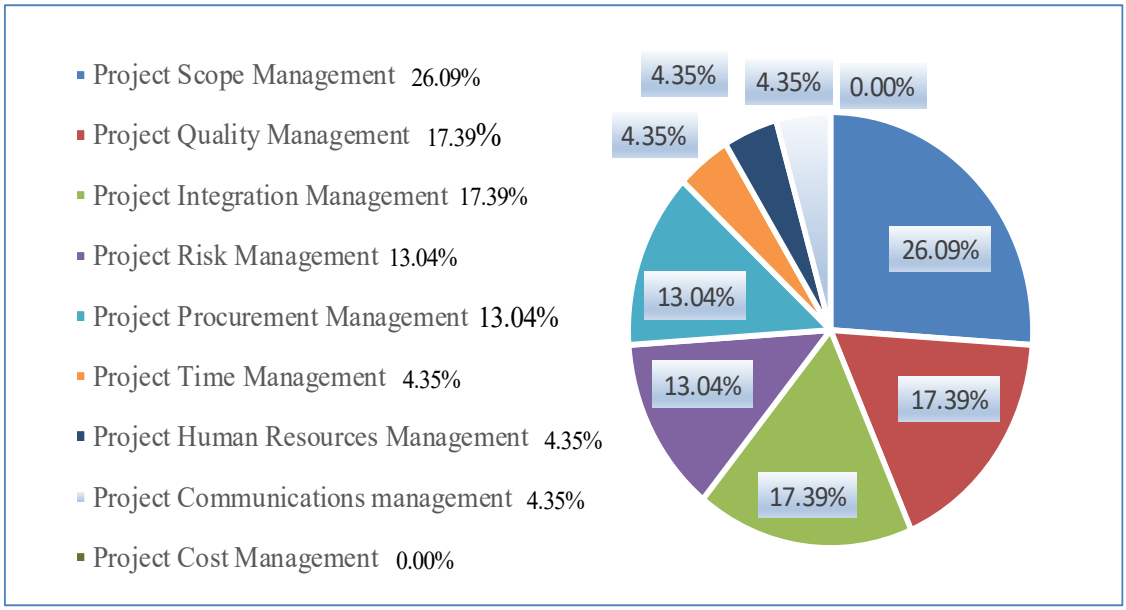


Figure 2 – Classification of the identified factors causing post contract design changes according to their project management knowledge areas



The above analysis emphasizes on the factors and knowledge areas requiring more attention from construction professionals as to reduce post contract design changes. The present project intends to justify the conclusion of the above analysis and examine if other factors are emerging in the UAE construction industry, then rank them based on their severe consequences on the time, cost and quality, then classifies them under the project management knowledge areas. Such ranking and classification shall encourage the construction professionals in the UAE in taking necessary preventive actions to reduce post contract design changes and eventually, their negative consequences.

Chapter 3 . METHODOLOGY

3.1 INTRODUCTION

The investigation of the factors causing post contract design changes in the UAE construction industry requires studying the data of the construction projects in this market.

This chapter explains the research methodology (illustrated in Figure 3) the researcher undertook to identify the factors causing post contract design changes in the UAE construction industry, then rank them from different perspectives, according to the severity of the caused changes' impact on the time, cost and quality. The researcher shall revise the learned lessons as to what is applied against the project management body of knowledge, and conclude the benefits to professionals working in the UAE construction industry.

3.2 RESEARCH STRATEGY

The research concentrates on projects in the United Arab Emirates (UAE). Several qualitative and quantitative research methods were explored, such as sample surveys, rapid rural appraisal, case studies, participant observation, participatory learning and action and specialized methods to conclude the method(s) for this study. A brief description of each method is shown in Table 2.

3.2.1 TRIANGULATION APPROACH

The exploration of the different qualitative and quantitative methods of Table 2 reveals that each method has its strengths, weaknesses and area of application. Hence, not only one method is suitable for this study, but rather a combination of methods, an approach known as triangulation, originally defined by Denzin (1978, p.291) as "the combination of methodologies in the study of the same phenomenon".

Figure 3 - Flow chart for the Research Methodology

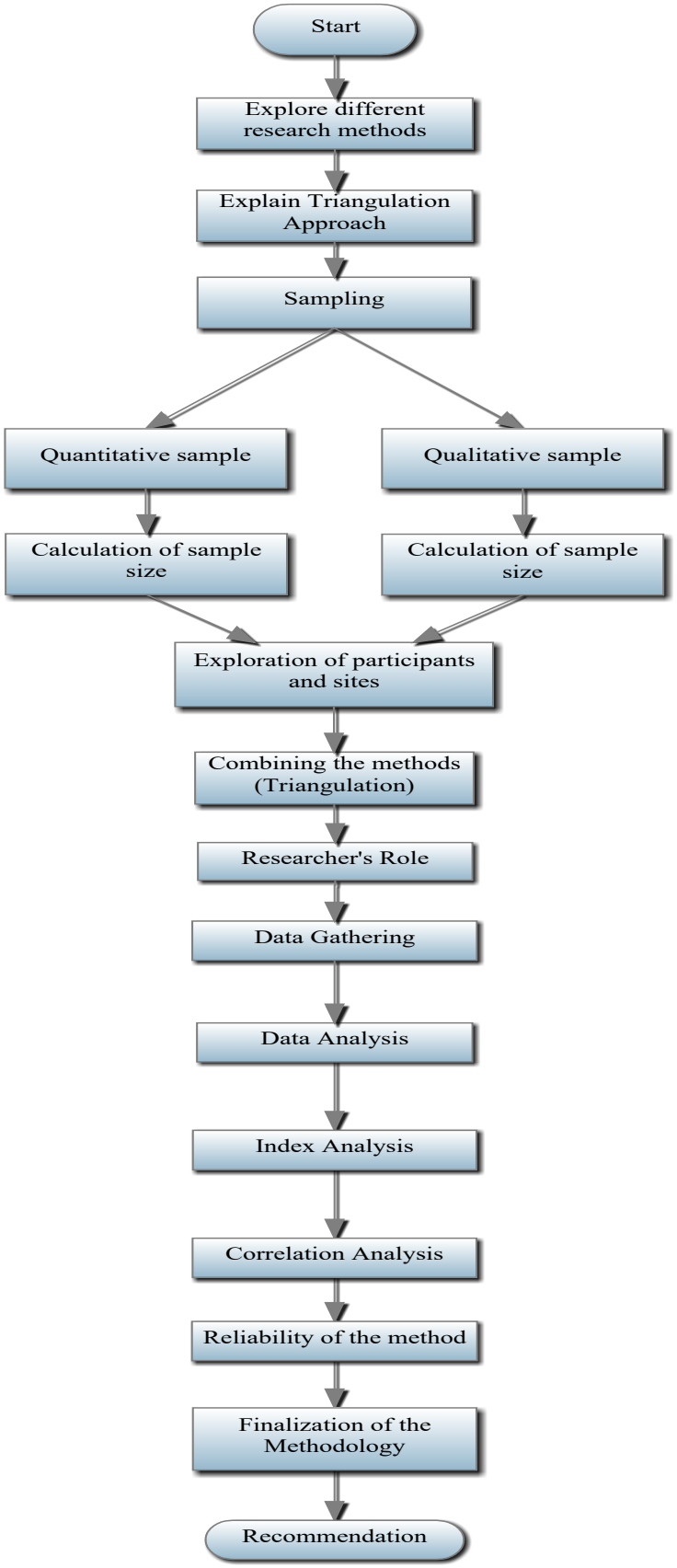


Table 2 - Available Research Methods

Research Method	Description
Sample surveys	Quantitative data is collected randomly Vide questionnaires and using control limits.
Rapid rural appraisal (RRA)	It is a quick and cost effective method; it involves multidisciplinary teams and focus groups, where information is collected only as needed, using semi-structured interviews, case studies, own participant opinions and sometimes other secondary sources (Chambers, 1981).
Participant observation	It is one of the qualitative methods where the participant shall thoroughly understand the people subject of their study, enter and participate in their world; in other words the researcher puts himself "in the shoes" of the people under study to try experiencing the events in a similar way (Jorgensen, 1989).
Case studies	Case studies mandate that the researcher carry out in-depth studies on a specific unit (group, organization, area, neighborhood) using unrestricted questionnaires to conclude histories about the studied subject.
Participatory learning and action	Pain et. al (2007) describes this method as being collective using the learning and action as the mean of gathering information, to utilize in a group or ecological subjects. It targets people distressed by or influenced by certain issue, to conclude the related information. This method utilizes control flow charts, village and areas' maps, security and capital ranking and other tools. This method shall conclude some action, for changing or improving the studied subject (Pain et. al, 2007).
Specialized methods	Such as photographic and video records, documentaries…

According to Bouchard (1976, p.268), the convergence of results among two or more methods improves the confidence in the validity of those results since the different methods don't share identical weaknesses or eventual for bias as explained by Rohner (1977, p.134).

It was continuously perceived that every method has its own assets and liabilities; the triangulation approach implicates exploiting the assets and neutralizing the liabilities, as stipulated by Jick (1979, p.604), who confirms that the efficiency of the triangulation resides in the counter-weighting of the weaknesses of a single method by the strengths of another

method. Nevertheless, triangulation may not be recommended for all study purposes, due to various limitations in time & cost, preventing its efficient usage, but it still has vital strengths, inspiring an innovative research, in highlighting the importance of the qualitative methods and, demonstrating the necessity of using quantitative methods in a balanced way.

The application of triangulation on the current research mandates the identification of the population being studied, to conclude the qualitative and quantitative approaches to be used, and how we combine results from the different methods to identify the factors causing post-contract design changes in the UAE construction industry. the application of triangulation assisted to prioritize the factors according to the impact of those changes on the time, cost and quality of the projects being studied and therefore, identify the project management knowledge areas requiring more attention from the professionals in the UAE, to conclude recommendations for reducing the negative impact of such design changes on time to completion, cost and quality of the works.

3.2.2 SAMPLING

QUANTITATIVE SAMPLE

The research concentrates on projects in the Emirates of Sharjah, Dubai and Abu Dhabi of the United Arab Emirates (UAE), where the majority of the Capital projects (several dozens of thousands) were built in the recent years of the construction booming.

For an accurate result, the researcher adopted a purposeful sampling where he selected “case studies” on a sample of typical capital projects with sufficient details, from the pool of all the projects built or being built in the UAE, where the *individual data was scrutinized* to reveal the real causes of the post contract design changes, and the actual impact of such changes on time to completion, cost and quality of the studied projects. In an attempt to obtain access to the information of few projects, the researcher faced several objections from

the top management of the different stakeholders of the projects (owners, project management companies, consultants, contractors) as they all classified such information as being confidential and cannot be disclosed to any party, for any reason.

In an attempt to understand the real reasons behind the objections, the researcher approached unofficially several professionals from the aforementioned stakeholders, to understand that, improper documentation and fear from compromising their reputation might be the main reasons of the objection. Moreover, such extensive examination of the projects' data would require time, longer than what is available for this research. In consequence, the researcher abandoned this quantitative method and started looking for alternatives.

An alternative quantitative method was to consider "sample surveys" on the same population of projects and approach the management teams from all parties who are/were responsible for building those projects and *collect their opinions* on the real reasons they had and that caused post contract design changes to their projects.

During and after the recession in the UAE, considerable number of projects were postponed or cancelled; therefore, it was virtually impossible to get any information on those projects, mainly due to unavailability of the project management teams who, in majority left the country while few moved to different companies. Therefore, this method was also excluded.

In a final attempt to collect data, the author has carried out a survey on the largest capital projects that are still under construction, and prepared a questionnaire that was addressed to the population of professionals in the UAE construction industry (developers, project management companies, consultants, main contractors & subcontractors), who are/were recently involved in design changes in one of their current or previous projects and are/were able to assess the real impact of those changes on the time, cost and quality. Such

professionals include project directors, project managers, design managers, senior engineers, planning engineers and quantity surveyors. The questionnaire's aim is recognizing the real factors that caused post contract design changes in a project of their choice (current or previous), and rate such factors according to the real impact of the design changes they had on the time, cost and quality, where sensitive data is kept optional.

The methodology adopted in structuring the questionnaire is described in Annex 1; the final list of identified factors is shown in Table 3.

SAMPLE SIZE

Given a population, Cochran (1963) provides a formula for calculating the sample size as follows:

$$n_0 = \frac{Z^2 pq}{e^2} \quad \textbf{(Equation 1)}$$

In which:

n_o : the size of the sample

Z^2 : the normal curve's abscissa cutting off an area at the tails; Z value is found in statistic books & tables, that include the area underneath the normal curve.

e : the anticipated level of precision

p : is the expected fraction of an attribute existing in the population

q : 1 – p

Having a large population at hand, we assume maximum variability of p = 0.5, a confidence level of 95% and a precision of ±7%; $Z^2 = 1.96$ (Vassar Stats)

Applying (Equation 1, the sample size is $n_0 = \frac{1.96\ x\ 0.5\ x\ (1-0.5)}{0.07^2} = 196$

Hence **at least 196 responses are required** for this quantitative method.

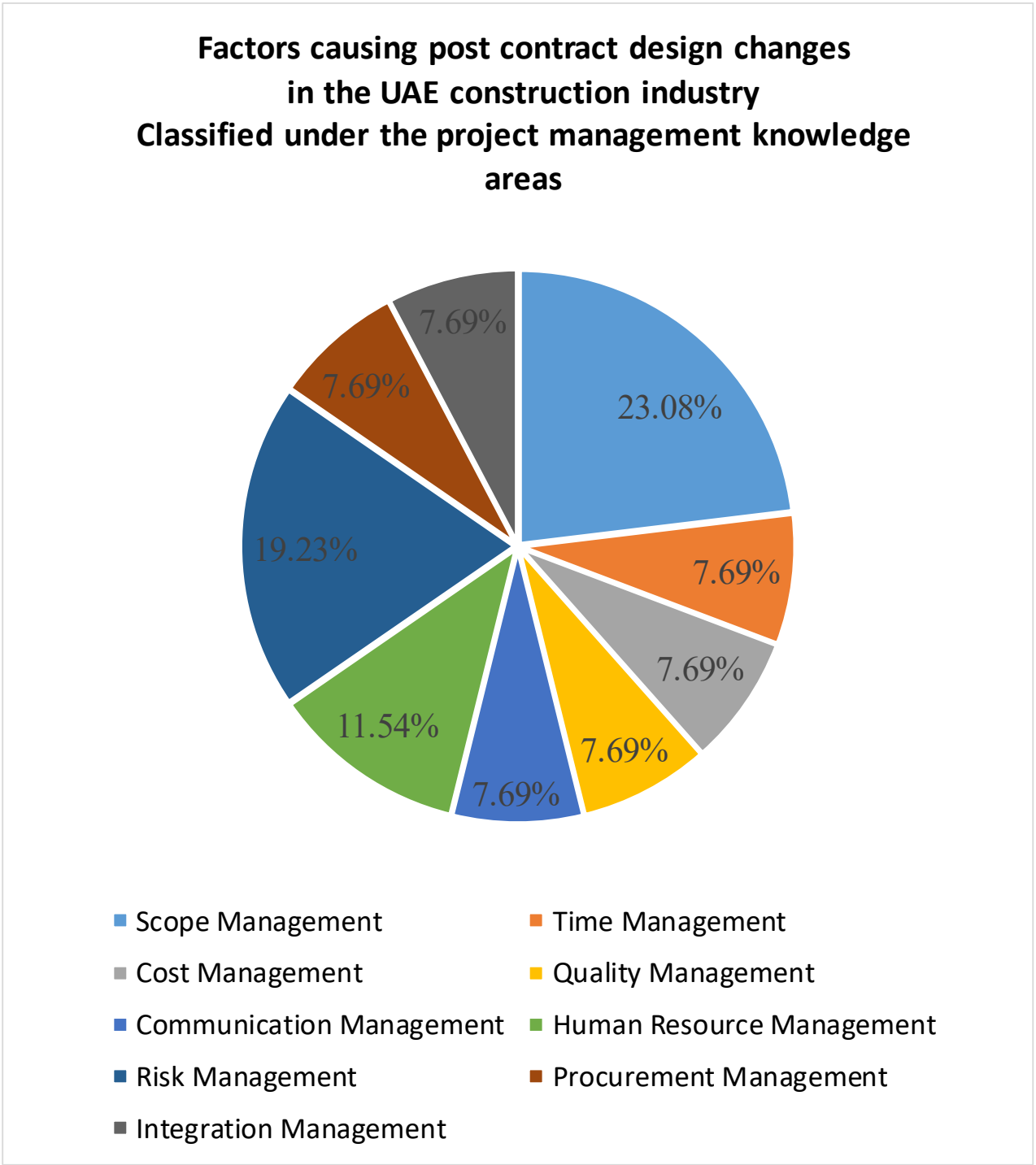
Table 3 - Identified factors causing post contract design changes in the UAE construction industry

S/N	Factor
1	Design changes due to Changes in Client's requirements
2	Design changes due to Changes requested by other stakeholders
3	Design changes due to Changes recommended by the contractor
4	Design changes due to Complexity of design/project
5	Design changes due to Unclear or mis-interpretation of client needs
6	Design changes due to Changes in Market conditions
7	Design changes due to Unrealistic design/project's periods
8	Design changes to reduce project duration
9	Design changes due to Value Engineering
10	Design changes due to budget constraints (omissions due to lack of funds)
11	Design changes due to Errors or Deficiencies made during Design Phase; example: Unclear/Incomplete/Inadequate/Inconsistent/Poor/Unrealistic Design, Conflicting Specifications, Outdated Design Criteria...
12	Design changes due to Errors/Omissions during Construction/ Fabrication/ Transportation Phase
13	Design changes due to Poor communication
14	Design changes due to Poor coordination
15	Design changes due to Incompetent designer or design team
16	Design changes due to incompetent contractor technical team
17	Design changes due to Consultant not aware of the current regulations
18	Design changes due to Unforeseen site/underground condition
19	Design changes due to Utilities requirements
20	Design changes due to Construction conflict
21	Design changes due to sustainability requirements (LEED/Estidama)
22	Design changes due to Change in government policies/regulations
23	Design changes due to Mistakes/Discrepancies/Omissions in Tender/ Contract Documents
24	Design changes due to Changes to Materials and/or Specifications
25	Design changes due to Field Conditions or Change in Site Conditions
26	Design changes due to Changes in Construction/Permanent works Method/Technology

Table 4 - Identified factors causing post contract design changes in the UAE construction industry, classified under the project management knowledge areas

Knowledge Area	Factors causing post contract design changes in the UAE construction industry
Scope Management	Design changes due to Changes in Client's requirements
	Design changes due to Changes requested by other stakeholders
	Design changes due to Changes recommended by the contractor
	Design changes due to Complexity of design/project
	Design changes due to Unclear or mis-interpretation of client needs
	Design changes due to Changes in Market conditions
Time Management	Design changes due to Unrealistic design/project's periods
	Design changes to reduce project duration
Cost Management	Design changes due to Value Engineering
	Design changes due to budget constraints (omissions due to lack of funds)
Quality Management	Design changes due to Errors or Deficiencies made during Design Phase; example: Unclear/Incomplete/Inadequate/Inconsistent/Poor/Unrealistic Design, Conflicting Specifications, Outdated Design Criteria...
	Design changes due to Errors/Omissions during Construction/ Fabrication/ Transportation Phase
Communication Management	Design changes due to Poor communication
	Design changes due to Poor coordination
Human Resource Management	Design changes due to Incompetent designer or design team
	Design changes due to incompetent contractor technical team
	Design changes due to Consultant not aware of the current regulations
Risk Management	Design changes due to Unforeseen site/underground condition
	Design changes due to Utilities requirements
	Design changes due to Construction conflict
	Design changes due to sustainability requirements (LEED/Estidama)
	Design changes due to Change in government policies/regulations
Procurement Management	Design changes due to Mistakes/Discrepancies/Omissions in Design/ Tender/ Contract Documents
	Design changes due to Changes to Materials and/or Specifications
Integration Management	Design changes due to Field Conditions or Change in Site Conditions
	Design changes due to Changes in Construction/Permanent works Method/Technology

Figure 4 - Factors causing post contract design changes in the UAE construction industry, classified under the project management knowledge areas



QUALITATIVE SAMPLE

Amongst the different methods described Table 2, the rapid rural appraisal method (RRA) serves the purpose. The researcher held semi-structured interviews with selected experienced professionals (more than 20 year experience), to answer the questionnaire and acquire a deeper understanding of the identified factors, and the circumstances that led to those factors, distributed as follows:

- ✓ 2 from developers or project management companies.
- ✓ 2 from consultants.
- ✓ 2 from contractors and/or subcontractors.

The selected professionals were part of the sample who already filled up the questionnaire on their own. They were approached with the results of the frequency of recurrence of the factors; during the interview they were asked for additional information such as their opinion on the main reasons behind the top ranked factors and they were given the option to change their answers if they wish to. Their answers were significant to conclude recommendations to the community of project management on how to reduce the impact of the identified factors on the time, cost and quality.

3.2.3 PARTICIPANTS AND/OR SITES

The sample of participants is distributed as much as possible in similar proportions among developers, consultants and contractors / subcontractors, noting that project management companies act on behalf of the clients & developers.

The researcher has built a database of professionals (approximately 300), from the largest developers, project management companies, consultants, contractors and subcontractors recently active in Abu Dhabi, Dubai and Sharjah. Each participant was contacted individually by phone, for getting his consent to participate in the survey, whereby the

researcher explains him the aims of the study, and why he was chosen, highlighting any ethical concerns such as the confidentiality of the information being collected or any other concerns the participant may have.

3.2.4 COMBINING THE METHODS - TRIANGULATION

During the interviews of the previous paragraph, the results of the quantitative research are presented graphically to the interviewees, for getting their consent and/or disagreement on the identified factors and their ranking, from different perspectives. The interviewees are asked for their recommendations to reduce post contract design changes and/or the impact of those changes on time to completion, cost and quality of the works in future construction projects. Such recommendations form part of the final section of this study.

3.2.5 ROLE OF THE RESEARCHER

During the quantitative research, the researcher committed an observer role while gathering the information. Upon receiving each participant's response, the researcher scrutinizes the gathered information for completeness, illogical answers and/or contradiction; if found so, the participant is contacted to confirm his understanding of the questions, and whether he wants to change his answers.

During the qualitative research, the researcher plays the role of clinical examiner while interviewing the selected participants, where he discusses the different types of variations to identify unnoticed design changes especially minor changes, for an in-depth understanding of the real factors causing post contract design changes and the impact of such changes on the time, cost and quality.

In both quantitative and qualitative methods, the researcher benefits from his previous experience to identify illogical and/or conflicting answers, but never interfered to influence the participants' response.

3.2.6 HOLDING THE INTERVIEWS

The research method provides opinions from the construction professionals in the UAE. The identified factors are real factors that already occurred in the projects. However, their opinion on the impact of such changes on time and the cost is more accurate when it is minimum or maximum; but in medium impact, the values used for the calculation of the impact may be approximate and hence, the answer would be an approximate guess. In all cases, the identified impact on quality is better defined and hence more reliable.

To strengthen the above method, the qualitative approach mandates interviews with selected participants. Detailed planning prior to starting the interviews was crucial and the following guidelines proposed by White (2000, pp. 30-32) were considered while holding the semi-structured interviews:

- ✓ Caution has been taken when selecting the interviewees: The selected interviewees are experienced professionals in the construction field; their experience is > 20 years.
- ✓ The interviewees were briefed on the dissertation's subject and aims, with the opportunity to read the final dissertation if they opt to. A full respect to persons from all ages at all time.
- ✓ The researcher starts with closed and concise questions of the questionnaire then moves to more open questions, jargon free, with more than one question on the same topic for a better understanding and cross checking and correlating the validity of the answers. In addition to the questionnaire questions, the interviewees were asked for their views on the best measures to take for reducing post contract design changes and/or their negative impact on the projects.
- ✓ Only relevant questions are asked.
- ✓ The interview does not last more than 30 minutes. The interviewee is informed in advance on the approximate time the interview will take.

- ✓ The responses are noted in writing. However, the researcher used an electronic voice recorder, with the consent of the interviewee for ensuring the accuracy.
- ✓ The language used was straightforward and explicit as recommended by Fisher (2010, p.183).
- ✓ Lastly, the researcher summarizes the discussion to the interviewee to avoid confusion.

3.2.7 ETHICAL ASPECTS OF THE RESEARCH

According to Churchill (1995), "ethics" are defined as the honest values and principles serving the administration of the approach a person or group carry out his activities. The researcher has given high importance to ethics while completing this research, by following the guidelines of White (2000, pp. 26-27):

- ✓ The researcher involved participants who gave their consent to participate in the research. They were given the option to drop the survey at any time if they wish to.
- ✓ Information on the actual research nature is made available to the participant at all times. Everyone is informed on the subject. The researcher conveys the truth about the study and never deceives the participants at any way.
- ✓ Avoid pushing people to do things hindering their self-confidence or self-resolution.
- ✓ Respect the participant's rights of privacy. All sensitive data (name, company, time and cost) are kept optional.
- ✓ Participants from all categories, experience and background are treated equally and respect is the common among all.

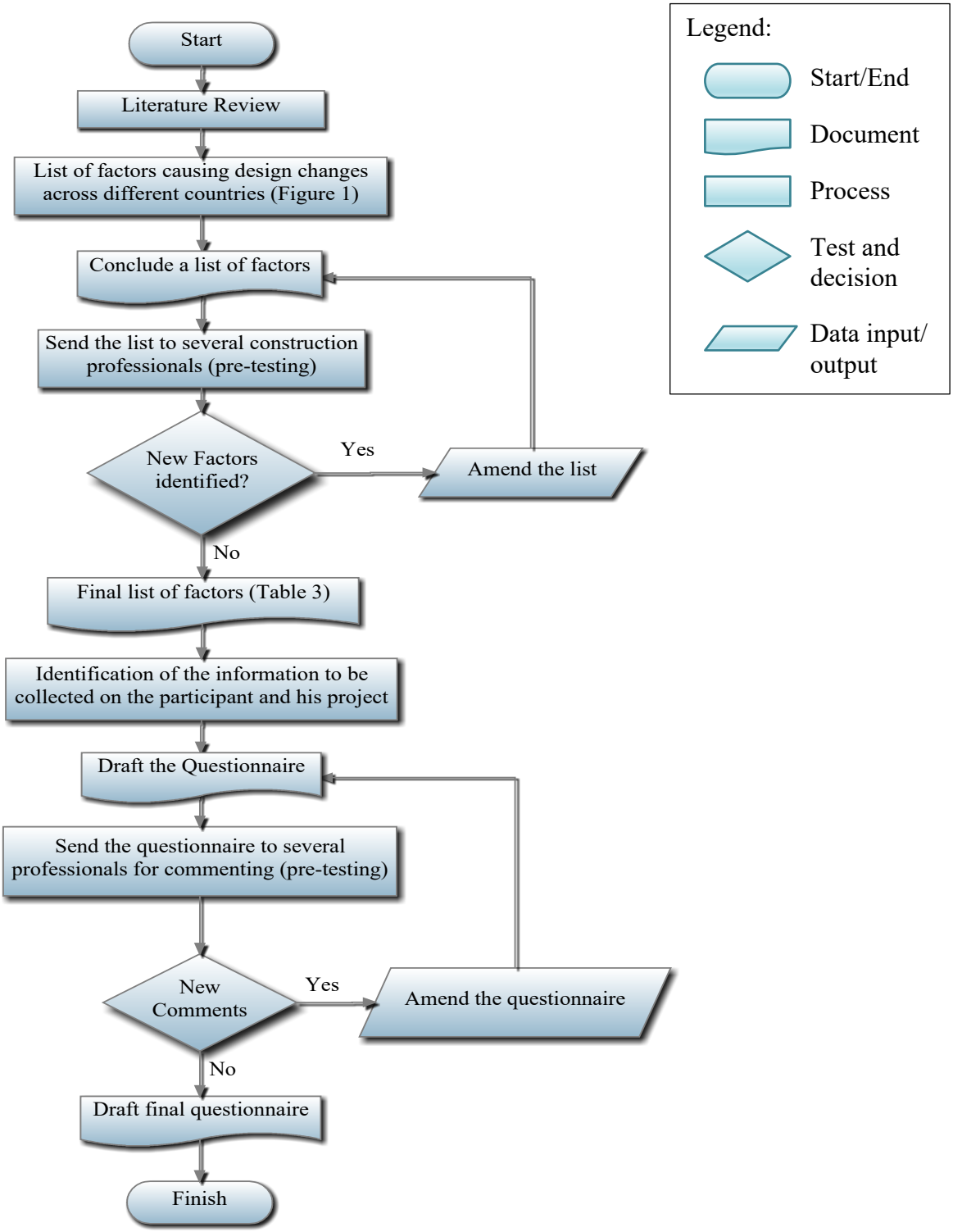
3.3 DATA GATHERING TECHNIQUES

The identified factors listed in Table 1 are drafted into a questionnaire addressed to the audience of construction professionals in the UAE, for their input on post contract design changes, met in their projects. Emerging factors are also identified and rated accordingly.

3.3.1 QUESTIONNAIRE STRATEGY

The methodology for building up the questionnaire is described in Figure 5.

Figure 5 - Flow chart for creating the questionnaire



3.3.2 STRUCTURE OF THE QUESTIONNAIRE

The questionnaire is made up of six sections as detailed in Annex 1.

- ✓ Introduction.
- ✓ Gathering the participant's information.
- ✓ Collecting the project's information.
- ✓ Listing the factors causing post contract design changes.
- ✓ Ranking the factors.
- ✓ Participant's feedback.

The survey is built using an online professional survey service (www.esurveyspro.com); the logo of the "University of Liverpool / Online Higher Education / Laureate Online Education" is shown at the top of each page, to show the academic side and give the research credibility.

A (*) is shown next to each mandatory question and made explicit in the header of each section. However, guidelines for answering the questions of each section are given at the top of each page. The questionnaire was sent by Email to various construction professionals for their evaluation of the questionnaire's structure, the questions and the way of asking, the questions' clarity and the flow between pages. The questionnaire is amended several times, implementing the respondents' suggestions.

The invitation sent by Email and the final layout of the questionnaire are included in Annex 2 and Annex 3 respectively.

3.3.3 DATA COLLECTION

The participants are contacted individually by phone, and the invitations of Annex 1 are distributed electronically; each Email is personalized and includes an exclusive link to complete the survey online only once. The responses are collected anonymously, and

participants are automatically notified by Email a “thank you” message for their contribution.

Upon completion of each survey, information is collected by the surveying software and added to the responses’ database. A timeframe of 45 days was given to complete the survey from 1st December 2012 till 15th January 2013.

3.3.4 POSSIBLE OBSTACLES AND RESOLUTION

During the online survey, many obstacles arose and resolved according the plan in Table 5.

Table 5 - Plan for resolving the obstacles during the data collection process

Obstacle	Resolution
Poor structure or wording of the questionnaire	The researcher has used simple English sentences, concise words, no jargon while asking the questions. He tried to avoid supposing and presuming questions. The questionnaire was sent to many professionals to identify unclear or long questions. They had the ability to correct the grammar, vocabulary, or even the structure of the questionnaire as to reach the final structure.
Low response percentage	Resend the invitation to the recipients with “No response” status. Phone calls to follow up and encourage the participants to complete the questionnaire.
	The researcher reconfirmed to all the participants that the sensitive information (time & cost) is optional and if entered, it will remain confidential.
Incomplete response	The participant is contacted by phone, informing him on the incomplete response and request him to complete the questionnaire till the end. If not completed after several follow ups, the response is deleted.
Conflicting response	Follow up with the participant in an interview.

3.4 DATA ANALYSIS

The collected data is downloaded into an Excel file for a descriptive and inferential analysis using SPSS software.

3.4.1 DESCRIPTIVE ANALYSIS

The participants' data is presented according to its distribution between Developers/Clients, project management companies, consultants, contractors and subcontractors in terms of invitations distributed and the collected responses.

The identified factors causing post contract design changes are presented from different perspectives as follows:

- ✓ According to the business type.
- ✓ According to the type of project.
- ✓ According to the contract type.

The above percentages are sorted according to their values representing the frequency of recurrence of the identified factors across projects, to reveal the most and least recurring factors among each category, to assist the researcher in identifying the knowledge areas requiring more attention from the project management professionals in the UAE construction industry.

3.4.2 FACTORS ANALYSIS (FACTOR IMPACT INDEX)

The data collected online is downloaded to an Excel file and analyzed using the SPSS software, according to the statistical techniques and indices, widely used by several researchers such as Assaf and Al-Hejji (2006), Olawale and Sun (2010), Sambasivan and Soon (2007), Abd El-Razek et. al (2008), Alnuaimi et. al (2010) and Le-Hoai et. al (2008) and many others, in their studies to investigate the factors causing delays and/or cost overrun to projects in different countries.

The Impact Index formula is used to rank the identified factors causing design changes, according to the impact of those changes on the time, cost and quality as given by the contributors:

Impact Index on Time: $$\mathbf{II_T} = \sum_{i=1}^{N} w(\frac{n_i}{3})$$ **(Equation 2)**

Impact Index on cost: $$\mathbf{II_C} = \sum_{i=1}^{N} w(\frac{n_i}{3})$$ **(Equation 3)**

Impact Index on quality: $$\mathbf{II_Q} = \sum_{i=1}^{N} w(\frac{n_i}{3})$$ **(Equation 4)**

Where:

- ✓ n_i is the responses' frequency.
- ✓ N is the entire number of responses.
- ✓ w the value representing the weight given to every single response as shown in Table 6.

Table 6 - Weight given to each response

w	Impact on Time	Impact on Cost	Impact on Quality
-3	major delay	major cost overrun	major decline in quality
-2	medium delay	medium cost overrun	medium decline in quality
-1	minor delay	minor cost overrun	minor decline in quality
0	no delay	no cost impact	no impact on quality
1	minor acceleration	minor cost saving	minor quality improvement
2	medium acceleration	medium cost saving	medium quality improvement
3	major acceleration	major cost saving	major quality improvement

3.4.3 SPEARMAN'S RANK CORRELATION

The ranking of the Impact indices serves identifying the factors causing design changes having the most impact on the time, cost and quality of construction projects. However, it is beneficial to identify whether a relationship does exist among these factors and the strength of such relationship, which reflects the agreement or disagreement among different parties on the factor being studied; the Spearman's correlation serves such purpose.

Spearman's rank correlation is defined by Bernstein and Bernstein (1999, pp. 394-395) as a nonparametric test (distribution free test), used when measurements are of an ordinal-level. This method examines the rapport among the two variables X and Y in a group of n sets (Xi, Yi) of measurements. The participants are ranked on every variable, and the level of such relation among the paired ranks is calculated. The Spearman test assesses the monotonic relationship (increasing or decreasing) between the variables; a variable value increases when the other variable increases and decreases when the other variable decreases. The Spearman rank correlation coefficient r_s is defined by Bernstein and Bernstein (1999, p. 395):

$$r_s = 1 - \frac{6 \sum_{i=1}^{n} d_i^2}{n^3 - n} \qquad \textbf{(Equation 5)}$$

Where n is the respondents' quantity in the database, d_i is the variance among the two compared ranks of every pair, as calculated in the previous paragraph.

The values of this coefficient fluctuate from -1 to +1, where the value +1 represents a perfect agreement and the value -1 a perfect disagreement among those two variables. When the values of the sample are very close to +1, it is said that there is a strong agreement between the 2 factors while values close to -1 represent a strong disagreement; values very close to zero signify no relationship between the two factors.

Chapter 4 . PRESENTATION AND INTERPRETATION OF THE RESULTS

4.1 GENERAL RESPONDENTS' CHARACTERISTICS

To complete this study, the researcher invited 333 construction professionals to complete the online questionnaire, of which only 200 have responded, with 60% response rate as shown in Table 7.

Table 7 - Distribution of Respondents per business type

	Developer/ Owner/ Client	Project Management	Designer/ Consultant	General Contractor	Subcontractor (MEP)	Subcontractor (Other)	**Total**
Invited	42	59	97	93	25	17	**333**
Responded	20	51	60	48	10	11	**200**
Percentage of response	47.61%	86.44%	61.85%	51.61%	40.00%	64.71%	**60.06%**

The respondents are grouped in three main groups:

- ✓ **Clients:** representing the developers/owners/clients and the project management companies who normally act on behalf of Clients. 71 Clients have responded to the survey out of 101 invited.
- ✓ **Consultants:** representing the designers and consultants. 60 Consultants have responded to the survey out of 97 invited.
- ✓ **Contractors:** representing the general contractors and subcontractors. 69 contractors have responded to the survey out of 135 invited.

The Table 8 shows almost equal proportions of the respondents: 35.50% Clients, 30% Consultants and 34.50% Contractors. Such distribution ensures that no one group will dominate the selection of a factor or the associated design changes' impact on the time, cost and quality. Such mix among the participants ensures a balance among the responses.

Table 8 - Distribution of Respondents among clients, consultants and contractors

	Clients	Consultants	Contractors	**Total**
Invited	101	97	135	**333**
Responded	71	60	69	**200**
Percentage of response	70.30%	61.86%	51.11%	**60.06%**

For realistic results, the majority of the participants are experienced professionals (experience more than 16 years) as to have reliable responses. The Table 9 representing the distribution of respondents according to their experience shows that 59% of the respondents have more than 16 years of experience while 28% has an experience of 11 to 15 years.

Table 9 - Distribution of Respondents per years of experience

<5 years	6 to 10 years	11 to 15 years	16 to 20 years	>20 years	**Total**
2	24	56	39	79	**200**
1.00%	12.00%	28%	19.50%	39.50%	**100%**

The respondents are also represented according to their distribution among different types of projects (Table 10) and different types of contracts (Table 11). Such presentation would serve to prioritize the factors causing post contract design changes according to the project type and to the contract type.

Table 10 - Distribution of Respondents per project type

Residential	Commercial (Offices, mall, retail...)	Mix use (Residential + commercial)	Industrial	Infrastructure (School, Hospital, Airport, other...)	Hotels	**Total**
43	35	70	9	33	10	**200**

Table 11 - Distribution of Respondents per contract type

Design-Bid-Build (lump sum)	Design-Bid-Build (Re-measurable)	Design-Build	Engineering, Procurement, Construction (EPC)	**Total**
104	25	21	50	**200**

4.2 FACTORS CAUSING POST CONTRACT DESIGN CHANGES IN THE UAE CONSTRUCTION INDUSTRY

The current research confirms that all the factors causing post contract design changes, identified during the literature review and presented in Table 3 are valid for the UAE construction industry as they were selected by the participants, in different proportions and rankings. Likewise, five emerging factors causing post contract design changes were identified in the UAE construction industry:

- ✓ Design changes to reduce project duration.
- ✓ Design changes due to value engineering.
- ✓ Design changes due to budget constraints (omissions due to lack of funds).
- ✓ Design changes due to incompetent contractor's technical team.
- ✓ Design changes due to sustainability requirements (LEED/Estidama).

In total, this research concludes 26 factors causing post contract design changes in the UAE construction industry as presented in Table 3.

In the following paragraphs, the identified factors are analyzed, ranked and presented from different perspectives (per business type, per project type, per contract type), according to their frequency of occurrence across the projects, and also according to the impact of the caused design changes on the time, cost and quality of the projects.

In the last section, the Spearman theory is applied to the factors' rankings to identify if the different parties (Clients, Consultants and Contractors) are in agreement or disagreement on the results.

4.3 FREQUENCY OF RECURRENCE OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES

The factors causing post contract design changes in the UAE and their frequency of recurrence are presented in Figure 6 where it is revealed "Changes in the Client's requirements" is the most recurred factor causing design changes in the UAE construction industry as quoted by 88.50% of the respondents; then "value Engineering" ranked second (57.5%), "errors or deficiencies made during the design phase" ranked third (52.50%), "change in government policies/regulations" ranked fourth (46.50%), "poor coordination" ranked fifth (42.50%), "utilities' requirements" ranked sixth (42%).

The least ranked factors (less than 15% recurrence) were "poor communication" (11%), "incompetent contractor technical team" (13%) and "Changes in Construction/Permanent works Method/Technology" (14.50%).

However, other relevant factors were identified, with an average recurrence (15% to 40%) including the emerging factors "to reduce project duration" (19%), "budget constraints (omissions due to lack of funds)" (30%) and "sustainability requirements (LEED/ Estidama)" (26%).

4.4 FREQUENCY OF RECURRENCE OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES FROM CLIENTS' PERSPECTIVE

The factors causing post contract design changes in the UAE and their frequency of recurrence from clients' perspective are presented in Figure 7 where it is revealed "Changes in the Client's requirements" is also the most recurred factor causing design changes in the

UAE construction industry as quoted by 83% of the Clients' respondents; "value Engineering" also ranked second (63.38%), "change in government policies/regulations"

Figure 6 – Factors causing post contract design changes in the UAE construction industry

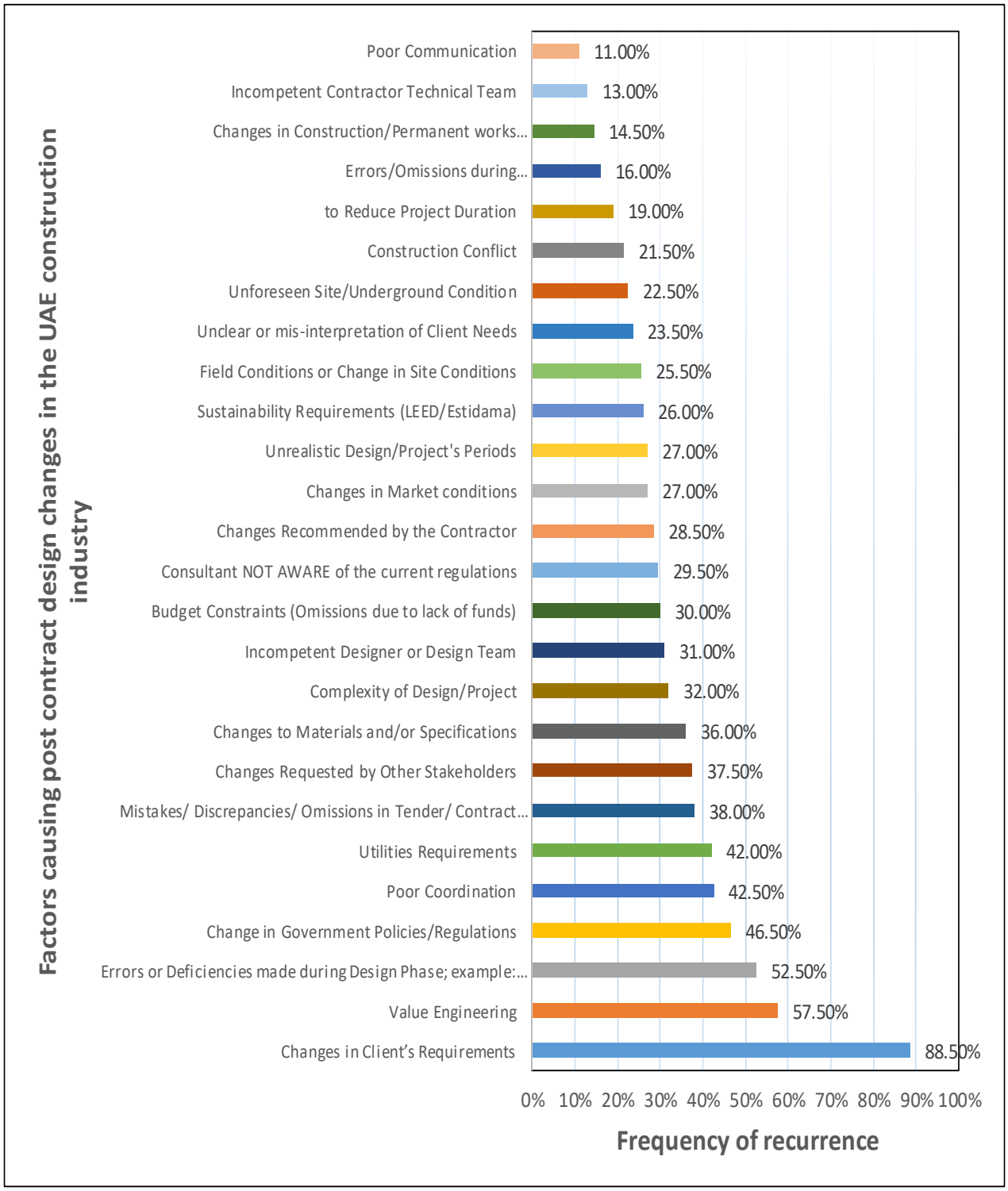
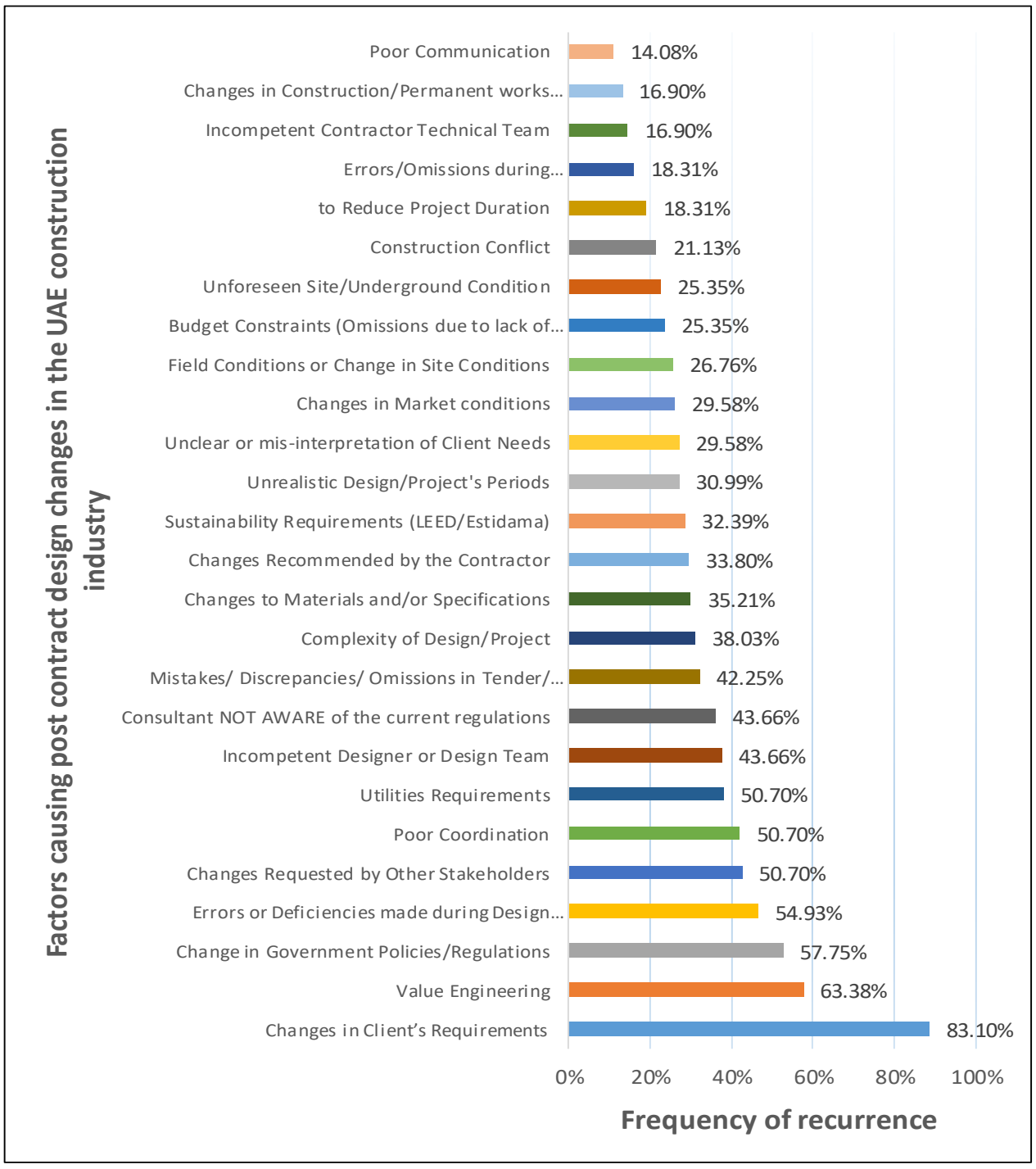


Figure 7 – Factors causing post contract design changes in the UAE construction industry from Clients' perspective



ranked third (57.75%), "errors or deficiencies made during the design phase" ranking fourth (54.93%), "Changes requested by other stakeholders", "poor coordination" and "utilities' requirements" ranked fifth (50.70%), "Incompetent designer or design team" and

"Consultant not aware of the current regulations" ranked sixth (43.66%), "Mistakes/ Discrepancies/ Omissions in Tender/ Contract Documents" ranked seventh (42.25%).

The least ranked factors were "poor communication" (14.08%), "incompetent contractor technical team" and "Changes in Construction/Permanent works Method/Technology" (16.90%).

However, other influential factors were identified, including the emergent factors "budget constraints (omissions due to lack of funds)" (25.35%) and "sustainability requirements (LEED/Estidama) (32.39%)".

4.5 FREQUENCY OF RECURRENCE OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES FROM CONSULTANTS' PERSPECTIVE

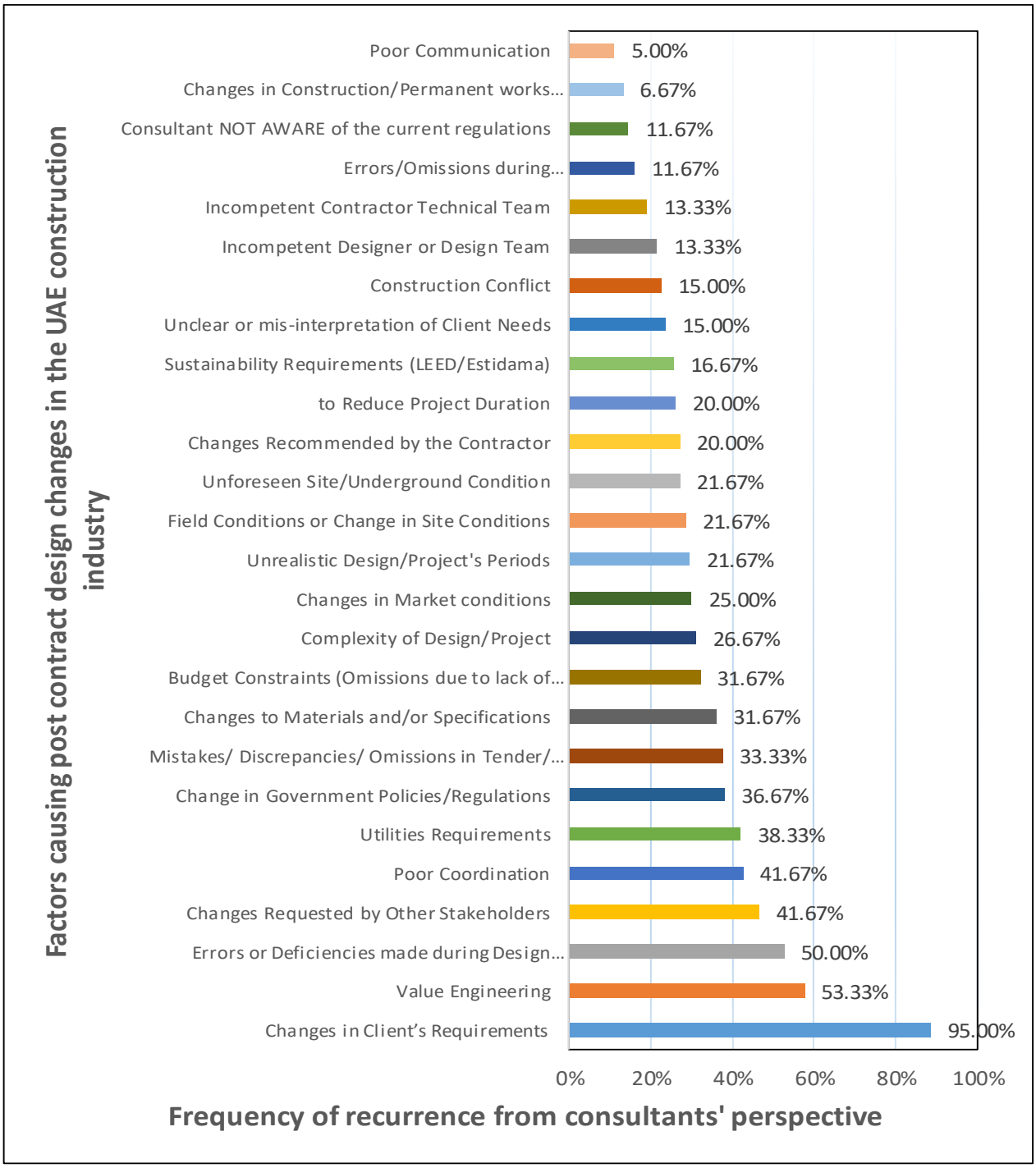
The factors causing post contract design changes in the UAE and their frequency of recurrence from consultants' perspective are presented in Figure 8 where it is discovered "Changes in the Client's requirements" is also the most recurred factor causing design changes in the UAE construction industry as quoted by (95%) of the Consultants' respondents; similarly "value Engineering" ranked second (53.33%), "errors or deficiencies made during the design phase" ranked third (50%), while "changes requested by other stakeholders" and "poor coordination" ranked fourth (41.67%).

The least 5 ranked factors were "poor communication" (5%), "Changes in Construction/ Permanent works Method/Technology" (6.67%), "Errors/Omissions during Construction/ Fabrication/ Transportation Phase" and "consultant NOT AWARE of the current regulations" (11.67%), "incompetent contractor technical team" and "Incompetent Designer or Design Team" (13.33%), finally "construction conflict" and "Unclear or misinterpretation of Client Needs" (15%).

However, the other emergent factors were ranked "sustainability requirements (LEED/

Estidama)" (16.67%), "To reduce project duration" (20%) and "budget constraints (omissions due to lack of funds)" (31.67%).

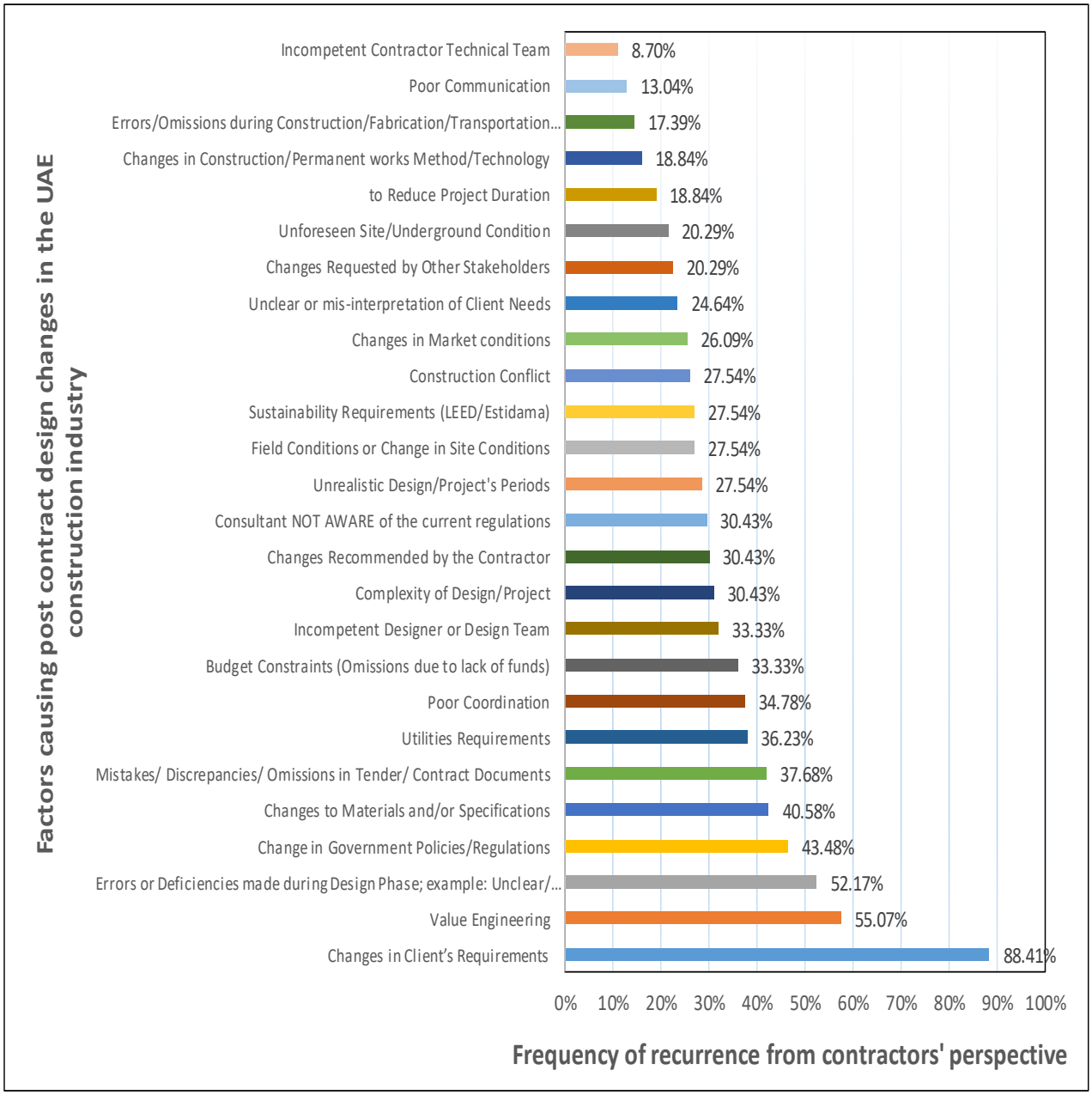
Figure 8 – Factors causing post contract design changes in the UAE construction industry from Consultants' perspective



4.6 FREQUENCY OF RECURRENCE OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES FROM CONTRACTORS' PERSPECTIVE

The factors causing post contract design changes in the UAE and their frequency of recurrence from Contractors' perspective are presented in Figure 9 where it is discovered

Figure 9 – Factors causing post contract design changes across the UAE from Contractors' perspective



“Changes in the Client’s requirements” is also the most recurred factor causing design changes in the UAE construction industry, as quoted by (88.41%) of the Contractors’ respondents; likewise “value Engineering” ranked second (55.07%), also “errors or deficiencies made during the design phase” ranked third (52.17%), “changes in Government Policies/Regulations” ranked fourth (43.48%), while “changes to materials and/or specifications” ranked fifth (40.58%). The least ranked factors were “Incompetent contractor technical team” (8.7%) and “poor communication” (13.04%).

Lastly, the other emergent factors were ranked: “budget constraints (Omissions due to lack of funds)” (33.33%), “changes recommended by the contractor” (30.43%), “sustainability requirements (LEED/ Estidama)” (27.54%) and “to reduce project duration” (18.84%).

4.7 RANKING OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES ACCORDING TO THEIR FREQUENCY OF RECURRENCE

The Table 12 compares the factors ranked in the previous sections (4.2) to (4.6) according to their frequency of recurrence across the projects in the UAE construction industry.

The Table 12 demonstrates a complete agreement amongst the consultants, the clients, and the contractors on the top four recurring factors causing post contract design changes in the UAE construction industry; “changes in the Client’s requirements” and the “Value Engineering” are ranked first and second respectively, while “Errors or deficiencies made during the design phase” and “change in Government Policies/Regulations” interchangeably ranked third and fourth.

Similarly, the least four ranked factors amongst the clients, consultants and contractors are “Errors/Omissions during construction/ Fabrication / Transportation Phase”, “Changes in Construction/Permanent works Method/Technology”, “Incompetent Contractor Technical Team” and “Poor communication”.

Table 12 –Ranking of the identified factors causing post contract design changes according to their frequency of recurrence

Rank	Global Rank	Rank from Clients' perspective	Rank from Consultants' perspective	Rank from Contractors' perspective
1	Changes in Client's Requirements	Changes in Client's Requirements	Changes in Client's Requirements	Changes in Client's Requirements
2	Value Engineering	Value Engineering	Value Engineering	Value Engineering
3	Errors or Deficiencies made during Design Phase	Change in Government Policies/Regulations	Change in Government Policies/Regulations	Errors or Deficiencies made during Design Phase
4	Change in Government Policies/Regulations	Errors or Deficiencies made during Design Phase	Errors or Deficiencies made during Design Phase	Change in Government Policies/Regulations
5	Poor Coordination	Changes Requested by Other Stakeholders	Changes Requested by Other Stakeholders	Changes to Materials and/or Specifications
6	Utilities Requirements	Poor Coordination	Poor Coordination	Mistakes/Discrepancies/Omissions in Design/Tender/Contract Documents
7	Mistakes/Discrepancies/Omissions in Design/Tender/Contract Documents	Utilities Requirements	Utilities Requirements	Utilities Requirements
8	Changes Requested by Other Stakeholders	Incompetent Designer or Design Team	Incompetent Designer or Design Team	Poor Coordination
9	Changes to Materials and/or Specifications	Consultant NOT AWARE of the current regulations	Consultant NOT AWARE of the current regulations	Budget Constraints (Omissions due to lack of funds)
10	Complexity of Design/Project	Mistakes/Discrepancies/Omissions in Design/Tender/Contract Documents	Mistakes/Discrepancies/Omissions in Design/Tender/Contract Documents	Incompetent Designer or Design Team
11	Incompetent Designer or Design Team	Complexity of Design/Project	Complexity of Design/Project	Complexity of Design/Project
12	Budget Constraints (Omissions due to lack of funds)	Changes to Materials and/or Specifications	Changes to Materials and/or Specifications	Changes Recommended by the Contractor
13	Consultant NOT AWARE of the current regulations	Changes Recommended by the Contractor	Changes Recommended by the Contractor	Consultant NOT AWARE of the current regulations
14	Changes Recommended by the Contractor	Sustainability Requirements (LEED/Estidama)	Sustainability Requirements (LEED/Estidama)	Unrealistic Design/Project's Periods
15	Changes in Market conditions	Unrealistic Design/Project's Periods	Unrealistic Design/Project's Periods	Field Conditions or Change in Site Conditions
16	Unrealistic Design/Project's Periods	Unclear or mis-interpretation of Client Needs	Unclear or mis-interpretation of Client Needs	Sustainability Requirements (LEED/Estidama)
17	Sustainability Requirements (LEED/Estidama)	Changes in Market conditions	Changes in Market conditions	Construction Conflict
18	Field Conditions or Change in Site Conditions	Field Conditions or Change in Site Conditions	Field Conditions or Change in Site Conditions	Changes in Market conditions
19	Unclear or mis-interpretation of Client Needs	Budget Constraints (Omissions due to lack of funds)	Budget Constraints (Omissions due to lack of funds)	Unclear or mis-interpretation of Client Needs
20	Unforeseen Site/Underground Condition	Unforeseen Site/Underground Condition	Unforeseen Site/Underground Condition	Changes Requested by Other Stakeholders
21	Construction Conflict	Construction Conflict	Construction Conflict	Unforeseen Site/Underground Condition
22	to Reduce Project Duration	to Reduce Project Duration	to Reduce Project Duration	to Reduce Project Duration
23	Errors/Omissions during Construction/Fabrication/Transportation Phase	Errors/Omissions during Construction/Fabrication/Transportation Phase	Errors/Omissions during Construction/Fabrication/Transportation Phase	Changes in Construction/Permanent works Method/Technology
24	Changes in Construction/Permanent works Method/Technology	Incompetent Contractor Technical Team	Incompetent Contractor Technical Team	Errors/Omissions during Construction/Fabrication/Transportation Phase
25	Incompetent Contractor Technical Team	Changes in Construction/Permanent works Method/Technology	Changes in Construction/Permanent works Method/Technology	Poor Communication
26	Poor Communication	Poor Communication	Poor Communication	Incompetent Contractor Technical Team

The remaining factors ranked interchangeably from fifth to twenty second place from the different participants' perspectives.

4.8 RANKING OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES ACCORDING TO THE IMPACT ON THE TIME, ON THE COST AND ON THE QUALITY

The Project Management Institute (2008, pp. 93-102) mandates the establishment of an integrated change control system to manage the changes in a project, including the post contract design changes, according to the caused impact on time to completion, cost and quality of the works, and update the associated baselines to reflect the changes. Hence, it is necessary to calculate the average impact for each factor and rank the identified factors according to the impact indices of the caused changes on the time, cost and quality as to identify what lessons the construction professionals in the UAE can learn to reduce the negative impact on the projects' time to completion, cost and quality in their current and future projects.

The Impact Indices of the caused changes on the time(II_T), cost (II_C) and quality (II_Q) are calculated using **(Equation 2)**, **(Equation 3)** and **(Equation 4)** from different perspectives:

- ✓ For all participants.
- ✓ From clients', consultants' and contractors' perspective.
- ✓ For diverse types of projects.
- ✓ For diverse types of contracts.

The Table 13 illustrates the ranking of the identified factors causing post contract design changes according to their Impact Indices on the time (II_T), cost (II_C) and quality (II_Q) for

Table 13 - Ranking of the identified factors causing post contract design changes according to their Impact Indices on the time (II_T), cost (II_C) and quality (II_Q).

Rank	Ranking according to the design changes' impact on the time			Ranking according to the design changes' impact on the cost			Ranking according to the design changes' impact on the quality		
	Factor causing post contract design changes	Mean	II_T	Factor causing post contract design changes	Mean	II_C	Factor causing post contract design changes	Mean	II_Q
1	Changes in Client's Requirements	-1.94	-115.33	Changes in Client's Requirements	-1.43	-84.67	Unforeseen Site/Underground Condition	-0.33	-58.67
2	Utilities Requirements	-1.64	-52.67	Changes Requested by Other Stakeholders	-1.39	-34.67	Sustainability Requirements (LEED/Estidama)	0.58	-49.67
3	Changes Requested by Other Stakeholders	-1.73	-43.33	Change in Government Policies/Regulations	-1.26	-32.00	Changes in Construction/ Permanent Works Method/ Technology	-0.10	-45.33
4	Change in Government Policies/Regulations	-1.41	-41.33	Utilities Requirements	-1.51	-27.33	Change in Government Policies/Regulations	0.00	-36.33
5	Budget Constraints (Omissions due to lack of funds)	-0.98	-34.67	Unclear or mis-interpretation of Client Needs	-1.45	-23.67	Changes to Materials and/or Specifications	0.14	-30.33
6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.57	-32.00	Unrealistic Design/Project's Periods	-1.27	-23.33	Poor Coordination	-1.14	-30.00
7	Unrealistic Design/Project's Periods	-1.64	-30.00	Complexity of Design/Project	-0.91	-19.67	Errors or Deficiencies made during Design Phase	-0.77	-27.67
8	Field conditions or Change in Site Conditions	-0.96	-29.33	Unforeseen Site/Underground Condition	-1.40	-18.00	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.39	-25.33
9	Complexity of Design/Project	-1.28	-27.67	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.61	-16.33	Poor Communication	-0.95	-24.33
10	Unclear or mis-interpretation of Client Needs	-1.55	-25.33	Changes in Market Conditions	-0.86	-16.00	Field conditions or Change in Site Conditions	-0.38	-23.33
11	Changes in Market Conditions	-1.30	-24.33	Field conditions or Change in Site Conditions	-0.96	-15.33	Consultant NOT AWARE of the Current Regulations	-0.78	-19.33
12	Poor Communication	-1.40	-23.67	Reduce Project Duration	-1.10	-14.67	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.64	-16.67
13	Incompetent Designer or Design Team	-1.82	-23.33	Changes to Materials and/or Specifications	-1.07	-13.67	Incompetent Contractor Technical Team	-1.58	-12.67
14	Changes in Construction/ Permanent Works Method/ Technology	-0.52	-21.00	Incompetent Contractor Technical Team	-1.31	-12.00	Reduce Project Duration	-0.90	-12.00
15	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.00	-19.67	Incompetent Designer or Design Team	-1.60	-10.67	Changes in Client's Requirements	-0.19	-11.00
16	Poor Coordination	-1.77	-16.00	Poor Coordination	-1.48	-8.67	Unrealistic Design/Project's Periods	-0.58	-10.67
17	Incompetent Contractor Technical Team	-1.92	-14.67	Poor Communication	-0.95	-7.33	Utilities Requirements	-0.16	-10.33
18	Value Engineering	-0.34	-12.67	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.68	-7.00	Construction Conflict	-0.37	-9.33
19	Changes to Materials and/or Specifications	-1.10	-11.33	Sustainability Requirements (LEED/Estidama)	-1.45	-6.33	Changes in Market Conditions	-0.46	-8.67
20	Construction Conflict	-1.19	-7.00	Changes in Construction/ Permanent Works Method/ Technology	-0.52	-5.00	Unclear or mis-interpretation of Client Needs	-0.45	-7.33
21	Sustainability Requirements (LEED/Estidama)	-1.36	-6.33	Construction Conflict	-0.91	-4.00	Complexity of Design/Project	-0.32	-7.00
22	Unforeseen Site/Underground Condition	-1.56	0.33	Budget Constraints (Omissions due to lack of funds)	0.02	-3.67	Changes Requested by Other Stakeholders	-0.15	-3.67
23	Errors or Deficiencies made during Design Phase	-1.73	5.67	Consultant NOT AWARE of the Current Regulations	-1.49	-1.33	Value Engineering	-0.04	-1.33
24	Reduce Project Duration	0.45	6.00	Errors or Deficiencies made during Design Phase	-1.55	-0.33	Changes recommended by the Contractor	-0.02	-0.33
25	Changes recommended by the Contractor	0.39	7.33	Changes recommended by the Contractor	0.30	5.67	Incompetent Designer or Design Team	-0.82	6.00
26	Consultant NOT AWARE of the Current Regulations	-1.54	30.00	Value Engineering	0.80	30.00	Budget Constraints (Omissions due to lack of funds)	-0.92	7.33

the entire studied sample, where the rank varies from 1 to 26. The rank 1 represents the factor causing design changes with maximum delays, cost overrun and decline in the quality while highest rank represents the factor causing design changes with maximum acceleration, cost saving and improvement to the quality. Likewise, the means of the impacts on the time, cost and quality are calculated for every factor for tentatively representing the range of the impact on the time, cost and quality as per the guidelines of the Table 30, included in Annex 1.

4.8.1 IMPACT ON TIME (II_T) AND COST (II_C)

In the aggregate, the calculated means shown in the Table 13 reveal that, no one factor causing design changes is producing major delays or major accelerations (more than 20%); likewise for the cost impact. Design changes caused by the majority of the factors are causing minor to medium delays and cost overrun (less than 20%). However, in the individual responses large amount of respondents has reported major delays and major cost overruns for the design changes caused by the top ten factors.

The design changes caused by the "changes in Clients' requirements" occupy the top of the factors' list, incurring medium delays to time to completion and medium cost overrun. The design changes caused by "utilities' requirements" rank second in terms of impact on the time (15% to 20% delays), fourth in terms of cost overrun (10% to 15%). The design changes caused by "Changes Requested by Other Stakeholders" ranked third in impacting the time (10% to 20%), second in terms of cost overrun (10% to 20%). The design changes caused by "Change in Government Policies/Regulations" ranked fourth in incurring medium delays (10% to 20%), third in terms of cost overrun (10% to 20%), while design changes caused by "Budget Constraints (Omissions due to lack of funds)" ranked fifth in the impact on the time (less than 10% delay) *with no remarkable improvement on the cost*.

The design changes caused by “Mistakes/ Discrepancies/ Omissions in Tender/ Contract Documents” ranked sixth with medium impact on the time; ninth in impacting the cost (medium cost overrun); design changes caused by “Unrealistic Design/Project's Periods” ranked seventh in causing medium delays and sixth in causing minor cost overrun. The design changes caused by “Field conditions or Change in Site Conditions” ranked eighth in causing minor delays and eleventh in causing minor cost overrun, while the design changes caused by “Complexity of Design/Project” ranked ninth in causing minor delays and seventh in causing minor cost overrun.

The design changes caused by “Unclear or misinterpretation of Client Needs” ranked tenth in causing medium delays and fifth in causing medium cost overrun. The design changes caused by “Changes in Market Conditions” ranked eleventh in causing minor delays and tenth in causing minor cost overrun.

However, design changes caused by other factors are ranking less in causing delays and cost overrun, but their impact is considerable. Design changes caused by “Poor communication”, “Poor coordination”, “Incompetent Designer or Design Team”, “Incompetent Contractor Technical Team”, “Consultant NOT AWARE of the Current Regulations”, “Sustainability Requirements (LEED/Estidama)”, “Unforeseen Site/Underground Condition” and “Errors or Deficiencies made during Design Phase” are causing medium delays and medium cost overrun.

Similarly, the design changes caused by “Changes in Construction/ Permanent Works Method/Technology”, “Errors/ Omissions during Construction/ Fabrication/Transportation Phase”, “Changes to Materials and/or Specifications” and “Construction Conflict” are ranking less in the list, but they are causing minor delays and minor cost overrun.

At the bottom of the list, the design changes caused by “Reduce Project Duration” are causing minor cost overrun and the design changes caused by “Changes recommended by the Contractor” are causing minor cost saving. Design changes caused by both factors are showing to cause minor acceleration to the projects. The design changes caused by the “value engineering” are showing to cause minor cost saving with minor delays.

4.8.2 IMPACT ON QUALITY (II_Q)

The Table 13 reveals that design changes caused by the majority of the factors are causing minor decline in the quality and some time with no remarkable impact, except design changes caused by “Incompetent Contractor Technical Team” are causing medium decline in the quality while design changes caused by “Sustainability Requirements (LEED/ Estidama)” are causing minor improvement to the quality.

The design changes caused by the “Unforeseen Site/Underground Condition” is ranking as the top factor in declining the quality; the design changes caused by the “Sustainability Requirements (LEED/Estidama)” is ranking the top factor in causing improvement to the quality. The design changes caused by “Changes in Construction/ Permanent Works Method/Technology”, “Change in Government Policies/Regulations”, “Changes to Materials and/or Specifications”, “Poor Coordination”, “Errors or Deficiencies made during Design Phase”, “Errors/Omissions during Construction/ Fabrication/ Transportation Phase”, “Poor Communication” and “Field conditions or Change in Site Conditions” ranked from third to tenth respectively in order.

The design changes caused by the “Consultant NOT AWARE of the Current Regulations”, “Mistakes/Discrepancies/Omissions in Tender/ Contract Documents”, “Incompetent Contractor Technical Team”, “Reduce Project Duration”, “Changes in the Client's Requirements”, “Unrealistic Design/Project's Periods”, “Utilities Requirements“,

"Construction Conflict", "Changes in Market Conditions", "Unclear or misinterpretation of Client Needs", "Complexity of Design/Project", "Changes Requested by Other Stakeholders", "Value Engineering", "Changes recommended by the Contractor", "Incompetent Designer or Design Team" and "Budget Constraints (Omissions due to lack of funds)" ranked from the eleventh to twenty sixth respectively in order.

4.9 RANKING OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES ACCORDING TO THE IMPACT ON THE TIME, COST AND QUALITY FROM CLIENTS', CONSULTANTS' AND CONTRACTORS' PERSPECTIVE

The identified factors causing post contract design changes are analyzed using the impact indices on the time($\mathbf{II_T}$), cost ($\mathbf{II_C}$) and quality ($\mathbf{II_Q}$) similarly to what was done in section (4.8) to rank them according to the impact of such design changes on the time, cost and quality, and presented from Clients', Consultants' and Contractors' perspective.

The individual rankings of the design changes' impact on the time, cost and quality obtained for the different factors are compared to each other and presented separately for the caused changes' impact on the time (Table 14), the cost (Table 15) and the quality (Table 16).

The calculated Impact Indices on the time($\mathbf{II_T}$), cost ($\mathbf{II_C}$) and quality ($\mathbf{II_Q}$) are sometimes equal for different factors within each category of business; therefore the associated ranks are considered also equal.

In the following sections, the researcher compares the top ten factors against the individual global rank (in the entire sample); the least factors are also exposed.

4.9.1 IMPACT ON THE TIME ($\mathbf{II_T}$)

The Table 14 reveals "Changes in the Client's Requirements" ranked first among clients, consultants and contractors. Clients and contractors ranked "Utilities Requirements" second

(same as global rank) while consultants ranked third. “Changes Requested by Other Stakeholders” globally ranked third, also ranked third by clients, second by consultants and eighth by contractors. “Change in Government Policies/Regulations” globally ranked fourth, ranked fourth by consultants, fifth by clients and third by contractors. “Budget Constraints (Omissions due to lack of funds)” globally ranked fifth, also ranked fifth by clients, forth by consultants and tenth by contractors.

The “Mistakes/Discrepancies/Omissions in Tender/Contract Documents” globally ranked sixth, also ranked sixth by contractors, forth by clients and tenth by consultants. The “Unrealistic Design/Project's Periods” globally ranked seventh, also ranked seventh by contractors, and sixth by clients and consultants. The “Field Conditions or Change in Site Conditions” globally ranked eighth, ranked twelfth by consultants, and fifth by clients and contractors. The “Complexity of Design/Project” globally ranked ninth, ranked fifth by consultants, and seventh by clients and contractors. The “Unclear or misinterpretation of Client Needs” globally ranked tenth, ranked eighth by Clients, forth by contractors and ninth by consultants.

The least ranked factor was “Consultant NOT AWARE of the current regulations” globally ranked twenty sixth, ranked last (twentieth) by clients, consultants and contractors. Similarly, the factor “Changes Recommended by the Contractor” globally ranked twenty fifth, ranked eighteenth by clients, seventeenth by consultants and nineteenth by contractors. Likewise, the factor “to Reduce Project Duration” globally ranked twenty fourth, ranked nineteenth by clients, eighteenth by consultants and seventeenth by contractors.

Table 14 –Factors causing post contract design changes ranked according to their Impact Indices on the time (II_T) from Clients', Consultants' and Contractors' perspective

Ranking according from Clients' perspective				Ranking according from Consultants' perspective				Ranking according from Contractors' perspective			
Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T
1	Changes in Client's Requirements	-1.69	-34.33	1	Changes in Client's Requirements	-1.98	-37.67	1	Changes in Client's Requirements	-2.17	-43.33
2	Utilities Requirements	-1.31	-17.67	2	Changes Requested by Other Stakeholders	-1.96	-17.00	2	Utilities Requirements	-1.80	-18.67
3	Changes Requested by Other Stakeholders	-1.49	-17.33	3	Utilities Requirements	-1.96	-16.33	3	Change in Government Policies/Regulations	-1.72	-13.00
4	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.37	-17.00	4	Budget Constraints (Omissions due to lack of funds)	-0.71	-14.67	4	Unclear or mis-interpretation of Client Needs	-2.18	-12.33
5	Budget Constraints (Omissions due to lack of funds)	-0.53	-13.67	4	Change in Government Policies/Regulations	-1.52	-14.67	5	Poor Communication	-1.78	-12.00
5	Change in Government Policies/Regulations	-1.13	-13.67	5	Complexity of Design/Project	-1.75	-9.33	5	Field conditions or Change in Site Conditions	-0.94	-12.00
5	Field conditions or Change in Site Conditions	-0.79	-13.67	6	Unrealistic Design/Project's Periods	-1.77	-7.67	6	Incompetent Designer or Design Team	-1.86	-10.00
6	Unrealistic Design/Project's Periods	-1.70	-13.00	6	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.57	-7.67	6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.80	-10.00
7	Complexity of Design/Project	-0.96	-9.00	7	Changes in Market Conditions	-1.38	-7.33	7	Complexity of Design/Project	-1.33	-9.33
8	Unclear or mis-interpretation of Client Needs	-1.05	-7.67	7	Changes in Construction/ Permanent Works Method/ Technology	-0.75	-7.33	7	Changes in Market Conditions	-1.56	-9.33
8	Changes in Market Conditions	-1.05	-7.67	8	Incompetent Designer or Design Team	-2.13	-5.67	7	Unrealistic Design/Project's Periods	-1.47	-9.33
8	Incompetent Designer or Design Team	-1.71	-7.67	9	Unclear or mis-interpretation of Client Needs	-1.60	-5.33	8	Changes Requested by Other Stakeholders	-1.93	-9.00
9	Poor Communication	-0.88	-6.67	10	Poor Communication	-1.67	-5.00	9	Changes in Construction/ Permanent Works Method/ Technology	-0.38	-8.33
10	Incompetent Contractor Technical Team	-2.00	-6.33	10	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.60	-5.00	10	Budget Constraints (Omissions due to lack of funds)	-1.57	-6.33
11	Poor Coordination	-1.57	-6.00	11	Value Engineering	-0.44	-4.67	10	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.91	-6.33
12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.77	-5.67	11	Poor Coordination	-1.88	-4.67	11	Poor Coordination	-1.96	-5.33
12	Changes to Materials and/or Specifications	-0.81	-5.67	11	Incompetent Contractor Technical Team	-2.14	-4.67	12	Value Engineering	-0.32	-4.00
13	Changes in Construction/ Permanent Works Method/ Technology	-0.58	-5.33	12	Field conditions or Change in Site Conditions	-1.23	-3.67	13	Incompetent Contractor Technical Team	-1.50	-3.67
14	Value Engineering	-0.28	-4.00	13	Construction Conflict	-1.44	-3.33	14	Changes to Materials and/or Specifications	-1.43	-2.67
15	Sustainability Requirements (LEED/Estidama)	-1.00	-2.00	14	Changes to Materials and/or Specifications	-1.00	-3.00	15	Construction Conflict	-1.33	-2.33
16	Construction Conflict	-0.88	-1.33	15	Sustainability Requirements (LEED/Estidama)	-1.80	-2.00	15	Sustainability Requirements (LEED/Estidama)	-1.58	-2.33
17	Unforeseen Site/Underground Condition	-1.22	-0.33	16	Errors or Deficiencies made during Design Phase	-1.79	0.33	16	Unforeseen Site/Underground Condition	-1.86	-1.33
18	Changes recommended by the Contractor	0.00	0.00	17	Changes recommended by the Contractor	0.33	1.33	17	Reduce Project Duration	0.62	2.67
18	Errors or Deficiencies made during Design Phase	-1.66	0.00	18	Reduce Project Duration	0.42	1.67	18	Errors or Deficiencies made during Design Phase	-1.75	5.33
19	Reduce Project Duration	0.33	1.67	19	Unforeseen Site/Underground Condition	-1.69	2.00	19	Changes recommended by the Contractor	0.86	6.00
20	Consultant NOT AWARE of the Current Regulations	-1.67	9.00	20	Consultant NOT AWARE of the Current Regulations	-1.38	12.67	20	Consultant NOT AWARE of the Current Regulations	-1.43	8.33

4.9.2 IMPACT ON THE COST (II_C)

The Table 15 reveals “Changes in the Client’s Requirements” ranked first among clients, consultants and contractors. The “Changes Requested by Other Stakeholders” globally ranked second, also ranked second by clients and consultants, eighth by contractors. The “Change in Government Policies/Regulations” globally ranked third, also ranked third by clients and consultants, forth by contractors. The “Utilities Requirements” globally ranked fourth, also ranked fourth by clients and consultants, fifth by contractors. The “Unclear or misinterpretation of Client Needs” globally ranked fifth, ranked seventh by Clients and consultants, second by contractors.

The “Unrealistic Design/Project's Periods” globally ranked sixth, also ranked sixth by clients and consultants, third by contractors. The “Complexity of Design/Project” globally ranked seventh, ranked tenth by clients, fifth by consultants and eighth by contractors. The “Unforeseen Site/Underground condition” globally ranked eighth, ranked fourteenth by clients, fifth by consultants and contractors. The “Mistakes/Discrepancies/Omissions in Tender/Contract Documents” globally ranked ninth, ranked fifth by clients, fourteenth by consultants and ninth by contractors. The “Changes in Market Conditions” globally ranked tenth, ranked ninth by clients and contractors, and eighth by consultants.

The factor “Value Engineering” globally top ranked in causing cost saving, also top ranked by clients, consultants and contractors in causing minor cost saving. Similarly, The “Changes recommended by the contractor” globally ranked second in causing cost saving, also ranked second by clients and consultants in causing minor cost saving, while it ranked third by contractors with no remarkable cost saving.

Table 15 - Factors causing post contract design changes ranked according to their Impact Indices on the cost (II_C) from Clients', Consultants' and Contractors' perspective

Ranking according from Clients' perspective				Ranking according from Consultants' perspective				Ranking according from Contractors' perspective			
Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C
1	Changes in Client's Requirements	-0.95	-19.33	1	Changes in Client's Requirements	-1.58	-30.00	1	Changes in Client's Requirements	-1.77	-35.33
2	Changes Requested by Other Stakeholders	-1.17	-13.67	2	Changes Requested by Other Stakeholders	-1.69	-14.67	2	Unclear or mis-interpretation of Client Needs	-2.12	-12.00
3	Change in Government Policies/Regulations	-0.98	-11.67	3	Change in Government Policies/Regulations	-1.29	-11.00	3	Unrealistic Design/Project's Periods	-1.58	-10.00
4	Utilities Requirements	-1.26	-11.33	4	Utilities Requirements	-1.78	-8.00	4	Change in Government Policies/Regulations	-1.62	-9.33
5	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.60	-10.67	5	Complexity of Design/Project	-1.44	-7.67	5	Unforeseen Site/Underground Condition	-1.79	-8.00
6	Unrealistic Design/Project's Periods	-1.00	-7.67	5	Unforeseen Site/Underground Condition	-1.69	-7.67	5	Utilities Requirements	-1.60	-8.00
6	Field conditions or Change in Site Conditions	-0.68	-7.67	6	Unrealistic Design/Project's Periods	-1.31	-5.67	6	Field conditions or Change in Site Conditions	-1.00	-7.00
7	Unclear or mis-interpretation of Client Needs	-0.91	-6.67	7	Unclear or mis-interpretation of Client Needs	-1.50	-5.00	7	Incompetent Designer or Design Team	-1.43	-6.67
8	Reduce Project Duration	-1.27	-6.33	7	Changes to Materials and/or Specifications	-0.74	-5.00	8	Changes Requested by Other Stakeholders	-1.36	-6.33
8	Changes to Materials and/or Specifications	-0.88	-6.33	8	Changes in Market Conditions	-0.88	-4.67	8	Complexity of Design/Project	-0.90	-6.33
9	Changes in Market Conditions	-0.82	-6.00	8	Reduce Project Duration	-1.17	-4.67	9	Changes in Market Conditions	-0.89	-5.33
10	Complexity of Design/Project	-0.61	-5.67	9	Incompetent Contractor Technical Team	-1.29	-3.67	9	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.56	-5.33
11	Incompetent Contractor Technical Team	-1.31	-4.00	10	Budget Constraints (Omissions due to lack of funds)	0.35	-2.33	10	Poor Communication	-0.78	-5.00
12	Incompetent Designer or Design Team	-1.65	-3.33	10	Poor Coordination	-1.69	-2.33	11	Incompetent Contractor Technical Team	-1.33	-4.33
13	Poor Coordination	-1.17	-3.00	11	Sustainability Requirements (LEED/Estidama)	-1.30	-1.67	12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.64	-4.00
14	Unforeseen Site/Underground Condition	-0.89	-2.33	12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.43	-1.33	13	Reduce Project Duration	-0.85	-3.67
15	Budget Constraints (Omissions due to lack of funds)	-0.05	-1.67	12	Poor Communication	-2.00	-1.33	13	Changes in Construction/ Permanent Works Method/ Technology	-0.23	-3.67
15	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.31	-1.67	12	Consultant NOT AWARE of the Current Regulations	-1.38	-1.33	14	Poor Coordination	-1.70	-3.33
15	Sustainability Requirements (LEED/Estidama)	-1.21	-1.67	12	Construction Conflict	-1.11	-1.33	15	Sustainability Requirements (LEED/Estidama)	-1.84	-3.00
16	Construction Conflict	-0.75	-1.33	13	Incompetent Designer or Design Team	-1.88	-0.67	16	Consultant NOT AWARE of the Current Regulations	-1.71	-2.67
17	Errors or Deficiencies made during Design Phase	-1.39	-1.00	13	Field conditions or Change in Site Conditions	-1.31	-0.67	17	Changes to Materials and/or Specifications	-1.46	-2.33
17	Poor Communication	-0.75	-1.00	13	Changes in Construction/ Permanent Works Method/ Technology	-0.75	-0.67	18	Construction Conflict	-0.94	-1.33
18	Changes in Construction/ Permanent Works Method/ Technology	-0.75	-0.67	14	Errors or Deficiencies made during Design Phase	-1.75	-0.33	19	Budget Constraints (Omissions due to lack of funds)	-0.17	0.33
19	Changes recommended by the Contractor	0.00	0.00	14	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.70	-0.33	20	Changes recommended by the Contractor	0.76	5.33
20	Consultant NOT AWARE of the Current Regulations	-1.37	2.67	15	Changes recommended by the Contractor	0.08	0.33	20	Errors or Deficiencies made during Design Phase	-1.56	1.00
21	Value Engineering	0.63	9.00	16	Value Engineering	1.19	12.67	21	Value Engineering	0.68	8.33

4.9.3 IMPACT ON THE QUALITY (II_Q)

The Table 16 reveals that the “Unforeseen Site/Underground Condition” globally ranked first in causing a decline in the quality also ranked first among clients, consultants and contractors. The “Sustainability Requirements (LEED/Estidama” globally ranked second in causing minor improvement to the quality, also ranked second by clients, consultants and by contractors. The “Change in Construction/ Permanent Works Method/Technology” globally ranked third, ranked also third by consultants and contractors, fifth by clients.

The “Change in Government Policies/Regulations” globally ranked fourth, ranked third by clients and contractors, seventh by consultants. The “Changes to Materials and/or Specifications” globally ranked fifth, ranked fourth by clients, twelfth by consultants and sixth by contractors. The “Poor coordination” globally ranked sixth, also ranked sixth by clients, fifth by consultants and seventh by contractors. The “Errors or Deficiencies made during Design phase” globally ranked seventh, also ranked seventh by clients and contractors, forth by consultants. The “Errors/ Omissions during Construction/ Fabrication/ Transportation Phase” globally ranked eighth, also ranked eighth by consultants, ninth by clients and forth by contractors. The “Poor communication” globally ranked ninth, also ranked ninth by clients, sixth by consultants and seventh by contractors. The “Field conditions or change in site conditions” globally ranked tenth, also ranked tenth by clients, sixth by consultants and eighth by contractors.

The factors “Budget Constraints (Omissions due to lack of funds” and “Incompetent Designer or Design Team” globally ranked lowest, also ranked lowest among clients, consultants and contractors.

Table 16 - Factors causing post contract design changes ranked according to their Impact Indices on the quality (II_Q) from Clients', Consultants' and Contractors' perspective

Ranking according from Clients' perspective				Ranking according from Consultants' perspective				Ranking according from Contractors' perspective			
Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q
1	Unforeseen Site/Underground Condition	-0.11	-21.00	1	Unforeseen Site/Underground Condition	-0.15	-16.67	1	Unforeseen Site/Underground Condition	-0.79	-21.00
2	Sustainability Requirements (LEED/Estidama)	0.46	-18.33	2	Sustainability Requirements (LEED/Estidama)	0.90	-16.33	2	Sustainability Requirements (LEED/Estidama)	0.58	-15.00
3	Change in Government Policies/Regulations	-0.08	-17.67	3	Changes in Construction/ Permanent Works Method/ Technology	-0.25	-15.00	2	Changes in Construction/ Permanent Works Method/ Technology	-0.08	-15.00
4	Changes to Materials and/or Specifications	0.15	-16.67	4	Errors or Deficiencies made during Design Phase	-0.75	-9.33	3	Change in Government Policies/Regulations	-0.03	-13.00
5	Changes in Construction/ Permanent Works Method/ Technology	-0.08	-15.33	5	Poor Coordination	-1.27	-7.67	4	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.36	-12.33
6	Poor Coordination	-1.00	-13.00	6	Poor Communication	-1.67	-7.33	5	Consultant NOT AWARE of the Current Regulations	-1.00	-12.00
7	Errors or Deficiencies made during Design Phase	-0.89	-9.00	6	Field conditions or Change in Site Conditions	-0.62	-7.33	6	Changes to Materials and/or Specifications	0.07	-10.00
8	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.50	-8.67	7	Changes in Client's Requirements	-0.30	-5.67	7	Errors or Deficiencies made during Design Phase	-0.67	-9.33
9	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.31	-7.67	7	Change in Government Policies/Regulations	0.19	-5.67	7	Poor Communication	-1.00	-9.33
9	Poor Communication	-0.63	-7.67	8	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.57	-5.33	7	Poor Coordination	-1.22	-9.33
10	Field conditions or Change in Site Conditions	-0.26	-7.33	9	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.65	-5.00	8	Field conditions or Change in Site Conditions	-0.33	-8.67
11	Reduce Project Duration	-0.80	-4.00	10	Incompetent Contractor Technical Team	-2.14	-4.67	9	Unrealistic Design/Project's Periods	-1.05	-6.67
11	Incompetent Contractor Technical Team	-1.46	-4.00	11	Consultant NOT AWARE of the Current Regulations	-0.25	-4.00	10	Changes in Client's Requirements	-0.27	-5.33
12	Consultant NOT AWARE of the Current Regulations	-0.77	-3.33	12	Reduce Project Duration	-0.92	-3.67	10	Construction Conflict	-0.39	-5.33
12	Unrealistic Design/Project's Periods	-0.43	-3.33	12	Utilities Requirements	-0.17	-3.67	11	Unclear or mis-interpretation of Client Needs	-0.88	-5.00
12	Utilities Requirements	-0.11	-3.33	12	Changes to Materials and/or Specifications	0.21	-3.67	12	Reduce Project Duration	-1.00	-4.33
13	Changes in Market Conditions	-0.41	-3.00	13	Changes Requested by Other Stakeholders	-0.27	-2.33	13	Complexity of Design/Project	-0.57	-4.00
14	Construction Conflict	-0.19	-2.33	13	Changes in Market Conditions	-0.44	-2.33	13	Incompetent Contractor Technical Team	-1.17	-4.00
15	Complexity of Design/Project	-0.18	-1.67	14	Construction Conflict	-0.67	-1.67	14	Changes in Market Conditions	-0.56	-3.33
15	Changes Requested by Other Stakeholders	-0.14	-1.67	15	Complexity of Design/Project	-0.25	-1.33	14	Utilities Requirements	-0.20	-3.33
16	Changes recommended by the Contractor	-0.13	-1.00	15	Unclear or mis-interpretation of Client Needs	-0.40	-1.33	15	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.80	-3.00
16	Unclear or mis-interpretation of Client Needs	-0.14	-1.00	15	Value Engineering	-0.13	-1.33	16	Value Engineering	-0.21	-2.67
17	Budget Constraints (Omissions due to lack of funds)	-0.37	0.00	16	Unrealistic Design/Project's Periods	-0.15	-0.67	17	Changes Requested by Other Stakeholders	0.07	0.33
17	Changes in Client's Requirements	0.00	0.00	17	Changes recommended by the Contractor	-0.08	-0.33	18	Changes recommended by the Contractor	0.14	1.00
18	Incompetent Designer or Design Team	-1.03	1.67	18	Budget Constraints (Omissions due to lack of funds)	-1.35	1.33	19	Incompetent Designer or Design Team	-0.76	2.67
19	Value Engineering	0.19	2.67	19	Incompetent Designer or Design Team	-0.13	1.67	20	Budget Constraints (Omissions due to lack of funds)	-1.04	6.00

4.10 RANKING OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES ACCORDING TO THE IMPACT ON THE TIME, COST AND QUALITY IN RESIDENTIAL, COMMERCIAL, MIX USE, HOTELS, INDUSTRIAL AND INFRASTRUCTURE PROJECTS

The identified factors causing post contract design changes are sorted according to the impact indices on the time($\mathbf{II_T}$), cost ($\mathbf{II_C}$) and quality ($\mathbf{II_Q}$), in different types of projects:

- ✓ The Table 17 illustrates the post contract design changes according to their impact on the time($\mathbf{II_T}$) in residential, commercial projects and mix-use projects.
- ✓ The Table 18 illustrates the post contract design changes according to their impact on the time($\mathbf{II_T}$) in hotels, industrial and infrastructure projects.
- ✓ The Table 19 illustrates the post contract design changes according to their impact on the cost ($\mathbf{II_C}$) in residential, commercial projects and mix-use projects.
- ✓ The Table 20 illustrates the post contract design changes according to their impact on the cost ($\mathbf{II_C}$) in hotels, industrial and infrastructure projects.
- ✓ The Table 21 illustrates the post contract design changes according to their impact on the quality ($\mathbf{II_Q}$) in residential, commercial projects and mix-use projects.
- ✓ The Table 22 illustrates the post contract design changes according to their impact on the quality ($\mathbf{II_Q}$) in hotels, industrial and infrastructure projects.

Table 17 - Factors causing post contract design changes ranked according to the impact on the time (II_T) in residential, commercial and mix-use projects

Ranking in Residential Projects				Ranking in Commercial Projects				Ranking in Mix Use Projects			
Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T
1	Changes in Client's Requirements	-2.03	-27.00	1	Changes in Client's Requirements	-1.72	-18.33	1	Changes in Client's Requirements	-2.14	-42.00
2	Utilities Requirements	-1.80	-13.00	2	Changes Requested by Other Stakeholders	-1.65	-9.33	2	Utilities Requirements	-1.74	-18.00
3	Change in Government Policies/Regulations	-1.72	-10.67	3	Utilities Requirements	-1.53	-8.33	3	Changes Requested by Other Stakeholders	-2.00	-14.00
4	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.80	-8.67	4	Budget Constraints (Omissions due to lack of funds)	-0.78	-8.00	4	Budget Constraints (Omissions due to lack of funds)	-0.96	-12.00
5	Unrealistic Design/Project's Periods	-1.47	-8.00	5	Change in Government Policies/Regulations	-1.76	-6.00	4	Change in Government Policies/Regulations	-1.35	-12.00
6	Changes Requested by Other Stakeholders	-1.93	-7.33	6	Complexity of Design/Project	-1.13	-5.67	5	Changes in Market Conditions	-1.30	-11.67
7	Poor Coordination	-1.96	-7.00	7	Unrealistic Design/Project's Periods	-1.75	-4.67	5	Field conditions or Change in Site Conditions	-0.93	-11.67
8	Unclear or mis-interpretation of Client Needs	-2.18	-6.67	8	Field conditions or Change in Site Conditions	-0.88	-4.33	6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.40	-11.33
8	Incompetent Designer or Design Team	-1.86	-6.67	8	Changes in Construction/ Permanent Works Method/ Technology	-1.33	-4.33	7	Poor Coordination	-1.60	-10.33
9	Changes in Market Conditions	-1.56	-6.33	9	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.50	-4.00	8	Incompetent Contractor Technical Team	-1.55	-9.67
10	Complexity of Design/Project	-1.33	-5.67	10	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.56	-3.67	9	Unclear or mis-interpretation of Client Needs	-1.27	-9.33
10	Poor Communication	-1.78	-5.67	11	Incompetent Designer or Design Team	-2.33	-3.33	10	Unrealistic Design/Project's Periods	-1.44	-8.67
11	Budget Constraints (Omissions due to lack of funds)	-1.57	-5.33	12	Changes in Market Conditions	-1.00	-3.00	11	Complexity of Design/Project	-1.09	-8.33
11	Field conditions or Change in Site Conditions	-0.94	-5.33	12	Poor Communication	-1.67	-3.00	11	Poor Communication	-1.33	-8.33
12	Value Engineering	-0.32	-4.00	13	Unclear or mis-interpretation of Client Needs	-1.14	-2.67	12	Incompetent Designer or Design Team	-1.58	-7.00
12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.91	-4.00	14	Construction Conflict	-1.00	-1.33	13	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.09	-6.33
13	Changes in Construction/ Permanent Works Method/ Technology	-0.38	-3.67	15	Incompetent Contractor Technical Team	-2.33	-1.00	14	Changes in Construction/ Permanent Works Method/ Technology	-0.62	-5.33
14	Changes to Materials and/or Specifications	-1.43	-2.33	16	Unforeseen Site/Underground Condition	-1.44	-0.67	15	Changes to Materials and/or Specifications	-1.17	-4.67
15	Sustainability Requirements (LEED/Estidama)	-1.58	-2.00	16	Changes to Materials and/or Specifications	-1.08	-0.67	16	Value Engineering	-0.14	-2.00
16	Incompetent Contractor Technical Team	-1.50	-1.33	17	Sustainability Requirements (LEED/Estidama)	-1.57	-0.33	16	Construction Conflict	-1.10	-2.00
17	Unforeseen Site/Underground Condition	-1.86	-1.00	18	Value Engineering	0.00	0.00	17	Sustainability Requirements (LEED/Estidama)	-1.28	-1.67
18	Construction Conflict	-1.33	0.00	19	Errors or Deficiencies made during Design Phase	-1.53	0.33	18	Changes recommended by the Contractor	-0.05	-0.33
19	Errors or Deficiencies made during Design Phase	-1.75	1.33	19	Poor Coordination	-1.91	0.33	19	Unforeseen Site/Underground Condition	-1.55	0.33
20	Reduce Project Duration	0.62	1.67	20	Changes recommended by the Contractor	0.36	1.67	20	Reduce Project Duration	0.47	2.67
21	Changes recommended by the Contractor	0.86	3.33	21	Reduce Project Duration	1.50	2.00	20	Errors or Deficiencies made during Design Phase	-1.76	2.67
22	Consultant NOT AWARE of the Current Regulations	-1.43	4.67	22	Consultant NOT AWARE of the Current Regulations	-1.88	6.33	21	Consultant NOT AWARE of the Current Regulations	-1.68	13.00

Table 18 - Factors causing post contract design changes ranked according to the impact on the time (II_T) in Hotels, Industrial and Infrastructure projects

Ranking in Hotels' Projects				Ranking in Industrial Projects				Ranking in Infrastructure Projects			
Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T
1	Changes in Client's Requirements	-1.44	-4.33	1	Changes in Client's Requirements	-2.43	-5.67	1	Changes in Client's Requirements	-1.74	-18.00
2	Changes Requested by Other Stakeholders	-1.67	-3.33	2	Changes in Construction/ Permanent Works Method/ Technology	0.00	-3.00	2	Utilities Requirements	-1.00	-10.00
3	Unrealistic Design/Project's Periods	-2.33	-2.33	3	Unclear or mis-interpretation of Client Needs	-2.67	-2.67	3	Change in Government Policies/Regulations	-1.00	-9.00
3	Budget Constraints (Omissions due to lack of funds)	-1.00	-2.33	4	Poor Communication	0.00	-2.00	4	Changes Requested by Other Stakeholders	-1.67	-8.33
3	Change in Government Policies/Regulations	-0.60	-2.33	4	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.33	-2.00	5	Complexity of Design/Project	-1.83	-7.33
4	Incompetent Designer or Design Team	-3.00	-2.00	4	Field conditions or Change in Site Conditions	-1.25	-2.00	6	Budget Constraints (Omissions due to lack of funds)	-0.14	-6.00
4	Utilities Requirements	-1.00	-2.00	5	Unrealistic Design/Project's Periods	-2.00	-1.33	7	Value Engineering	-0.94	-5.33
5	Value Engineering	-0.71	-1.67	5	Utilities Requirements	-3.00	-1.33	7	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.92	-5.33
6	Changes in Market Conditions	-1.00	-1.00	5	Change in Government Policies/Regulations	-2.00	-1.33	7	Field conditions or Change in Site Conditions	-1.00	-5.33
6	Incompetent Contractor Technical Team	-3.00	-1.00	6	Changes Requested by Other Stakeholders	-3.00	-1.00	8	Unrealistic Design/Project's Periods	-1.36	-5.00
6	Sustainability Requirements (LEED/Estidama)	-0.60	-1.00	6	Budget Constraints (Omissions due to lack of funds)	-1.50	-1.00	8	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.29	-5.00
6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.33	-1.00	7	Complexity of Design/Project	-2.00	-0.67	9	Poor Communication	-1.40	-4.00
6	Changes in Construction/ Permanent Works Method/ Technology	0.00	-1.00	7	Changes in Market Conditions	-2.00	-0.67	10	Incompetent Designer or Design Team	-1.90	-3.67
7	Unclear or mis-interpretation of Client Needs	-0.67	-0.67	7	Incompetent Designer or Design Team	-2.00	-0.67	10	Changes in Construction/ Permanent Works Method/ Technology	-0.50	-3.67
7	Reduce Project Duration	-0.67	-0.67	7	Incompetent Contractor Technical Team	-2.00	-0.67	11	Unclear or mis-interpretation of Client Needs	-2.00	-3.33
7	Poor Communication	-3.00	-0.67	7	Changes to Materials and/or Specifications	0.50	-0.67	11	Construction Conflict	-1.13	-3.33
7	Field conditions or Change in Site Conditions	0.00	-0.67	8	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.50	-0.33	12	Changes to Materials and/or Specifications	-0.92	-3.00
8	Changes recommended by the Contractor	0.00	0.00	8	Poor Coordination	-1.00	-0.33	13	Changes in Market Conditions	-2.50	-1.67
8	Complexity of Design/Project	0.00	0.00	8	Construction Conflict	-1.00	-0.33	14	Sustainability Requirements (LEED/Estidama)	-0.75	-1.33
8	Errors or Deficiencies made during Design Phase	-1.00	0.00	9	Unforeseen Site/Underground Condition	-1.33	0.00	15	Incompetent Contractor Technical Team	-2.00	-1.00
8	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	0.00	0.00	9	Sustainability Requirements (LEED/Estidama)	-1.00	0.00	16	Reduce Project Duration	-0.20	-0.33
8	Unforeseen Site/Underground Condition	-1.50	0.00	10	Value Engineering	0.33	0.33	17	Poor Coordination	-1.69	0.00
8	Construction Conflict	-2.50	0.00	11	Changes recommended by the Contractor	1.00	0.67	18	Errors or Deficiencies made during Design Phase	-1.76	0.67
8	Changes to Materials and/or Specifications	-0.50	0.00	11	Reduce Project Duration	1.00	0.67	19	Unforeseen Site/Underground Condition	-1.40	1.67
9	Poor Coordination	-2.50	1.33	11	Errors or Deficiencies made during Design Phase	-1.50	0.67	20	Changes recommended by the Contractor	0.75	2.00
10	Consultant NOT AWARE of the Current Regulations	-2.50	1.67	12	Consultant NOT AWARE of the Current Regulations	-2.00	1.33	21	Consultant NOT AWARE of the Current Regulations	-1.07	3.00

Table 19 - Factors causing post contract design changes ranked according to the impact on the cost (II_C) in residential, commercial and mix-use projects

Ranking in Residential Projects				Ranking in Commercial Projects				Ranking in Mix Use Projects			
Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C
1	Changes in Client's Requirements	-1.77	-19.67	1	Changes in Client's Requirements	-1.34	-14.33	1	Changes in Client's Requirements	-1.42	-28.00
8	Changes Requested by Other Stakeholders	-1.36	-5.33	2	Changes Requested by Other Stakeholders	-1.41	-8.00	2	Changes Requested by Other Stakeholders	-1.71	-12.00
25	Changes recommended by the Contractor	0.76	1.33	25	Changes recommended by the Contractor	0.07	0.33	25	Changes recommended by the Contractor	0.36	2.67
11	Complexity of Design/Project	-0.90	-4.00	5	Complexity of Design/Project	-0.80	-4.00	10	Complexity of Design/Project	-0.83	-6.33
7	Unclear or mis-interpretation of Client Needs	-2.12	-5.67	8	Unclear or mis-interpretation of Client Needs	-1.29	-3.00	7	Unclear or mis-interpretation of Client Needs	-1.14	-8.33
4	Changes in Market Conditions	-0.89	-7.00	24	Changes in Market Conditions	0.11	0.33	3	Changes in Market Conditions	-1.15	-10.33
5	Unrealistic Design/Project's Periods	-1.58	-6.67	6	Unrealistic Design/Project's Periods	-1.25	-3.33	8	Unrealistic Design/Project's Periods	-1.17	-7.00
19	Reduce Project Duration	-0.85	-1.33	18	Reduce Project Duration	-0.75	-1.00	5	Reduce Project Duration	-1.71	-9.67
26	Value Engineering	0.68	4.67	26	Value Engineering	1.12	6.33	26	Value Engineering	0.89	13.00
22	Budget Constraints (Omissions due to lack of funds)	-0.17	-0.33	20	Budget Constraints (Omissions due to lack of funds)	-0.22	-0.33	17	Budget Constraints (Omissions due to lack of funds)	0.04	-3.00
23	Errors or Deficiencies made during Design Phase	-1.56	-0.33	13	Errors or Deficiencies made during Design Phase	-1.47	-1.67	23	Errors or Deficiencies made during Design Phase	-1.42	0.33
20	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.64	-1.00	9	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.67	-2.67	21	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.55	-1.00
21	Poor Communication	-0.78	-0.33	19	Poor Communication	-0.33	-0.67	15	Poor Communication	-0.83	-4.67
9	Poor Coordination	-1.70	-5.00	17	Poor Coordination	-1.64	-1.00	16	Poor Coordination	-1.20	-3.33
13	Incompetent Designer or Design Team	-1.43	-3.33	14	Incompetent Designer or Design Team	-1.83	-1.33	18	Incompetent Designer or Design Team	-1.42	-3.00
16	Incompetent Contractor Technical Team	-1.33	-2.33	22	Incompetent Contractor Technical Team	-0.67	-0.33	9	Incompetent Contractor Technical Team	-1.27	-6.67
14	Consultant NOT AWARE of the Current Regulations	-1.71	-3.33	23	Consultant NOT AWARE of the Current Regulations	-1.63	-0.33	24	Consultant NOT AWARE of the Current Regulations	-1.59	1.67
10	Unforeseen Site/Underground Condition	-1.79	-5.00	10	Unforeseen Site/Underground Condition	-1.44	-2.67	11	Unforeseen Site/Underground Condition	-1.45	-6.00
3	Utilities Requirements	-1.60	-7.33	3	Utilities Requirements	-1.47	-4.00	6	Utilities Requirements	-1.61	-8.67
24	Construction Conflict	-0.94	0.67	15	Construction Conflict	-0.71	-1.33	19	Construction Conflict	-0.85	-1.67
18	Sustainability Requirements (LEED/Estidama)	-1.84	-2.00	12	Sustainability Requirements (LEED/Estidama)	-0.86	-1.67	20	Sustainability Requirements (LEED/Estidama)	-1.56	-1.33
2	Change in Government Policies/Regulations	-1.62	-8.33	4	Change in Government Policies/Regulations	-1.41	-4.00	4	Change in Government Policies/Regulations	-1.29	-10.00
6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.56	-6.00	21	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.13	-0.33	14	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.64	-5.00
15	Changes to Materials and/or Specifications	-1.46	-2.33	11	Changes to Materials and/or Specifications	-0.92	-2.33	13	Changes to Materials and/or Specifications	-1.21	-5.33
12	Field conditions or Change in Site Conditions	-1.00	-3.67	7	Field conditions or Change in Site Conditions	-0.63	-3.00	12	Field conditions or Change in Site Conditions	-1.13	-5.33
17	Changes in Construction/ Permanent Works Method/ Technology	-0.23	-2.00	16	Changes in Construction/ Permanent Works Method/ Technology	-0.67	-1.00	22	Changes in Construction/ Permanent Works Method/ Technology	-0.77	-0.33

Table 20 - Factors causing post contract design changes ranked according to the impact on the cost (II_C) in Hotels, Industrial and Infrastructure projects

Ranking in Hotels' Projects				Ranking in Industrial Projects				Ranking in Infrastructure Projects			
Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C
3	Changes in Client's Requirements	-0.67	-2.00	1	Changes in Client's Requirements	-1.71	-4.00	1	Changes in Client's Requirements	-1.61	-16.67
1	Changes Requested by Other Stakeholders	-1.17	-2.33	4	Changes Requested by Other Stakeholders	-3.00	-1.00	3	Changes Requested by Other Stakeholders	-1.20	-6.00
18	Changes recommended by the Contractor	0.00	0.00	25	Changes recommended by the Contractor	1.00	0.67	23	Changes recommended by the Contractor	0.25	0.67
19	Complexity of Design/Project	0.00	0.00	12	Complexity of Design/Project	-1.00	-0.33	4	Complexity of Design/Project	-1.25	-5.00
11	Unclear or mis-interpretation of Client Needs	-0.67	-0.67	2	Unclear or mis-interpretation of Client Needs	-2.00	-2.00	6	Unclear or mis-interpretation of Client Needs	-2.40	-4.00
25	Changes in Market Conditions	1.33	1.33	13	Changes in Market Conditions	-1.00	-0.33	21	Changes in Market Conditions	0.00	0.00
4	Unrealistic Design/Project's Periods	-2.00	-2.00	8	Unrealistic Design/Project's Periods	-1.00	-0.67	7	Unrealistic Design/Project's Periods	-1.00	-3.67
9	Reduce Project Duration	-1.00	-1.00	10	Reduce Project Duration	-1.00	-0.67	18	Reduce Project Duration	-0.60	-1.00
26	Value Engineering	0.71	1.67	26	Value Engineering	1.33	1.33	26	Value Engineering	0.53	3.00
23	Budget Constraints (Omissions due to lack of funds)	0.00	0.67	18	Budget Constraints (Omissions due to lack of funds)	0.00	0.00	19	Budget Constraints (Omissions due to lack of funds)	0.71	-0.67
21	Errors or Deficiencies made during Design Phase	-1.50	0.33	22	Errors or Deficiencies made during Design Phase	-1.00	0.00	24	Errors or Deficiencies made during Design Phase	-1.76	1.00
22	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	0.00	0.33	24	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.50	0.33	10	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.43	-3.00
16	Poor Communication	-3.00	0.00	17	Poor Communication	0.00	0.00	14	Poor Communication	-0.80	-1.67
24	Poor Coordination	-1.75	0.67	19	Poor Coordination	-1.00	0.00	22	Poor Coordination	-1.69	0.00
10	Incompetent Designer or Design Team	-3.00	-0.67	5	Incompetent Designer or Design Team	-2.00	-1.00	16	Incompetent Designer or Design Team	-1.60	-1.33
13	Incompetent Contractor Technical Team	0.00	-0.33	14	Incompetent Contractor Technical Team	-2.00	-0.33	13	Incompetent Contractor Technical Team	-1.50	-2.00
6	Consultant NOT AWARE of the Current Regulations	-1.00	-1.33	23	Consultant NOT AWARE of the Current Regulations	-2.00	0.00	25	Consultant NOT AWARE of the Current Regulations	-1.14	2.00
12	Unforeseen Site/Underground Condition	-1.50	-0.67	16	Unforeseen Site/Underground Condition	-1.50	-0.33	8	Unforeseen Site/Underground Condition	-1.10	-3.33
2	Utilities Requirements	-0.40	-2.33	11	Utilities Requirements	-3.00	-0.33	5	Utilities Requirements	-1.17	-4.67
20	Construction Conflict	-1.00	0.00	20	Construction Conflict	0.00	0.00	15	Construction Conflict	-1.13	-1.67
7	Sustainability Requirements (LEED/Estidama)	-0.20	-1.00	21	Sustainability Requirements (LEED/Estidama)	-1.00	0.00	20	Sustainability Requirements (LEED/Estidama)	-2.00	-0.33
5	Change in Government Policies/Regulations	0.00	-1.33	9	Change in Government Policies/Regulations	-1.75	-0.67	2	Change in Government Policies/Regulations	-1.00	-7.67
8	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.67	-1.00	3	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.67	-1.00	9	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.85	-3.00
14	Changes to Materials and/or Specifications	-0.50	-0.33	15	Changes to Materials and/or Specifications	-1.00	-0.33	11	Changes to Materials and/or Specifications	-0.92	-3.00
17	Field conditions or Change in Site Conditions	0.50	0.00	7	Field conditions or Change in Site Conditions	-1.25	-0.67	12	Field conditions or Change in Site Conditions	-1.10	-2.67
15	Changes in Construction/ Permanent Works Method/ Technology	0.00	0.00	6	Changes in Construction/ Permanent Works Method/ Technology	0.00	-0.67	17	Changes in Construction/ Permanent Works Method/ Technology	-0.75	-1.00

Table 21 - Factors causing post contract design changes ranked according to the impact on the quality (II_Q) in residential, commercial and mix-use projects

Ranking in Residential Projects				Ranking in Commercial Projects				Ranking in Mix Use Projects			
Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q
1	Unforeseen Site/Underground Condition	-0.79	-14.33	1	Unforeseen Site/Underground Condition	-0.33	-8.67	1	Unforeseen Site/Underground Condition	-0.09	-22.33
2	Sustainability Requirements (LEED/Estidama)	0.58	-13.00	2	Changes in Construction/ Permanent Works Method/ Technology	-0.33	-7.67	2	Changes in Construction/ Permanent Works Method/ Technology	0.00	-18.00
2	Changes in Construction/ Permanent Works Method/ Technology	-0.08	-13.00	3	Sustainability Requirements (LEED/Estidama)	0.43	-7.00	3	Sustainability Requirements (LEED/Estidama)	0.72	-16.00
3	Change in Government Policies/Regulations	-0.03	-9.67	4	Errors or Deficiencies made during Design Phase	-0.71	-5.67	4	Change in Government Policies/Regulations	0.06	-12.67
4	Poor Coordination	-1.22	-8.00	5	Changes to Materials and/or Specifications	0.00	-5.00	5	Changes to Materials and/or Specifications	0.28	-12.33
5	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.36	-6.67	6	Poor Coordination	-1.09	-4.67	6	Poor Communication	-0.67	-11.67
6	Poor Communication	-1.00	-6.33	6	Change in Government Policies/Regulations	0.06	-4.67	7	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.45	-9.33
7	Consultant NOT AWARE of the Current Regulations	-1.00	-6.00	7	Field conditions or Change in Site Conditions	-0.25	-4.33	8	Poor Coordination	-1.00	-8.67
8	Errors or Deficiencies made during Design Phase	-0.67	-5.67	8	Poor Communication	-1.67	-3.00	9	Errors or Deficiencies made during Design Phase	-0.68	-8.33
9	Changes in Market Conditions	-0.56	-5.00	8	Utilities Requirements	-0.20	-3.00	9	Consultant NOT AWARE of the Current Regulations	-0.73	-8.33
9	Field conditions or Change in Site Conditions	-0.33	-5.00	9	Complexity of Design/Project	-0.53	-2.67	10	Reduce Project Duration	-1.18	-6.67
10	Changes to Materials and/or Specifications	0.07	-4.33	9	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.67	-2.67	11	Changes in Client's Requirements	-0.31	-6.00
11	Incompetent Contractor Technical Team	-1.17	-4.00	10	Consultant NOT AWARE of the Current Regulations	-1.13	-2.33	12	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.76	-5.67
12	Unrealistic Design/Project's Periods	-1.05	-3.33	10	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.63	-2.33	12	Field conditions or Change in Site Conditions	-0.87	-5.67
12	Value Engineering	-0.21	-3.33	11	Changes recommended by the Contractor	-0.36	-1.67	13	Unclear or mis-interpretation of Client Needs	-0.64	-4.67
13	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.80	-3.00	11	Construction Conflict	-0.14	-1.67	14	Utilities Requirements	0.03	-4.00
14	Changes in Client's Requirements	-0.27	-2.33	12	Changes in Client's Requirements	-0.13	-1.33	15	Changes in Market Conditions	-0.37	-3.33
14	Reduce Project Duration	-1.00	-2.33	12	Unrealistic Design/Project's Periods	-0.50	-1.33	16	Changes Requested by Other Stakeholders	-0.43	-3.00
15	Construction Conflict	-0.39	-1.67	13	Changes in Market Conditions	-0.33	-1.00	16	Unrealistic Design/Project's Periods	-0.50	-3.00
16	Complexity of Design/Project	-0.57	-1.00	14	Unclear or mis-interpretation of Client Needs	-0.29	-0.67	17	Construction Conflict	-0.30	-2.67
17	Changes Requested by Other Stakeholders	0.07	-0.33	15	Changes Requested by Other Stakeholders	-0.06	-0.33	18	Incompetent Contractor Technical Team	-1.45	-2.00
18	Changes recommended by the Contractor	0.14	-0.33	15	Reduce Project Duration	-0.25	-0.33	19	Complexity of Design/Project	-0.13	-1.00
18	Unclear or mis-interpretation of Client Needs	-0.88	-0.33	15	Value Engineering	-0.06	-0.33	20	Budget Constraints (Omissions due to lack of funds)	-0.69	-0.33
19	Utilities Requirements	-0.20	0.00	16	Incompetent Contractor Technical Team	-2.33	0.00	21	Changes recommended by the Contractor	0.05	0.33
20	Incompetent Designer or Design Team	-0.76	1.67	17	Budget Constraints (Omissions due to lack of funds)	-0.89	1.67	22	Value Engineering	0.11	1.67
21	Budget Constraints (Omissions due to lack of funds)	-1.04	3.33	18	Incompetent Designer or Design Team	-0.17	2.00	23	Incompetent Designer or Design Team	-0.63	2.67

Table 22 - Factors causing post contract design changes ranked according to the impact on the quality (II_Q) in in Hotels, Industrial and Infrastructure projects

Ranking in Hotels' Projects				Ranking in Industrial Projects				Ranking in Infrastructure Projects			
Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q
1	Sustainability Requirements (LEED/Estidama)	0.40	-3.33	1	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	0.00	-2.67	1	Unforeseen Site/Underground Condition	-0.30	-10.00
2	Poor Coordination	-1.00	-2.33	1	Field conditions or Change in Site Conditions	0.25	-2.67	2	Sustainability Requirements (LEED/Estidama)	-0.50	-9.00
3	Incompetent Contractor Technical Team	-1.00	-1.67	2	Unforeseen Site/Underground Condition	-0.33	-2.00	3	Errors or Deficiencies made during Design Phase	-0.82	-7.33
3	Changes to Materials and/or Specifications	0.00	-1.67	2	Change in Government Policies/Regulations	0.00	-2.00	4	Change in Government Policies/Regulations	-0.42	-6.33
3	Changes in Construction/ Permanent Works Method/ Technology	0.00	-1.67	2	Changes to Materials and/or Specifications	0.50	-2.00	5	Incompetent Contractor Technical Team	-1.50	-5.33
4	Value Engineering	-0.57	-1.33	3	Poor Coordination	-0.50	-1.33	6	Poor Coordination	-1.44	-5.00
4	Consultant NOT AWARE of the Current Regulations	0.00	-1.33	3	Sustainability Requirements (LEED/Estidama)	2.00	-1.33	6	Changes to Materials and/or Specifications	0.15	-5.00
4	Unforeseen Site/Underground Condition	0.00	-1.33	4	Unrealistic Design/Project's Periods	-1.50	-1.00	7	Field conditions or Change in Site Conditions	-0.10	-4.67
5	Poor Communication	-3.00	-1.00	4	Consultant NOT AWARE of the Current Regulations	-0.67	-1.00	8	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.46	-4.00
5	Construction Conflict	-0.50	-1.00	4	Changes in Construction/ Permanent Works Method/ Technology	0.00	-1.00	8	Changes in Construction/ Permanent Works Method/ Technology	-0.25	-4.00
5	Change in Government Policies/Regulations	0.60	-1.00	5	Errors or Deficiencies made during Design Phase	-0.25	-0.67	9	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.71	-3.33
5	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.00	-1.00	5	Poor Communication	0.00	-0.67	10	Complexity of Design/Project	-0.75	-3.00
5	Field conditions or Change in Site Conditions	1.50	-1.00	5	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	0.00	-0.67	10	Utilities Requirements	-0.42	-3.00
6	Unrealistic Design/Project's Periods	-0.67	-0.67	6	Reduce Project Duration	-0.50	-0.33	11	Construction Conflict	-0.25	-2.33
6	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	0.00	-0.67	6	Utilities Requirements	0.00	-0.33	12	Changes in Client's Requirements	-0.19	-2.00
6	Incompetent Designer or Design Team	-3.00	-0.67	7	Changes in Client's Requirements	0.00	0.00	12	Reduce Project Duration	-1.20	-2.00
7	Reduce Project Duration	-0.33	-0.33	7	Changes Requested by Other Stakeholders	0.00	0.00	13	Unclear or mis-interpretation of Client Needs	-1.00	-1.67
8	Unclear or mis-interpretation of Client Needs	0.00	0.00	7	Changes recommended by the Contractor	0.00	0.00	13	Poor Communication	-0.20	-1.67
8	Budget Constraints (Omissions due to lack of funds)	-0.50	0.00	7	Unclear or mis-interpretation of Client Needs	0.00	0.00	14	Unrealistic Design/Project's Periods	-0.36	-1.33
8	Errors or Deficiencies made during Design Phase	-1.75	0.00	7	Changes in Market Conditions	0.00	0.00	15	Changes Requested by Other Stakeholders	-0.13	-0.67
8	Utilities Requirements	0.40	0.00	7	Value Engineering	0.00	0.00	16	Incompetent Designer or Design Team	-0.90	-0.33
9	Changes recommended by the Contractor	1.00	0.33	7	Construction Conflict	1.00	0.00	17	Consultant NOT AWARE of the Current Regulations	-0.57	-0.33
9	Complexity of Design/Project	1.00	0.33	8	Complexity of Design/Project	1.00	0.33	18	Changes in Market Conditions	0.00	0.00
10	Changes in Client's Requirements	0.22	0.67	8	Incompetent Contractor Technical Team	-1.00	0.33	19	Changes recommended by the Contractor	0.38	1.00
10	Changes Requested by Other Stakeholders	0.33	0.67	9	Budget Constraints (Omissions due to lack of funds)	-0.50	0.67	20	Value Engineering	0.38	2.00
10	Changes in Market Conditions	0.67	0.67	9	Incompetent Designer or Design Team	-1.00	0.67	20	Budget Constraints (Omissions due to lack of funds)	-1.43	2.00

4.11 RANKING OF THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES ACCORDING TO THE IMPACT ON THE TIME, COST AND QUALITY IN DESIGN-BID-BUILD (LUMP SUM), DESIGN-BID-BUILD (RE-MEASURE), DESIGN-BUILD AND EPC CONTRACTS

The identified factors causing post contract design changes are sorted according to the impact indices on the time($\mathbf{II_T}$), cost ($\mathbf{II_C}$) and quality ($\mathbf{II_Q}$), in different types of contracts:

- ✓ The Table 23 illustrates the post contract design changes according to their impact on the time($\mathbf{II_T}$) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build and Engineering, Procurement, Construction (EPC) Contracts.
- ✓ The Table 24 illustrates the post contract design changes according to their impact on the cost ($\mathbf{II_C}$) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build and Engineering, Procurement, Construction (EPC) Contracts.
- ✓ The Table 25 illustrates the post contract design changes according to their impact on the quality ($\mathbf{II_Q}$) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build and Engineering, Procurement, Construction (EPC) Contracts.

Table 23 - Factors causing post contract design changes ranked according to the impact on the time(II_T) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build And EPC Contracts

Design-Bid-Build (Lump sum) contracts				Design-Bid-Build (re-measure) contracts				Design-Build contracts				Engineering, Procurement, Construction (EPC) contracts			
Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T	Rank	Factor causing post contract design changes	Mean	II_T
1	Changes in Client's Requirements	-1.94	-60.00	1	Changes in Client's Requirements	-1.91	-14.00	1	Changes in Client's Requirements	-1.82	-10.33	1	Changes in Client's Requirements	-2.02	-31.00
2	Utilities Requirements	-1.59	-28.00	2	Changes Requested by Other Stakeholders	-2.42	-9.67	2	Change in Government Policies/Regulations	-1.80	-3.67	2	Utilities Requirements	-1.45	-13.67
3	Change in Government Policies/Regulations	-1.20	-23.67	3	Utilities Requirements	-2.10	-8.00	3	Complexity of Design/Project	-1.50	-3.00	3	Unclear or mis-interpretation of Client Needs	-2.31	-12.33
4	Changes Requested by Other Stakeholders	-1.63	-21.67	4	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.70	-7.33	3	Unrealistic Design/Project's Periods	-1.80	-3.00	4	Poor Communication	-1.56	-11.33
5	Budget Constraints (Omissions due to lack of funds)	-0.72	-18.00	5	Budget Constraints (Omissions due to lack of funds)	-1.78	-6.33	3	Utilities Requirements	-1.86	-3.00	5	Changes Requested by Other Stakeholders	-1.56	-9.33
6	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.49	-17.33	6	Field conditions or Change in Site Conditions	-1.00	-5.33	4	Changes Requested by Other Stakeholders	-1.60	-2.67	5	Changes in Market Conditions	-1.87	-9.33
7	Unrealistic Design/Project's Periods	-1.55	-15.00	7	Poor Communication	-1.60	-5.00	4	Budget Constraints (Omissions due to lack of funds)	-0.14	-2.67	5	Unrealistic Design/Project's Periods	-2.00	-9.33
8	Complexity of Design/Project	-1.23	-14.33	7	Change in Government Policies/Regulations	-1.33	-5.00	4	Poor Coordination	-2.29	-2.67	6	Change in Government Policies/Regulations	-1.73	-9.00
8	Field conditions or Change in Site Conditions	-0.96	-14.33	8	Changes in Construction/ Permanent Works Method/ Technology	0.25	-4.33	5	Changes in Construction/ Permanent Works Method/ Technology	-1.00	-2.33	7	Complexity of Design/Project	-1.39	-8.33
9	Incompetent Designer or Design Team	-1.82	-12.67	9	Unclear or mis-interpretation of Client Needs	-1.33	-4.00	6	Changes in Market Conditions	-1.50	-2.00	7	Field conditions or Change in Site Conditions	-0.79	-8.33
10	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.91	-11.67	10	Unrealistic Design/Project's Periods	-1.14	-2.67	6	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.00	-2.00	8	Budget Constraints (Omissions due to lack of funds)	-1.43	-7.67
11	Changes in Market Conditions	-1.07	-10.67	10	Incompetent Contractor Technical Team	-2.00	-2.67	7	Incompetent Designer or Design Team	-1.00	-1.67	9	Incompetent Designer or Design Team	-2.20	-7.33
11	Changes in Construction/ Permanent Works Method/ Technology	-0.57	-10.67	10	Changes to Materials and/or Specifications	-1.13	-2.67	7	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-2.00	-1.67	10	Value Engineering	-0.58	-6.00
12	Poor Coordination	-1.70	-9.33	11	Changes in Market Conditions	-1.00	-2.33	8	Field conditions or Change in Site Conditions	-1.40	-1.33	11	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.55	-5.67
13	Unclear or mis-interpretation of Client Needs	-1.19	-8.33	12	Complexity of Design/Project	-1.00	-2.00	9	Value Engineering	-0.33	-1.00	12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.20	-4.33
14	Incompetent Contractor Technical Team	-2.14	-8.00	12	Construction Conflict	-1.20	-2.00	9	Changes to Materials and/or Specifications	-1.17	-1.00	13	Incompetent Contractor Technical Team	-1.20	-3.67
15	Value Engineering	-0.35	-6.67	12	Sustainability Requirements (LEED/Estidama)	-1.60	-2.00	10	Unclear or mis-interpretation of Client Needs	-0.67	-0.67	13	Changes in Construction/ Permanent Works Method/ Technology	-0.70	-3.67
15	Poor Communication	-1.00	-6.67	13	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.83	-1.67	10	Poor Communication	-1.00	-0.67	14	Poor Coordination	-1.89	-2.67
16	Changes to Materials and/or Specifications	-0.80	-6.00	13	Incompetent Designer or Design Team	-1.77	-1.67	11	Reduce Project Duration	-0.33	-0.33	15	Sustainability Requirements (LEED/Estidama)	-1.33	-2.33
17	Construction Conflict	-1.12	-2.67	14	Poor Coordination	-1.55	-1.33	11	Errors or Deficiencies made during Design Phase	-1.83	-0.33	16	Construction Conflict	-1.20	-2.00
18	Sustainability Requirements (LEED/Estidama)	-1.08	-2.00	15	Value Engineering	0.20	1.00	11	Incompetent Contractor Technical Team	-2.00	-0.33	17	Changes to Materials and/or Specifications	-1.72	-1.67
19	Unforeseen Site/Underground Condition	-1.71	-1.67	16	Reduce Project Duration	0.83	1.67	11	Construction Conflict	-2.00	-0.33	18	Unforeseen Site/Underground Condition	-1.38	-1.33
20	Changes recommended by the Contractor	0.04	0.33	16	Unforeseen Site/Underground Condition	-1.63	1.67	12	Sustainability Requirements (LEED/Estidama)	-2.00	0.00	19	Reduce Project Duration	0.40	1.33
21	Errors or Deficiencies made during Design Phase	-1.72	1.00	17	Changes recommended by the Contractor	0.55	2.00	13	Changes recommended by the Contractor	0.33	0.33	20	Errors or Deficiencies made during Design Phase	-1.61	2.67
22	Reduce Project Duration	0.48	3.33	18	Errors or Deficiencies made during Design Phase	-1.93	2.33	14	Unforeseen Site/Underground Condition	-1.00	1.67	21	Changes recommended by the Contractor	0.88	4.67
23	Consultant NOT AWARE of the Current Regulations	-1.41	14.33	19	Consultant NOT AWARE of the Current Regulations	-2.13	5.00	15	Consultant NOT AWARE of the Current Regulations	-2.00	4.00	22	Consultant NOT AWARE of the Current Regulations	-1.47	6.67

Table 24 - Factors causing post contract design changes ranked according to the impact on the cost (II_C) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build And EPC Contracts

Design-Bid-Build (Lump sum) contracts				Design-Bid-Build (re-measure) contracts				Design-Build contracts				Engineering, Procurement, Construction (EPC) contracts			
Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C	Rank	Factor causing post contract design changes	Mean	II_C
1	Changes in Client's Requirements	-1.39	-43.00	1	Changes in Client's Requirements	-1.23	-9.00	1	Changes in Client's Requirements	-1.59	-9.00	1	Changes in Client's Requirements	-1.54	-23.67
2	Changes Requested by Other Stakeholders	-1.35	-18.00	2	Changes Requested by Other Stakeholders	-1.58	-6.33	2	Change in Government Policies/Regulations	-1.50	-3.00	2	Unclear or mis-interpretation of Client Needs	-2.13	-11.33
2	Change in Government Policies/Regulations	-1.17	-18.00	3	Unclear or mis-interpretation of Client Needs	-1.67	-5.00	3	Changes Requested by Other Stakeholders	-1.60	-2.67	3	Changes Requested by Other Stakeholders	-1.28	-7.67
3	Utilities Requirements	-1.46	-16.67	4	Unforeseen Site/Underground Condition	-1.63	-4.67	3	Changes in Market Conditions	-2.00	-2.67	4	Unrealistic Design/Project's Periods	-1.57	-7.33
4	Unrealistic Design/Project's Periods	-1.31	-12.67	4	Change in Government Policies/Regulations	-0.92	-4.67	4	Poor Coordination	-1.57	-2.33	5	Change in Government Policies/Regulations	-1.50	-6.33
4	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.54	-12.67	5	Utilities Requirements	-2.10	-4.33	5	Complexity of Design/Project	-1.00	-2.00	6	Utilities Requirements	-1.35	-6.00
5	Complexity of Design/Project	-1.00	-11.67	6	Field conditions or Change in Site Conditions	-1.17	-3.33	6	Unrealistic Design/Project's Periods	-1.00	-1.67	7	Field conditions or Change in Site Conditions	-0.79	-5.33
6	Changes in Market Conditions	-0.93	-9.33	7	Incompetent Contractor Technical Team	-1.60	-3.00	7	Changes to Materials and/or Specifications	-1.67	-1.33	8	Unforeseen Site/Underground Condition	-1.38	-4.67
7	Unforeseen Site/Underground Condition	-1.33	-9.00	8	Reduce Project Duration	-1.33	-2.67	8	Field conditions or Change in Site Conditions	-1.40	-1.00	9	Complexity of Design/Project	-0.72	-4.33
8	Reduce Project Duration	-1.14	-8.00	8	Changes to Materials and/or Specifications	-1.25	-2.67	9	Unclear or mis-interpretation of Client Needs	-0.67	-0.67	10	Reduce Project Duration	-1.10	-3.67
9	Changes to Materials and/or Specifications	-0.63	-7.33	9	Poor Communication	-1.20	-2.33	10	Budget Constraints (Omissions due to lack of funds)	0.71	-0.67	11	Poor Communication	-0.78	-3.33
10	Unclear or mis-interpretation of Client Needs	-0.95	-6.67	9	Changes in Construction/ Permanent Works Method/ Technology	0.25	-2.33	11	Changes recommended by the Contractor	-0.33	-0.33	11	Incompetent Designer or Design Team	-1.70	-3.33
10	Incompetent Contractor Technical Team	-1.29	-6.67	10	Sustainability Requirements (LEED/Estidama)	-1.70	-2.00	11	Reduce Project Duration	-0.33	-0.33	12	Changes in Market Conditions	-0.53	-2.67
11	Incompetent Designer or Design Team	-1.58	-6.33	11	Complexity of Design/Project	-0.83	-1.67	11	Incompetent Designer or Design Team	-1.25	-0.33	12	Sustainability Requirements (LEED/Estidama)	-1.42	-2.67
12	Field conditions or Change in Site Conditions	-0.92	-5.67	11	Unrealistic Design/Project's Periods	-0.71	-1.67	11	Incompetent Contractor Technical Team	-1.50	-0.33	12	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.55	-2.67
13	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.73	-4.00	11	Construction Conflict	-0.80	-1.67	11	Utilities Requirements	-1.43	-0.33	13	Changes to Materials and/or Specifications	-1.78	-2.33
14	Poor Coordination	-1.51	-3.33	12	Changes in Market Conditions	-0.57	-1.33	11	Sustainability Requirements (LEED/Estidama)	-2.00	-0.33	14	Incompetent Contractor Technical Team	-1.00	-2.00
15	Budget Constraints (Omissions due to lack of funds)	-0.17	-2.00	12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-1.00	-1.33	12	Errors or Deficiencies made during Design Phase	-1.50	0.00	15	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.60	-1.67
15	Errors or Deficiencies made during Design Phase	-1.58	-2.00	12	Poor Coordination	-1.36	-1.33	12	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.25	0.00	15	Poor Coordination	-1.42	-1.67
15	Poor Communication	-1.20	-2.00	13	Budget Constraints (Omissions due to lack of funds)	0.56	-1.00	12	Consultant NOT AWARE of the Current Regulations	-2.00	0.00	16	Consultant NOT AWARE of the Current Regulations	-1.47	-1.33
15	Construction Conflict	-1.06	-2.00	13	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.70	-1.00	12	Construction Conflict	-1.00	0.00	17	Changes in Construction/ Permanent Works Method/ Technology	-0.40	-1.00
15	Changes in Construction/ Permanent Works Method/ Technology	-0.79	-2.00	14	Errors or Deficiencies made during Design Phase	-1.60	-0.67	12	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-2.17	0.00	18	Construction Conflict	-0.80	-0.33
16	Sustainability Requirements (LEED/Estidama)	-1.21	-1.33	14	Incompetent Designer or Design Team	-1.69	-0.67	13	Poor Communication	0.00	0.33	19	Budget Constraints (Omissions due to lack of funds)	-0.29	0.00
17	Consultant NOT AWARE of the Current Regulations	-1.34	-1.00	15	Consultant NOT AWARE of the Current Regulations	-2.00	1.00	13	Unforeseen Site/Underground Condition	-1.40	0.33	20	Errors or Deficiencies made during Design Phase	-1.46	2.33
18	Changes recommended by the Contractor	0.11	1.00	16	Changes recommended by the Contractor	0.64	2.33	13	Changes in Construction/ Permanent Works Method/ Technology	-1.00	0.33	21	Changes recommended by the Contractor	0.50	2.67
19	Value Engineering	0.75	14.33	17	Value Engineering	1.00	5.00	14	Value Engineering	1.33	4.00	22	Value Engineering	0.65	6.67

Table 25 - Factors causing post contract design changes ranked according to the impact on the quality (II_Q) in Design-Bid-Build (Lump sum), Design-Bid-Build (Re-measure), Design-Build And EPC Contracts

Design-Bid-Build (Lump sum) contracts				Design-Bid-Build (re-measure) contracts				Design-Build contracts				Engineering, Procurement, Construction (EPC) contracts			
Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q	Rank	Factor causing post contract design changes	Mean	II_Q
1	Unforeseen Site/Underground Condition	-0.25	-30.33	1	Unforeseen Site/Underground Condition	-0.88	-9.67	1	Sustainability Requirements (LEED/Estidama)	0.29	-5.33	1	Unforeseen Site/Underground Condition	-0.38	-15.00
2	Sustainability Requirements (LEED/Estidama)	0.50	-26.67	2	Change in Government Policies/Regulations	-0.17	-7.67	2	Changes in Construction/ Permanent Works Method/ Technology	0.00	-4.33	2	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.10	-12.33
3	Changes in Construction/ Permanent Works Method/ Technology	-0.71	-24.33	3	Changes in Construction/ Permanent Works Method/ Technology	1.00	-7.00	3	Unforeseen Site/Underground Condition	0.20	-3.67	3	Sustainability Requirements (LEED/Estidama)	1.00	-12.00
4	Change in Government Policies/Regulations	-0.09	-20.00	4	Sustainability Requirements (LEED/Estidama)	0.50	-5.67	4	Errors or Deficiencies made during Design Phase	-0.17	-3.00	4	Changes in Construction/ Permanent Works Method/ Technology	0.30	-9.67
5	Poor Coordination	-1.15	-15.00	4	Changes to Materials and/or Specifications	0.50	-5.67	4	Poor Coordination	-1.29	-3.00	5	Poor Communication	-0.89	-9.33
5	Changes to Materials and/or Specifications	0.12	-15.00	5	Consultant NOT AWARE of the Current Regulations	-1.25	-5.33	5	Changes in Market Conditions	-1.75	-2.33	5	Poor Coordination	-1.00	-9.33
6	Errors or Deficiencies made during Design Phase	-0.89	-14.33	6	Field conditions or Change in Site Conditions	-0.50	-4.33	6	Poor Communication	-1.00	-2.00	6	Errors or Deficiencies made during Design Phase	-0.64	-8.33
7	Field conditions or Change in Site Conditions	-0.64	-13.67	7	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.83	-4.00	7	Field conditions or Change in Site Conditions	-0.40	-1.67	6	Changes to Materials and/or Specifications	0.00	-8.33
8	Poor Communication	-0.80	-10.67	8	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-1.20	-3.33	8	Utilities Requirements	0.00	-1.33	7	Change in Government Policies/Regulations	0.36	-7.33
9	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.62	-10.00	9	Reduce Project Duration	-1.50	-3.00	8	Change in Government Policies/Regulations	-0.20	-1.33	8	Consultant NOT AWARE of the Current Regulations	-0.94	-6.67
10	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	-0.55	-8.33	10	Poor Coordination	-1.27	-2.67	8	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	0.00	-1.33	9	Incompetent Contractor Technical Team	-1.40	-6.00
11	Changes in Client's Requirements	-0.24	-7.33	10	Construction Conflict	-0.40	-2.67	8	Changes to Materials and/or Specifications	0.17	-1.33	10	Construction Conflict	-0.33	-4.67
12	Consultant NOT AWARE of the Current Regulations	-0.53	-7.00	11	Changes in Client's Requirements	-0.32	-2.33	9	Incompetent Contractor Technical Team	-2.00	-1.00	11	Utilities Requirements	-0.15	-4.00
13	Reduce Project Duration	-0.95	-6.67	11	Unclear or mis-interpretation of Client Needs	-0.78	-2.33	10	Changes in Client's Requirements	-0.12	-0.67	12	Field conditions or Change in Site Conditions	0.14	-3.67
13	Incompetent Contractor Technical Team	-1.57	-6.67	11	Poor Communication	-1.20	-2.33	10	Changes Requested by Other Stakeholders	-0.40	-0.67	13	Unclear or mis-interpretation of Client Needs	-0.63	-3.33
14	Unrealistic Design/Project's Periods	-0.66	-6.33	12	Errors or Deficiencies made during Design Phase	-0.87	-2.00	10	Errors/Omissions during Construction/ Fabrication/ Transportation Phase	0.00	-0.67	13	Unrealistic Design/Project's Periods	-0.71	-3.33
15	Complexity of Design/Project	-0.34	-4.00	13	Utilities Requirements	0.00	-1.67	11	Unrealistic Design/Project's Periods	-0.20	-0.33	14	Reduce Project Duration	-0.60	-2.00
16	Changes in Market Conditions	-0.33	-3.33	14	Complexity of Design/Project	-0.67	-1.33	11	Reduce Project Duration	-0.33	-0.33	14	Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	-0.59	-2.00
16	Utilities Requirements	-0.22	-3.33	14	Changes in Market Conditions	-0.57	-1.33	11	Incompetent Designer or Design Team	0.00	-0.33	15	Complexity of Design/Project	-0.28	-1.67
17	Changes Requested by Other Stakeholders	-0.15	-2.00	15	Changes Requested by Other Stakeholders	-0.25	-1.00	11	Consultant NOT AWARE of the Current Regulations	-1.50	-0.33	15	Changes in Market Conditions	-0.33	-1.67
17	Changes recommended by the Contractor	-0.22	-2.00	16	Changes recommended by the Contractor	-0.18	-0.67	11	Construction Conflict	-1.00	-0.33	16	Value Engineering	-0.13	-1.33
17	Unclear or mis-interpretation of Client Needs	-0.29	-2.00	16	Unrealistic Design/Project's Periods	-0.29	-0.67	12	Changes recommended by the Contractor	0.00	0.00	17	Changes in Client's Requirements	-0.04	-0.67
18	Construction Conflict	-0.35	-1.67	17	Value Engineering	0.20	1.00	12	Complexity of Design/Project	0.00	0.00	18	Changes Requested by Other Stakeholders	0.00	0.00
19	Value Engineering	-0.05	-1.00	17	Incompetent Contractor Technical Team	-1.60	1.00	12	Value Engineering	0.00	0.00	19	Incompetent Designer or Design Team	-0.80	1.33
20	Budget Constraints (Omissions due to lack of funds)	-0.93	0.33	18	Incompetent Designer or Design Team	-0.23	1.67	13	Unclear or mis-interpretation of Client Needs	0.33	0.33	20	Changes recommended by the Contractor	0.44	2.33
20	Incompetent Designer or Design Team	-1.15	3.33	19	Budget Constraints (Omissions due to lack of funds)	-1.56	2.00	13	Budget Constraints (Omissions due to lack of funds)	0.14	0.33	21	Budget Constraints (Omissions due to lack of funds)	-1.00	4.67

4.12 SPEARMAN ANALYSIS

The identified factors causing post contract design changes in the UAE construction industry, ranked by the Clients, Consultants and Contractors according to the design changes' impact on the time (Table 14), cost (Table 15) and quality (Table 16), are compared in pairs to recognize any correlation among the groups of respondents.

The following correlations are studied:

- ✓ Impact on the time (Table 26): Clients & Consultants, Clients & Contractors, Consultants & Contractors.
- ✓ Impact on cost (Table 27): Clients & Consultants, Clients & Contractors, Consultants & Contractors.
- ✓ Impact on quality (Table 28): Clients & Consultants, Clients & Contractors, Consultants & Contractors.

The ranks of the different factors for the impact of the design changes on the time, cost and quality are drafted together (Table 26, Table 27 and Table 28). The shown ranks are extremely close to each other, meaning the participants from different groups are ranking in similar ways, which reflects good accuracy of the results.

4.12.1 IMPACT ON TIME

- ✓ The Spearman correlation factor for the impact on the time between clients and consultants r_s=0.931 (with a significance level of 0.95) means there is a complete agreement among consultants and clients on the ranking of the factors causing post contract design changes according to their impact on time to completion of the projects.

- ✓ The Spearman correlation factor for the impact on the time between clients and contractors r_s=0.952 (with a significance level of 0.95) means there is a complete agreement among clients and contractors on the ranking of the factors causing post contract design changes according to their impact on time to completion of the projects.

- ✓ The Spearman correlation factor for the impact on the time between consultants and contractors r_s=0.916 (with a significance level of 0.95) means there is a complete agreement among consultants and contractors on the ranking of the factors causing post contract design changes according to their impact on time to completion of the projects.

4.12.2 IMPACT ON COST

- ✓ The Spearman correlation factor for the impact on the cost between clients and consultants r_s=0.835 (with a significance level of 0.95) means there is a very strong agreement among clients and consultants on the ranking of the factors causing post contract design changes according to their impact on the cost of the projects.

- ✓ The Spearman correlation factor for the impact on the cost between clients and contractors r_s=0.852 (with a significance level of 0.95) means there is a very strong agreement among clients and contractors on the ranking of the factors causing post contract design changes according to their impact on the cost of the projects.

- ✓ The Spearman correlation factor for the impact on the cost between consultants and contractors r_s=0.803 (with a significance level of 0.95) means there is a very strong agreement among consultants and contractors on the ranking of the factors causing post contract design changes according to their impact on the cost of the projects.

4.12.3 IMPACT ON QUALITY

- ✓ The Spearman correlation factor for the impact on the quality between clients and consultants r_s=0.910 (with a significance level of 0.95) means there is a complete agreement among clients and consultants on the ranking of the factors causing post contract design changes according to their impact on the quality of the projects.

- ✓ The Spearman correlation factor for the impact on the quality between clients and contractors r_s=0.903 (with a significance level of 0.95) means there is a complete agreement among clients and contractors on the ranking of the factors causing post contract design changes according to their impact on the quality of the projects.

- ✓ The Spearman correlation factor for the impact on the quality between consultants and contractors r_s=0.901 (with a significance level of 0.95) means there is a complete agreement among consultants and contractors on the ranking of the factors causing post contract design changes according to their impact on the quality of the projects.

Table 26 - Spearman correlation among the different businesses according to their inputs on the post contract design changes' impact on the project's time to completion

Factor causing post contract design changes in the UAE construction industry	Rank according to the design changes' impact on the time			$\frac{6d_i^2}{n^3-n}$		
	Clients	Consultants	Contractors	Clients & Consultants	Clients & Contractors	Consultants & Contractors
Changes in Client's Requirements	1	1	1	0.000000	0.000000	0.000000
Changes Requested by Other Stakeholders	3	2	8	0.000342	0.008547	0.012308
Changes Recommended by the Contractor	18	17	19	0.000342	0.000342	0.001368
Complexity of Design/Project	7	5	7	0.001368	0.000000	0.001368
Unclear or mis-interpretation of Client Needs	8	9	4	0.000342	0.005470	0.008547
Changes in Market conditions	8	7	7	0.000342	0.000342	0.000000
Unrealistic Design/Project's Periods	6	6	7	0.000000	0.000342	0.000342
to Reduce Project Duration	19	18	17	0.000342	0.001368	0.000342
Value Engineering	14	11	12	0.003077	0.001368	0.000342
Budget Constraints (Omissions due to lack of funds)	5	4	10	0.000342	0.008547	0.012308
Errors or Deficiencies made during Design Phase	18	16	18	0.001368	0.000000	0.001368
Errors/Omissions during Construction/ Fabrication/ Transportation Phase	12	6	10	0.012308	0.001368	0.005470
Poor Communication	9	10	5	0.000342	0.005470	0.008547
Poor Coordination	11	11	11	0.000000	0.000000	0.000000
Incompetent Designer or Design Team	8	8	6	0.000000	0.001368	0.001368
Incompetent Contractor Technical Team	10	11	13	0.000342	0.003077	0.001368
Consultant NOT AWARE of the current regulations	20	20	20	0.000000	0.000000	0.000000
Unforeseen Site/Underground Condition	17	19	16	0.001368	0.000342	0.003077
Utilities Requirements	2	3	2	0.000342	0.000000	0.000342
Construction Conflict	16	13	15	0.003077	0.000342	0.001368
Sustainability Requirements (LEED/Estidama)	15	15	15	0.000000	0.000000	0.000000
Change in Government Policies/Regulations	5	4	3	0.000342	0.001368	0.000342
Mistakes/Discrepancies/Omissions in Tender/Contract Documents	4	10	6	0.012308	0.001368	0.005470
Changes to Materials and/or Specifications	12	14	14	0.001368	0.001368	0.000000
Field Conditions or Change in Site Conditions	5	12	5	0.016752	0.000000	0.016752
Changes in Construction/Permanent works Method/ Technology	13	7	9	0.012308	0.005470	0.001368
	$\frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			0.068718	0.047863	0.083761
Spearman Correlation	$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			**0.931**	**0.952**	**0.916**

Table 27 - Spearman correlation among the different businesses according to their inputs on the post contract design changes' impact on the project's cost`

Factor causing post contract design changes in the UAE construction industry	Rank according to the design changes' impact on the cost			$\frac{6d_i^2}{n^3-n}$		
	Clients	Consultants	Contractors	Clients & Consultants	Clients & Contractors	Consultants & Contractors
Changes in Client's Requirements	1	1	1	0.000000	0.000000	0.000000
Changes Requested by Other Stakeholders	2	2	8	0.000000	0.012308	0.012308
Changes Recommended by the Contractor	19	15	20	0.005470	0.000342	0.008547
Complexity of Design/Project	10	5	8	0.008547	0.001368	0.003077
Unclear or mis-interpretation of Client Needs	7	7	2	0.000000	0.008547	0.008547
Changes in Market conditions	9	8	9	0.000342	0.000000	0.000342
Unrealistic Design/Project's Periods	6	6	3	0.000000	0.003077	0.003077
to Reduce Project Duration	8	8	13	0.000000	0.008547	0.008547
Value Engineering	21	16	21	0.008547	0.000000	0.008547
Budget Constraints (Omissions due to lack of funds)	15	10	19	0.008547	0.005470	0.027692
Errors or Deficiencies made during Design Phase	17	14	20	0.003077	0.003077	0.012308
Errors/Omissions during Construction/ Fabrication/ Transportation Phase	15	12	12	0.003077	0.003077	0.000000
Poor Communication	17	12	10	0.008547	0.016752	0.001368
Poor Coordination	13	10	14	0.003077	0.000342	0.005470
Incompetent Designer or Design Team	12	13	7	0.000342	0.008547	0.012308
Incompetent Contractor Technical Team	11	9	11	0.001368	0.000000	0.001368
Consultant NOT AWARE of the current regulations	20	12	16	0.021880	0.005470	0.005470
Unforeseen Site/Underground Condition	14	5	5	0.027692	0.027692	0.000000
Utilities Requirements	4	4	5	0.000000	0.000342	0.000342
Construction Conflict	16	12	18	0.005470	0.001368	0.012308
Sustainability Requirements (LEED/Estidama)	15	11	15	0.005470	0.000000	0.005470
Change in Government Policies/Regulations	3	3	4	0.000000	0.000342	0.000342
Mistakes/Discrepancies/Omissions in Tender/Contract Documents	5	14	9	0.027692	0.005470	0.008547
Changes to Materials and/or Specifications	8	7	17	0.000342	0.027692	0.034188
Field Conditions or Change in Site Conditions	6	13	6	0.016752	0.000000	0.016752
Changes in Construction/Permanent works Method/ Technology	18	13	13	0.008547	0.008547	0.000000
	$\frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			0.164786	0.148376	0.196923
Spearman Correlation	$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			**0.835**	**0.852**	**0.803**

Table 28 - Spearman correlation among the different businesses according to their inputs on the post contract design changes' impact on the project's quality

Factor causing post contract design changes in the UAE construction industry	Rank according to the design changes' impact on the quality			$\frac{6d_i^2}{n^3-n}$		
	Clients	Consultants	Contractors	Clients & Consultants	Clients & Contractors	Consultants & Contractors
Changes in Client's Requirements	17	7	10	0.034188	0.016752	0.003077
Changes Requested by Other Stakeholders	15	13	17	0.001368	0.001368	0.005470
Changes Recommended by the Contractor	16	17	18	0.000342	0.001368	0.000342
Complexity of Design/Project	15	15	13	0.000000	0.001368	0.001368
Unclear or mis-interpretation of Client Needs	16	15	11	0.000342	0.008547	0.005470
Changes in Market conditions	13	13	14	0.000000	0.000342	0.000342
Unrealistic Design/Project's Periods	12	16	9	0.005470	0.003077	0.016752
to Reduce Project Duration	11	12	12	0.000342	0.000342	0.000000
Value Engineering	19	15	16	0.005470	0.003077	0.000342
Budget Constraints (Omissions due to lack of funds)	17	18	20	0.000342	0.003077	0.001368
Errors or Deficiencies made during Design Phase	7	4	7	0.003077	0.000000	0.003077
Errors/Omissions during Construction/ Fabrication/ Transportation Phase	9	8	4	0.000342	0.008547	0.005470
Poor Communication	9	6	7	0.003077	0.001368	0.000342
Poor Coordination	6	5	7	0.000342	0.000342	0.001368
Incompetent Designer or Design Team	18	19	19	0.000342	0.000342	0.000000
Incompetent Contractor Technical Team	11	10	13	0.000342	0.001368	0.003077
Consultant NOT AWARE of the current regulations	12	11	5	0.000342	0.016752	0.012308
Unforeseen Site/Underground Condition	1	1	1	0.000000	0.000000	0.000000
Utilities Requirements	12	12	14	0.000000	0.001368	0.001368
Construction Conflict	14	14	10	0.000000	0.005470	0.005470
Sustainability Requirements (LEED/Estidama)	2	2	2	0.000000	0.000000	0.000000
Change in Government Policies/Regulations	3	7	3	0.005470	0.000000	0.005470
Mistakes/Discrepancies/Omissions in Tender/Contract Documents	8	9	15	0.000342	0.016752	0.012308
Changes to Materials and/or Specifications	4	12	6	0.021880	0.001368	0.012308
Field Conditions or Change in Site Conditions	10	6	8	0.005470	0.001368	0.001368
Changes in Construction/Permanent works Method/ Technology	5	3	2	0.001368	0.003077	0.000342
	$\frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			0.090256	0.097436	0.098803
Spearman Correlation	$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n^3-n}$			**0.910**	**0.903**	**0.901**

Chapter 5 . RECOMMENDATIONS

5.1 INTRODUCTION

The identified factors causing post contract design changes in the UAE construction industry are high level descriptions of the actual circumstances causing the post contract design changes. The researcher held interviews with expert project management professionals from all business types, to get a thorough understanding of the circumstances triggering each factor, and record their recommendations on the best ways to prevent or reduce such design changes, and/or their negative impact on time to completion, the cost and the quality of the works. It has been noticed that, the majority of the interviewees' recommendations endorse the recommendations of Olawale and Sun (2010, p. 518) in mitigating the "design changes". The identified factors are classified into two key categories:

- ✓ Factors that are beyond the control of the main stakeholders, requiring mitigation measures to reduce the negative impact of the associated design changes on the time, cost and quality.
- ✓ Factors that require more attention from the project management professionals in the UAE construction industry, where preventive actions are necessary to reduce the recurrence of such design changes and mitigation measures to reduce the negative impact of the associated design changes on the time, cost and quality.

The identified factors causing post contract design changes in the UAE construction industry are studied in the next paragraphs; recommendations are drafted to prevent/reduce post contract design changes and reduce their negative impact on the time, cost and quality.

5.2 FACTORS BEYOND THE MAIN STAKEHOLDERS' CONTROL

- ✓ **Design changes due to Changes in Market conditions**

  The construction sector in the UAE is relatively new (less than 20 years), and the country's needs are being elaborated progressively. In the absence of thorough feasibility studies and clear expectations of future market demands, the clients usually update their strategies to maximize the revenue of the project during the construction stage, considering the forecasted changes in market demands; accordingly, the design might change to accommodate the new requirement. Changing the use of the buildings from residential to commercial or mixed use or vice versa is one example of these changes in the UAE.

  Recommendation

  The client/developer shall have a clear business plan on what he wants to achieve prior to starting the design stage; a long strategy that does not change with every fluctuation in the market. The client/developer shall determine his strategy at a high level, set out a procurement strategy, allocate a budget and a time to his project, and communicate them to the designer who shall be clear on what he has to do.

- ✓ **Design changes due to Unforeseen site/underground condition**

  In the UAE, the tender documents are often issued including an initial soil survey report. In some cases, such report do not represent the actual soil condition, such in the constructions built in the islands and/or in the vicinity of the coast, where the water table's level fluctuates or a poor soil bearing capacity is determined; in other places, cavities do exist and are causing continuous settlements. Such inconsistencies often do occur in projects with a large footprint or in infrastructure projects, where the pre-tender soil survey cannot cover all areas.

Whenever any of the aforementioned conditions does exist, the foundation design included in the tender documents might be inaccurate, when the contractor carries out his own soil investigation, to verify the design criteria assumed in the design stage and therefore, design changes become required.

Recommendation

Before starting the tender stage, the client/developer shall appoint an expert laboratory who had previous experience in the area being studied, to explore the construction sub-soil conditions; however, it is advised to increase the number and depth of the boreholes as to have a better understanding of the underground conditions and obtain a realistic design.

In the UAE tenders, designers maintain a budget for the soil investigation in the bills of quantities (BOQ); it is advisable that such amount be omitted from the BOQ and paid by the client in advance, to achieve a reasonable sub-structure design and avoid surprises; hence the contractor cannot claim for any extension of time or additions to his price.

- ✓ **Design changes due to Utilities requirements**

Mechanical, Electrical and Plumbing (MEP) works require the approval of the concerned authorities who entail alterations to the related design, which are sometimes beyond the applicable regulations. In several occasions, such changes occur during/prior the handing over stage.

Recommendation

Maintain an open dialog with the authorities and ensure that the design integrates all authority requirements.

- ✓ **Design changes due to sustainability requirements (LEED/Estidama)**

  The "LEED" requirements were introduced in Dubai and partially in Abu Dhabi as to comply with the country leaders' vision to transform the UAE into a sustainable environment, not relying only on the oil resources.

  The regulations of "Estidama" – the Arabic acronym to sustainability – were introduced in 2010 in the Emirate of Abu Dhabi and became a mandatory design requirement for all newly constructed buildings even those contracts awarded prior to that date, and that were still processing the building permit from the Municipality. On the other hand, several owners of buildings started in 2009 and 2010 were keen to obtain such certification to enhance marketing their construction as green buildings, mandating design changes.

  Recommendation

  Complying with "LEED" or "Estidama" requirements is a design exercise more than a construction issue. To mitigate such risk, consultants shall teach their employees on "LEED" and "Estidama" requirements and ensure they understand comprehensively and in details those requirements, in order to maintain their design fully complying. An alternative option is to hire companies specialized in sustainability; then initiate a process for evaluating the compliance of materials with "Estidama"'s requirements prior to approvals.

- ✓ **Design changes due to Change in government policies/regulations**

  The governments in the UAE are regularly issuing new regulations and amending the current regulations where some regulations have an impact on the construction sector. Similarly, the authorities in all the Emirates have gone into restructuring; continuously and periodically they are upgrading their existing regulations to comply with the changes in international standards and technology. The contractors are the most

suffering especially during the handing over to the authorities at the end of the project when they face new regulations and new requirements. Such changes are continuously causing design changes in the construction projects.

Recommendation

The contractor shall liaise with the authorities early in the project, prepare his shop drawings at earliest and get the authorities' approvals at the early stage of the project.

A liaison engineer may be required to ensure that all designs issued by the designer and the shop drawings issued by the contractor are all in line with the latest authorities' regulations

Usually, authorities honor their previous written approvals on the shop drawings and do not enforce the new regulations. However, some authorities such as Abu Dhabi Food Control Authority (ADFCA) do not approve in writing the drawings at the early stage to keep for themselves the flexibility for introducing changes at a later stage. Contractors can deal with such a risk by getting early feedback from ADFCA via informal site visits by ADFCA officers and verbal comments.

It is beneficial to include clauses in the contract on how to deal with such changes and maintain a contingency in the budget that will be used only if regulations are changed, to avoid a higher price by the contractor for a risk that it may never happen.

- ✓ **Design changes due to Field Conditions or Change in Site Conditions**

This is a typical case in external works of building projects, when utilities' connections and underground utility networks are required. The contractors get the as-built drawings from the authorities to identify the existing services, but when starting trial pits, new existing services (pipes or cables) are unexpectedly identified, while they have never been recognized or displayed in the as-built drawings provided by the authorities.

In consequence, design changes for re-routing of the new services (water supply, storm water and drainage networks, electrical and data cables etc.) become unavoidable.

Recommendation

The contractor has to get as many as-built drawings from the authorities on the existing services, and examine what is actually existing based on numerous trial pits to avoid last-minute surprises. It is also advisable to use cable detectors equipment to detect live power cables.

5.3 FACTORS REQUIRING MORE ATTENTION FROM PROJECT MANAGEMENT PROFESSIONALS

- ✓ **Design changes due to Changes in the Client's requirements**

This factor is the top ranking in recurrence and the caused design changes have the highest impact on the time, cost and quality as concluded earlier.

In several instances, the clients are not always engineers or experienced in developing construction projects; in many instances, they are unable to imagine the final product only from the drawings. Once the product is ready, they may not like it, and they request changes. In other instances, clients would like to implement a theme or design or system they have seen in another project or another developed country, even at a late stage of the project. On the opposite, it happens also that sometimes, clients would seek to change a pattern because they have seen a similar one executed somewhere else, and they want their product to be unique.

It is necessary to note that, some clients believe it is their privilege to change anything at any time since they are paying the cost and absorbing the other impacts, and may be difficult to convince them for changing their mind; Project managers, consultants and contractors are keen to keep their clients happy by changing the design to their clients' satisfaction.

Recommendation

At first it is advisable that clients/developers assign a project manager to manage the consultant and the contractor, for a successful delivery of the project.

At concept stage and prior to sign off of the design, the project manager shall briefly explain to the client the design at hand, the technical requirements of the project, in accordance with the current authorities' rules & regulations and the nature of the project to avoid further directions from the Client during the Construction stage. Frequent presentations to the client/developer shall be held; sample rooms and mockups are to be built, for a better understanding of the end product.

On the other side, the project manager shall inform the client, on when he can and when he cannot make changes. The project manager shall use his due diligence to evaluate the benefits of change and compare them to the cost and time impacts that may be required; he shall be honest with the client on the possible ramifications if such changes are adopted at every stage. Several project management companies/ consultants or contractors tell the client what he wants to hear, but they should be honest with him on what he can and what he cannot change at a certain stage.

In the design programme, there should be reservation for making changes and what kind of changes; fundamental changes can occur during the concept or schematic design, but not during the detailed design. A definitive milestone in the construction programme is to be set out, where no more changes can be accepted or absorbed.

- ✓ **Design changes due to Changes requested by other stakeholders**

The pool of stakeholders is widespread including customers, tenants, hotel operators, facility management, authorities, shareholders, financing and insurance institutions… Improper or incomplete identification of the stakeholders at the initiating stage and/or poor management of the identified stakeholders' expectations often cause changes to

fulfill new mandatory requirements of newly identified stakeholders, who have their own needs and requirements, predicting some changes to the design.

Recommendation

Early identification of the stakeholders is essential to implement their needs in the design; proper management of stakeholders' expectations throughout the project and identification of new stakeholders are required as to reduce design changes and their negative impact. When a request for change rise, it has to be evaluated for the possibility of implementation or it shall be considered a separate project to be done after handing over of the current project.

- ✓ **Design changes due to Changes recommended by the contractor**

A considerable amount of the respondents to the questionnaire claimed in the feedback section that, contractors usually propose changes only if they are for their own benefit, either to increase their profit and/or to mitigate a delay for which they are responsible, to avoid penalty. This was confirmed by the interviewees from the different categories, who also claimed that rarely the employer's benefit is a priority for a contractor. However, other respondents claimed that poor design by the designer who is also the supervision consultant will cause site problems that might be detected during the construction phase and raised by the contractor who may suggest some changes; after validating such problems; the designer is forced to perform the related design changes to overcome the problem and cover his mistakes.

Recommendation

The client and the consultant should not be excited for immediately accepting a change proposed by the contractor, but rather investigating the circumstances. The contractor has to demonstrate what is the advantage to the client (cost or time), and the time required for such a change, without impacting the project. When such change is

financially beneficial to the client, the design change may be accepted without extension of time; otherwise it has to be denied.

- ✓ **Design changes due to Complexity of design/project**

  These changes are typically incurred in projects having intricate design (irregular type of structure, hybrid structures); such as in iconic and/or high rise buildings, also in large horizontal projects where infrastructure networks are required.

  Recommendation

  From the design stage, the project is to be divided into phases, for an easier delivery. The same methodology is to be followed in the planning of the construction phase. An early and full coordination of the drawings, and a review of the constructability can address and resolve the complexity in the design. Complexity is not a problem to be solved, but a difficult situation requiring more coordination efforts. However, it is advisable at the early stage of the project that the contractor provides different options of construction with the cost and time impacts of each option.

- ✓ **Design changes due to Unclear or misinterpretation of client needs**

  It happens that project managers and/or consultants establish the scope of work based on clients' requirements rather than the clients' needs. On various occasions, such requirements do not reflect the Clients' actual needs, thus changes to the design become necessary to overcome such problems.

  Recommendation

  At an early stage, the project manager shall meet the client frequently to understand his needs and requirements. More meetings and professional presentations at the initiation stage are required to ensure that all stakeholders including the client, are aware of the deliverables, and their needs and requirements are implemented, then a formal approval

has to be given. The project manager shall not rush the start of the project. The stakeholders are also to be educated when they can or cannot make a design change.

- ✓ **Design changes due to Unrealistic design/project's periods**

The recent construction era in the UAE was the fast track projects era; skyscrapers were built in less than 2 years, large developments and malls in similar periods. The investors were looking for the shortest time to start using their properties by not allowing enough time for the design and by imposing short periods for the completion; majority of the projects were starting before completion of the design. Design changes were required for successful completion.

Recommendation

The designer shall use the historical information from his company in designing previous projects, to estimate the proper time required for the design, and prepare a realistic programme for the design. A peer review of the design will ensure the design is complete, and no alterations are required later on. Applying other delivery approach such as design-build contracts may address this issue as well when the Client has no time to wait until the design is fully completed for starting the construction.

- ✓ **Design changes to reduce project duration**

In the recent years, there was evolution in the construction methodologies and techniques, to assist the contractors in reducing the projects' durations, which is the key point encouraging and tempting the contractors to implement especially if clients do not incur additional costs; such new techniques might require substantial design changes such as changing the structural systems.

Recommendation

Such change shall not be accepted unless there is a financial benefit for the client.

- ✓ **Design changes due to Value Engineering**

  Value engineering became a trend in the UAE. Clients, consultants and contractors strive to bring value management for their projects just after construction starts; i.e. achieve equal or better quality of the end product, by using alternative materials, technologies, procedures… at less price, offering some cost saving to the client. The conclusion is some post contract design changes.

  Recommendation

  Value engineering has to be made from the onset of the project, during the concept design, not in detailed design stage. A peer review of the design by a consultant specialist in value engineering, other than the designer, will serve the purpose. However, when the contractor is on board and is proposing value engineering, he shall demonstrate how long the implementation is going to take, without negative time impact. Normally the contractor proposes to share the profits with the client. Hence, the client shall be prepared to offer incentives. Regular value engineering workshops are to be held at different stages of the construction. As a preventive action, only the provisional sum items can be designed or modified during the construction stage because they are tendered and procured in that stage.

- ✓ **Design changes due to budget constraints (omissions due to lack of funds)**

  Projects are rarely properly budgeted and, cost overrun may materialize for several reasons. At the end, the client finds himself unable to pay all the increasing cost, opting to reduce the price by reducing the scope. As an example, following the financial crisis in 2008, the banks stopped financing the construction projects for a while; several clients who largely rely on the banks' finance rather than their own funds, opted to reduce the scope to be able to complete their projects; the post contract design changes were inevitable.

Recommendation

Ensure appropriate cost estimate is in place at the early stage of the project; it is advisable that the evaluation is done by an expert to ensure the cost is reasonable.

- ✓ **Design changes due to Errors or Deficiencies made during Design Phase**

Designer's errors during the design phase are recurring and include unclear/ incomplete/ inadequate/ inconsistent/ poor/ unrealistic design, conflicting Specifications, outdated design criteria... Several designers rely on specialized subcontractors' design that is implemented in their tender documents, without exercising their due diligence in verifying the provided design. Such mistakes are rectified by elaborating / changing/ upgrading the design.

Recommendation

The appointment of a competent designer with previous experience in similar projects is a key factor to reduce such design mistakes. A peer review of the design by a third party prior to finalizing the drawings will overcome such problem, then ensure that a detailed design (not schematic) is issued to the contractor. A comfortable duration for the design and the design review is necessary to reduce design mistakes.

- ✓ **Design changes due to Errors/Omissions during Construction/ Fabrication/ Transportation Phase**

When the contractor's supervision staff is not enough to cover all the ongoing activities, errors and rework are frequent. For example, in precast elements, errors might occur when attempting to deliver elements without considering the intermediate construction phases.

Recommendation

The appointment of a first class contractor is a key ingredient to solve this problem. The project manager and the consultant shall ensure that the contractor's team is qualified

from the early stage of the project. Appointment of specialist subcontractors reputed in their business is another factor for reducing such mistakes.

- ✓ **Design changes due to Poor communication**

  This is a recurring factor when a poor or no communication plan is at hand inside the clients'/ contractor's / consultants' organizations or between the different departments in the same organization. As an example, shop drawings on the site are not updated promptly whenever alterations occur due to the lack of communication between the engineering and the construction teams; the executed works may not be reversible and additional design changes might be required to rectify what has been built.

  Recommendation

  From the onset, ensure that a communication plan (protocol) is clear to everyone, ensure it is easy, tested and is working smoothly and not creating any issues. More frequent meetings will ensure that the information and the project objective are conveyed to all the teams, thus reducing such mistakes.

  The use of communication systems like ACONEX will simplify the communication and avoid missing papers, reduce the errors due to human mistakes.

  Set out timelines to reply to queries related to design issues and decisions/approvals.

- ✓ **Design changes due to Poor coordination**

  Another common factor among designers or contractors' technical teams who have less experience or are reluctant to make all the necessary coordination, between the different components of the project, to resolve the clashes among the different trades. The resolution of subsequent problems may require design changes to the end product.

  Recommendation

  The appointment of a competent designer, a competent contractor, and the peer review of the design are all measures that reduce the design changes. The designer has to

ensure that his design is coordinated; he has an obligation to check that the contractor is doing his job. The contractor shall ensure that he has a professional technical team on site, one engineer from each trade, other than the construction team to identify the problems before they occur. Early coordination is the perfect solution to deal with such a risk.

- ✓ **Design changes due to Incompetent designer or design team**

  An incompetent designer would produce a poor design or a costly execution of the works. Such poor design may be discovered during the execution or by a third party reviewing the design. A redesign would be required for a cost effective product.

  Recommendation

  Implement strong Prequalification process for the appointment of the designer. The appointment of a qualified reputed designer, with previous similar experience and a third party review of the design will reduce the hassles.

- ✓ **Design changes due to incompetent contractor technical team**

  The Incompetent contractor technical team would result in poor understanding of the drawings and/or specifications; such as submitting non-compliant materials, poor quality control of the executed works, shortfalls in the design, production of non-coordinated shop drawings; alterations to the existing design might be a way of rectifying the resulting problems.

  Recommendation

  Implement a strong Prequalification process for the appointment of the contractor taking into consideration his technical teams' qualifications and experience. The project manager and the consultant shall be exceptionally careful and ensure that, only experienced contractor's teams are on the job.

- ✓ **Design changes due to Consultant not aware of the current regulations**

  In the recent years, it became a trend in the UAE to hire international consultants to prepare the concept design and urban planning for large or iconic projects, even though without physical existence in the UAE. It has been noticed that several local regulations were ignored in the provided designs, caused by the designer's ignorance of the local regulations, making them difficult to implement without further design changes.

  Recommendation

  Ensure that the appointed design consultant has a vast experience with the local authority regulations.

- ✓ **Design changes due to Construction conflict**

  In construction projects, there is potential for conflicts during the construction. Persons in key positions may push for the use of a non-compliant material or non-approved subcontractor due to a conflict of interest. Design changes might be unavoidable. In other cases, conflict does exist between the main contractor and the subcontractor nominated by the client; design changes might be required to overcome such conflict.

  Recommendation

  The project manager shall interfere to solve the problem; all the entities shall work as one team for successful completion of the project.

- ✓ **Design changes due to Mistakes/Discrepancies/Omissions in Tender/ Contract Documents**

  Tender/contract documents are not prepared from scratch, but rather by copying specifications/ particular conditions of contract & bills of quantities from previous successful projects, then altering them to meet the new project's conditions. Teams preparing the tenders may miss correcting some sections, or omit sections or even

include complete sections not relevant to the project at hand. Such mistakes/omissions/discrepancies are wealthy source of design changes.

Recommendation

The appointment of a competent designer is the basis for issuing a full tender. However, the designer has to be given enough time to prepare the tender; it is advisable that the tender is reviewed by qualified people before sending to the bidders; ensure enough time is given to the bidders to send their queries and allow for responses; issue amendments to the original tender to clarify ambiguities and/or omissions.

- ✓ **Design changes due to Changes to Materials and/or Specifications**

  During the construction phase, it happens that some required materials might be unavailable in the supplier's stock or requiring a long delivery time, or upon realizing that the specified material is found to be costly while alternative cheaper material can serve the purpose without compromising the quality standards. Such amendments may entail deviations from the specifications.

  Recommendation

  Ensure that clear specifications are in place, and all the materials meet the client's needs; no change is to be tolerated unless the article is missing from the specifications.

- ✓ **Design changes due to Changes in Construction/Permanent works Method/ Technology**

  The UAE is an open market where all the latest technologies in construction and/or permanent works are being imported and implemented whenever possible. Such changes are recurring at different stages of the construction, mainly in security/ new technologies/ information technology, regularly generating design changes in the construction projects.

Recommendation

Upon finalizing the design, a peer review of the design will ensure the constructability of the design. If the designer is confident in his design, such changes are to be denied.

5.4 LEARNED LESSONS

The preceding factors and recommendations are summarized in Table 29. In addition, below are some measures recommended by Olawale and Sun (2010, p. 518), that aid in better management of the post contract design changes:

- ✓ Ensure that the reason of the change is always identified and recorded.
- ✓ Prepare a strategy on how to handle the design changes, implement in the contract, particularly in design-build contracts.
- ✓ Whenever possible, decide the time and cost impact before proceeding further.
- ✓ Appoint a design manager to handle all the design related changes.
- ✓ Try to avoid late design changes as it has extremely serious impact on the time, cost and quality.

5.5 TRUSTWORTHINESS OF THE METHOD

The trustworthiness of this research method is dictated by the validity of the collected data, the reliability of the results and the possibility of generalization to a wider population.

5.5.1 DATA VALIDITY

Every researcher strives to maximize the internal and external validity of his research.

The researcher has taken care of the common threats hindering the internal validity of the gathered data. The candidates were randomly and impartially selected from the pool of senior construction professionals in the UAE (Clients, Consultants and Contractors), very experienced (see Table 9), which makes their responses mature and reliable. The

questionnaire was tested and re-tested several times prior to sending to the actual participants, to improve the clearness of the questions and eliminate ambiguities, and ensure that only appropriate and relevant questions are asked since wrong questions incur erroneous results.

External validity dictates to what extent a study can be generalizable to the bigger population from which the sample was selected. External validity highly depends on the internal validity. The participants were selected from the pool of construction professionals who worked across the UAE and are recently working in Abu Dhabi, Dubai or Sharjah, in different types of projects in the construction and infrastructure, using different types of contracts. Their responses reveal mature understanding of the design change process, the reasons behind and the consequences; this was confirmed in the qualitative study during the interviews, where the interviewees confirmed the results of the survey. The collected data was scrutinized for inconsistencies and/or erroneous values that were omitted from the responses' database.

The number of respondents (200) was higher than the required sample size (196) for a large population, with a confidence level of 95% and a precision of ±7%; with a high response rate (60%) as shown in Table 7 which provided a better accuracy in the responses; therefore, selecting a wider sample would most probably provide extremely close answers to what was obtained in this sample.

5.5.2 RESULTS' RELIABILITY

The reliability of the results tells whether the results of the present research can be generalized to a broader group of construction professionals in the UAE.

Lincoln and Guba (1985, p. 301) recommended a reliability assessment to determine how credible are the interpretations made by a researcher.

The reliability and integrity of this research were improved due to the below recommendations of Lincoln and Guba (1985, pp. 301-319) respected by the researcher when interpreting the results:

- ✓ The researcher used various research techniques (quantitative survey and qualitative interviews) with triangulation of the findings.
- ✓ The researcher got the opinion of other project management professionals not related to the current study, and that even did not participate in the survey, to learn how realistic were the questionnaire, the means of the data gathering and the explanation of the results.
- ✓ The researcher had constantly examined the interpretations against the collected data and had revisited and revised them several times, after every interview.
- ✓ All the research data is archived electronically and in hard copies, for reference and supplementary analysis if required.
- ✓ The interpretations of the results were crossed checked with various professionals who filled up the survey, to find almost identical interpretations and further examples that broadened the researcher's understanding of the actual situations.

In conclusion, the results of the present research are reliable and can be generalized to the UAE construction industry.

5.6 CONCLUSION

The factors causing post contract design changes in the UAE construction industry, classified under the different project management knowledge areas (Figure 4) reveal that the scope management, human resource management and risk management are the project management knowledge areas requiring the most attention from the construction professionals in the UAE, in order to deliver projects successfully. However, the remaining

knowledge areas need attention as well since some of them may cause severe impacts on the projects, especially that some time, one design change may result from more than one factor, which makes the mitigation more challenging.

The present research has identified the factors causing post contract design changes in the UAE construction industry and ranked them from different perspectives according to their impact on the time, cost and quality. Considering the identified factors, future studies would consider case studies and qualitative surveys from the UAE, for a better understanding of what is being done to overcome the risk of design changes and propose improvement to the processes being adopted and/or mitigation measures for reducing their recurrence and/or their negative impact on the projects. Separate studies would be done on design-build contracts where construction starts prior to completion of the final design.

Moreover, the construction in the Gulf region follows similar techniques used in the UAE; considerable amount of developers, project management companies, consultants and contractors are working cross-Gulf countries, the construction professionals working in other countries of the Gulf are from the same countries of those working in the UAE, and many of them have worked previously in the UAE and vice versa; the present study can be run in any other Gulf Country where conditions are remarkably similar.

Table 29 – Preventive and mitigation measures to reduce design changes and/or reduce their impact on the time, cost and quality

S/N	Factor causing post contract design change	Preventive and Mitigation measures to reduce design changes and/or reduce the impact of such changes on the time, cost and quality
1	Design changes due to Changes in the Client's requirements	1. Client to assign a project manager. 2. The project manager shall explain to the client the design at hand and the consequences of such change (domino effect). Be honest with the client. 3. Hold professional presentations, make sample rooms and mockups. 4. Educate the client when he can and when he cannot change; include a milestone in the programme on when the design is frozen; no more changes are accepted. 5. Fundamental changes to be accepted during concept or schematic design phase, not after detailed design's completion.
2	Design changes due to Changes requested by other stakeholders	1. Early identification of the stakeholers. 2. Manage the stakeholders' expectation and try to identify new stakeholders. 3. Keep the stakeholders updated on the current design and how their needs and requirements have been implemented. 4. Educate the stakeholders on when they can and when they can not make design changes.
3	Design changes due to Changes recommended by the contractor	1. The contractor shall demonstrate the advantage to the client; the cost saving provided and confirm that there is no time impact. 2. Design changes shall not be accepted unless they are benefitial to the client.
4	Design changes due to Complexity of design/project	1. Divide the project into phases, from the design onset till the construction phase. 2. Review the constructibility. 3. The contractor has to provide the client different options for construction, with the time and cost impact of each option.
5	Design changes due to Unclear or mis-interpretation of client needs	1. The project manager is to hold regular meetings with the client and prepare presentations, at the early stage to understand all his needs, and translate them into understandable requirements. 2. Get a formal approval.
6	Design changes due to Changes in Market conditions	1. Develop clear business plan & strategy 2. Communicate to the designer
7	Design changes due to Unrealistic design/project's periods	1. Prepare a realistic programme for the design. 2. Peer review of the design to ensure its completeness. 3. In design-build projects, set a milestone when the design shall be completed and no more fundamental changes will be tolerated.
8	Design changes to reduce project duration	Shall be accepted only if it is beneficial to the client.
9	Design changes due to Value Engineering	1. Value engineering to be carried out in the early stage of the project. 2. Hold a peer review of the design by value engineering specialist consultant. 3. It is advised that only provisional sums be designed or changed during the construction stage.

Table 29 (continued) - Preventive and mitigation measures to reduce design changes and/or reduce their impact on the time, cost and quality

S/N	Factor causing post contract design change	Preventive and Mitigation measures to reduce design changes and/or reduce the impact of such changes on the time, cost and quality
10	Design changes due to budget constraints (omissions due to lack of funds)	Ensure an appropriate cost estimation done by an expert, from the early stage of a project.
11	Design changes due to Errors or Deficiencies made during Design Phase	1. Appoint competent designer with previous experience in similar projects. 2. Allocate a realistic time for the design. 3. Hold peer review of the design. 4. Deliver a very detailed design.
12	Design changes due to Errors/Omissions during Construction/ Fabrication/ Transportation Phase	1. Appoint a first class contractor. 2. Ensure that only contractor's qualified and experienced team members are on the job
13	Design changes due to Poor communication	1. Ensure a communication plan is clear, easy, tested, and smoothly working. 2. Hold more frequent meetings to ensure the information is conveyed to all team members. 3. Use communication software.
14	Design changes due to Poor coordination	1. Appoint competent designer. 2. Hold peer review of the design. 3. Appoint competent contractor. Appoint one engineer per trade other than the team on site, to coordinate and discover any discrepancies.
15	Design changes due to Incompetent designer or design team	1. Implement strong prequalification process for appointing the designer. 2. Undertake a a third party peer review of the design.
16	Design changes due to incompetent contractor technical team	1. Implement strong prequalification process for appointing the contractor, considering the technical teams' qualifications, not only the lowest price. 2. Ensure only experienced contractor's teams are on the job.
17	Design changes due to Consultant not aware of the current regulations	Appoint a consultant who has vast experience with the local authorities' regulations.
18	Design changes due to Unforeseen site/underground condition	1. Appoint an expert laboratory with previous experience in the area. 2. Increase the number and depth of boreholes. 3. Carry out a full soil investigation prior to starting the design.

Table 29 (continued) - Preventive and mitigation measures to reduce design changes and/or reduce their impact on the time, cost and quality

S/N	Factor causing post contract design change	Preventive and Mitigation measures to reduce design changes and/or reduce the impact of such changes on the time, cost and quality
19	Design changes due to Utilities requirements	1. Maintain a dialog with the authorities. 2. Ensure integration of all authorities requirements in the design.
20	Design changes due to Construction conflict	1. The project manager shall interfere to solve the problem. 2. All the entities shall work as one team for successful completion of the project.
21	Design changes due to sustainability requirements (LEED/Estidama)	1. Designer to train his employees on the new requirements. 2. Hire consultant companies specialized in sustainability.
22	Design changes due to Change in government policies/regulations	1. Appoint a liaison engineer to ensure that the design and the shop drawings comply with the latest authorities' regulations. 2. Complete the shop drawings at the early stage of the project.
23	Design changes due to Mistakes/Discrepancies/Omissions in Tender/ Contract Documents	5. Develop the design to a detailed level prior to issue the tender.
24	Design changes due to Changes to Materials and/or Specifications	1. Ensure clear specifications are available. 2. Deny change unless the article is missing from the specifications.
25	Design changes due to Field Conditions or Change in Site Conditions	1. contractor to get as many as-built drawings from the authorities on the existing services. 2. Make numeros trial pits 3. use cable detector equipment.
26	Design changes due to Changes in Construction/Permanent works Method/Technology	1. Peer review of the deisgn to ensure constructibility of the design. 2. If the designer is confident in his design, such changes shall be denied.

ANNEXES

ANNEX 1 – BUILDING THE QUESTIONNAIRE

1. INTRODUCTION

The researcher starts the questionnaire by introducing himself and the aims of his dissertation, and inviting the candidate to participate in the survey. The researcher informs the participant that his contribution is voluntary, and no foreseeable risks are associated with the study, giving him the option to drop his participation at any time during the survey. Moreover, he is notified on the anonymity when collecting the results and confidentiality in maintaining the participants' records. The participant is also informed on the importance of his participation and the value of his inputs as a professional, in identifying the factors causing post contract design changes in the UAE construction industry. At the end, the author posts his contact details for further clarifications if required and a "Thank you" to the participant.

The purpose of each question and how the data will be used in the analysis are considered while structuring the questionnaire; hence, redundant questions are avoided as a long survey will discourage the participant from completing it till the end.

2. GATHERING THE PARTICIPANT'S INFORMATION

In this section, the participant is required to enter the following information:

- ✓ Name.
- ✓ Position / Title.
- ✓ Years of experience.
- ✓ Email.
- ✓ Company name.

- ✓ Company's business type (Developer/ Owner/ Client, Project Management, Designer/Consultant, General Contractor, Subcontractor MEP (Mechanical, Electrical, Plumbing), Subcontractor (other) or other to be specified.

For reasons of anonymity, the participant is informed that his name, Email and company's name are optional while the other information is required.

3. COLLECTING THE PROJECT'S INFORMATION

In order to achieve realistic responses, the researcher intended to obtain information specific on projects completed/or under construction, on a rate of one project per participant; hence, the participant is informed in this section, not to provide general information from various projects, but rather from **only one** of his completed or under construction projects.

In this section, the participant is required to enter information about his project:

- ✓ Type of project (residential, commercial, mix use, industrial, infrastructure or other type to be specified).
- ✓ Contract type (design-bid-build, design-build, Engineering-procurement-construction, re-measure or other type to be specified).
- ✓ Original time for completion.
- ✓ Actual or expected time for completion.
- ✓ The Original budget.
- ✓ Actual or estimated budget.

For reasons of anonymity, the information on the time & budget is optional while the remaining information is required.

4. LISTING THE FACTORS CAUSING POST CONTRACT DESIGN CHANGES

This section starts by a brief description of post contract design changes as "the changes occurring to the drawings &/or specifications of a project during the construction stage",

then asking the participant on the real factors that caused design changes during the performance of his project. The participant is notified that in the next section, he is required to rank the selected factors according to the caused design change's impact on the time, cost & quality, then include any emergent factors and classify them at the end of the next section.

The literature review led the researcher to a list of factors causing post contract design changes as shown in Table 1. The list of factors has been sent to several construction professionals to identify any emergent factors causing post contract design changes under the different project management knowledge areas, in the UAE construction industry and the list was amended accordingly several times.

The preliminary responses revealed that many participants are not familiar with the project management knowledge areas; hence, the author decided to drop the knowledge areas from the list and maintain the identified factors as a simple list as shown in Table 3.

5. RANKING THE FACTORS

In this section, the participant is requested to rank the factors he selected according to the caused design changes' impact on the cost, time & quality he had in his selected project. Each factor is ranked on a scale from '-3' to '+3' as shown in Table 30.

Table 30 - Guideline for ranking the identified factors causing post contract design changes in the UAE construction industry

Factor rating	Impact on time	Impact on cost	Impact on quality
-3	Major delay time increase >20%	Major cost overrun cost increase >20%	Major decline in quality
-1	Minor delay 0 < time increase ≤ 10%	Minor cost overrun 0% < cost increase ≤ 10%	Minor decline in quality
0	No impact	No impact	No impact
1	Minor acceleration 0% < time reduction ≤ 10%	Minor cost saving 0 < cost saving ≤ 10%	Minor improvement
3	Major acceleration time reduction > 20%	Major cost saving cost saving > 20%	Major improvement

6. PARTICIPANT'S FEEDBACK

In this final section, the participant can optionally include his feedback. Such feedback enables the researcher to get a broader opinion of the participants and assists him in getting an in-depth understanding of the different factors.

ANNEX 2 - INVITATION TO PARTICIPATE

Dear #FirstName#,

As an essential and final step for achieving the Msc in Project Management (Construction & Infrastructure) from the University of Liverpool (UK), I am carrying out a study for identifying the factors causing design changes during the construction stage, in the UAE construction industry.

The following survey is addressed to construction professionals like you, whom opinion is very important in understanding the factors causing design changes during the construction stage, in the UAE construction industry. The complete survey may take up to 10 minutes from your valuable time.

PLEASE BE CAREFUL ABOUT THE RATING OF THE FACTORS BETWEEN POSITIVE AND NEGATIVE RATING.

Your response is highly appreciated.

The link to the survey is:
#surveylink#

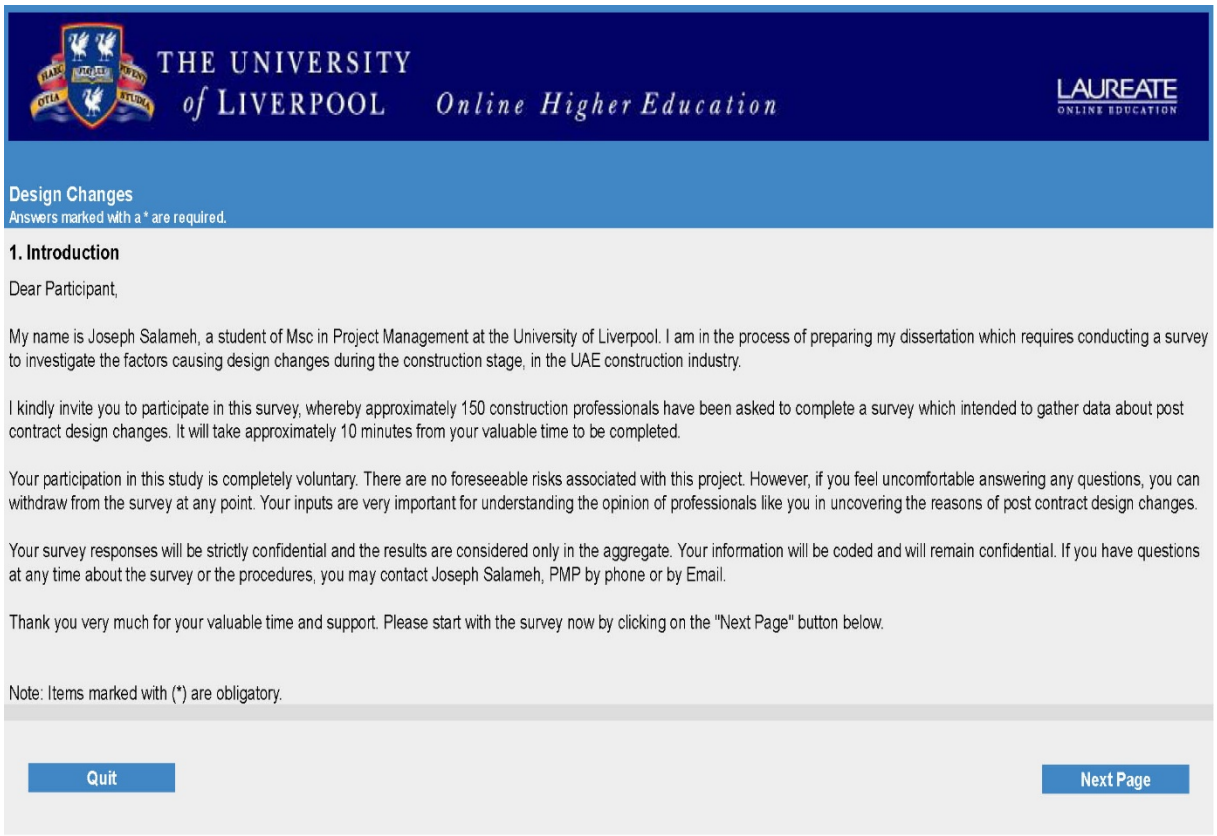
to stop receiving my Emails, please click the following link #RemoveLink#

Thank you for your help.

Best Regards,

#Researcher Name & Telephone#

ANNEX 3 - QUESTIONNAIRE LAYOUT



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Design Changes

Answers marked with a * are required.

1. Introduction

Dear Participant,

My name is Joseph Salameh, a student of Msc in Project Management at the University of Liverpool. I am in the process of preparing my dissertation which requires conducting a survey to investigate the factors causing design changes during the construction stage, in the UAE construction industry.

I kindly invite you to participate in this survey, whereby approximately 150 construction professionals have been asked to complete a survey which intended to gather data about post contract design changes. It will take approximately 10 minutes from your valuable time to be completed.

Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. Your inputs are very important for understanding the opinion of professionals like you in uncovering the reasons of post contract design changes.

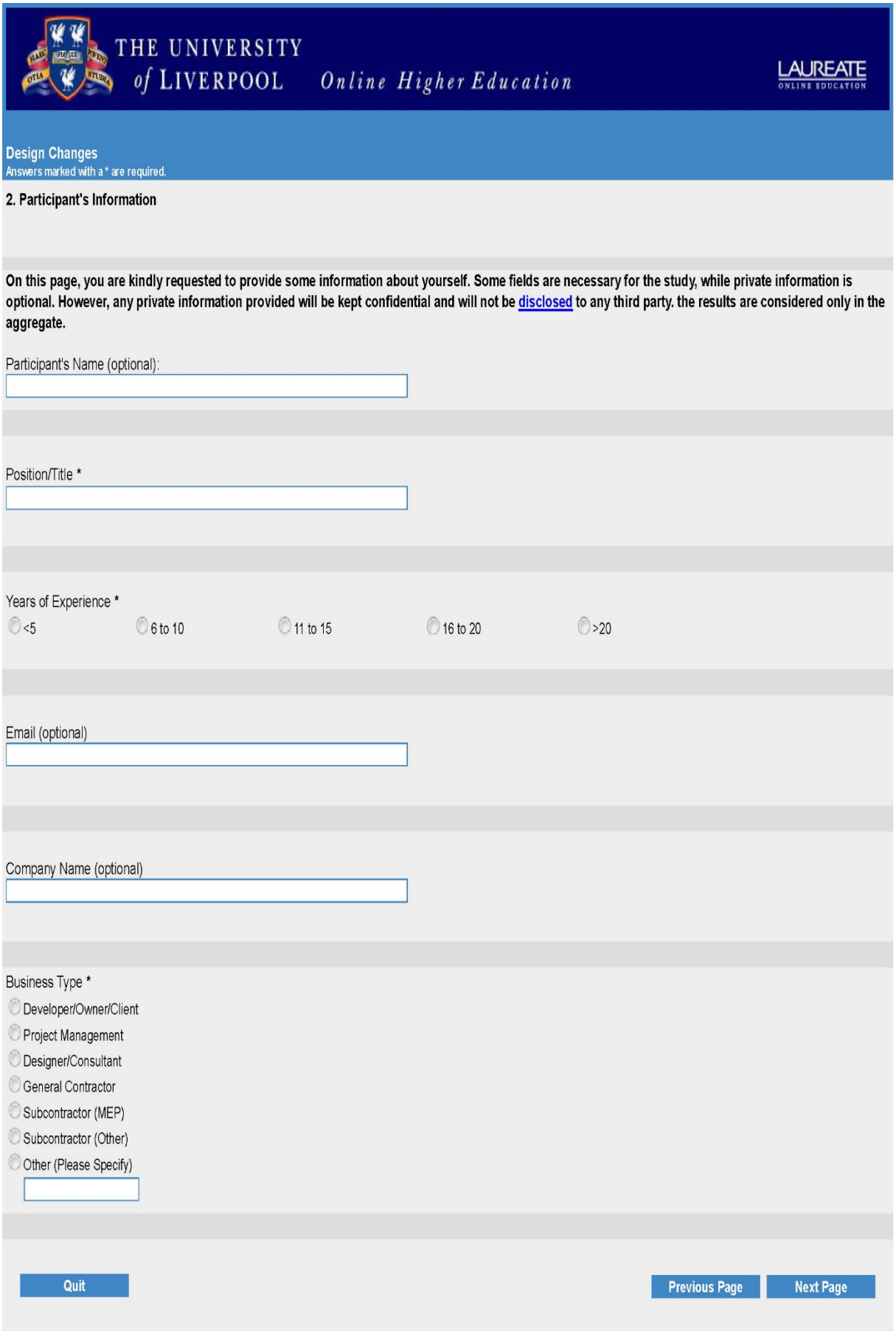
Your survey responses will be strictly confidential and the results are considered only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Joseph Salameh, PMP by phone or by Email.

Thank you very much for your valuable time and support. Please start with the survey now by clicking on the "Next Page" button below.

Note: Items marked with (*) are obligatory.

Quit

Next Page



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Answers marked with a * are required.

2. Participant's Information

On this page, you are kindly requested to provide some information about yourself. Some fields are necessary for the study, while private information is optional. However, any private information provided will be kept confidential and will not be disclosed to any third party. the results are considered only in the aggregate.

Participant's Name (optional):

Position/Title *

Years of Experience *

<5 6 to 10 11 to 15 16 to 20 >20

Email (optional)

Company Name (optional)

Business Type *

Developer/Owner/Client
Project Management
Designer/Consultant
General Contractor
Subcontractor (MEP)
Subcontractor (Other)
Other (Please Specify)

Quit Previous Page Next Page

Design Changes
Answers marked with a * are required.

3. Project Information

The current survey shall cover the information from ONLY ONE of your current or last completed projects in the UAE. Please DO NOT provide general information from several projects, as this would lead to erroneous conclusion.

Type of project *

- ○ Residential
- ○ Commercial (Offices, mall, retail...)
- ○ Mix use (Residential + commercial)
- ○ Industrial
- ○ Infrastructure (School, Hospital, Airport, other...)
- ○ Other (Please Specify)

Contract Type *

- ○ Design-Bid-Build (lump sum)
- ○ Design-Bid-Build (Remeasurable)
- ○ Design-Build
- ○ Engineering, Procurement, Construction (EPC)
- ○ Other (Please Specify)

Original Time for Completion in months (optional)

Actual (or expected) Time for Completion in months (optional)

Original budget of the project in AED (optional)

Actual (or estimated) budget in AED (optional)

Quit | Previous Page | Next Page

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Design Changes
Answers marked with a * are required.

4. Factors causing design changes during the construction stage

Post Contract Design changes are changes occurring to the drawings &/or specifications of a project during the construction stage. During the execution of your project selected in page 1, what were the actual factors causing design changes?

Important Note:
On the next page, you will be required to rate the selected factors according to the caused design change's impact on the time, cost & quality. Please remember to rate any additional factors you may include under the last section of this page.

Please select all factors that apply

- ☐ Design changes due to Changes in Client's Requirements
- ☐ Design changes due to Changes Requested by Other Stakeholders
- ☐ Design changes due to Changes Recommended by the Contractor
- ☐ Design changes due to Complexity of Design/Project
- ☐ Design changes due to Unclear or mis-interpretation of Client Needs
- ☐ Design changes due to Changes in Market conditions

- ☐ Design changes due to Unrealistic Design/Project's Periods
- ☐ Design changes to Reduce Project Duration

- ☐ Design changes due to Value Engineering
- ☐ Design changes due to Budget Constraints (Omissions due to lack of funds)

- ☐ Design changes due to Errors or Deficiencies made during Design Phase; example: Unclear/Incomplete/Inadequate/Inconsistent/Poor/Unrealistic Design, Conflicting Specifications, Outdated Design Criteria...
- ☐ Design changes due to Errors/Omissions during Construction/Fabrication/Transportation Phase

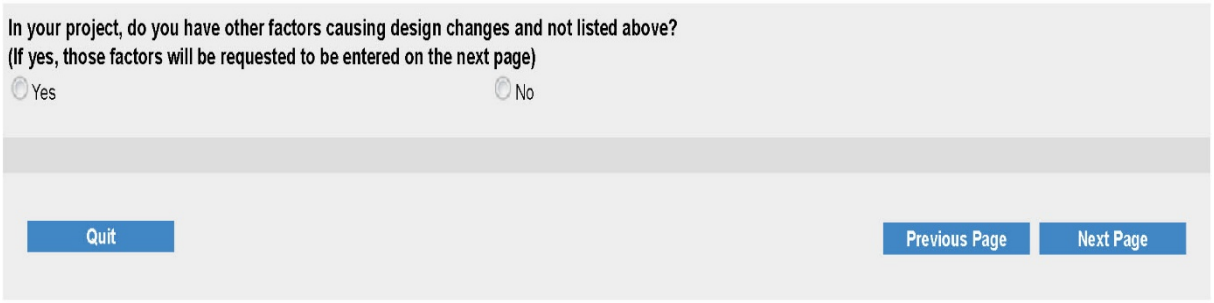
- ☐ Design changes due to Poor Communication
- ☐ Design changes due to Poor Coordination

- ☐ Design changes due to Incompetent Designer or Design Team
- ☐ Design changes due to Incompetent Contractor Technical Team
- ☐ Design changes due to Consultant NOT AWARE of the current regulations

- ☐ Design changes due to Unforeseen Site/Underground Condition
- ☐ Design changes due to Utilities Requirements
- ☐ Design changes due to Construction Conflict
- ☐ Design changes due to Sustainability Requirements (LEED/Estidama)
- ☐ Design changes due to Change in Government Policies/Regulations

- ☐ Design changes due to Mistakes/Discrepancies/Omissions in Tender/Contract Documents
- ☐ Design changes due to Changes to Materials and/or Specifications

- ☐ Design changes due to Field Conditions or Change in Site Conditions
- ☐ Design changes due to Changes in Construction/Permanent works Method/Technology


In your project, do you have other factors causing design changes and not listed above?
(If yes, those factors will be requested to be entered on the next page)
Yes
No
Quit
Previous Page
Next Page

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Design Changes
Answers marked with a * are required.

5. Ranking of the identified factors on time, cost and quality

Design Changes during the construction stage have their impact on the time to completion, cost and quality. Projects may be delayed or accelerated, over budget or under budget, with more or less quality, and in rare situations have no impact.

Please indicate the impact of the design changes caused by ONLY the factors you selected, on the time to completion, on the cost and on the quality of your project. Unselected factors are ranked as have no impact.

General Note
Negative impact (-3, -2, -1) means delays to the project, cost overrun, decline in the quality
Positive impact (1, 2, 3) means shortening the duration of the project, cost reduction, improvement in the quality

Important Note: Be careful, non-rated factors are considered as NO IMPACT

Impact on Time	Impact on Cost	Impact on Quality
(**-3**) Major delay i.e. time increase >20%	(**-3**) Major cost overrun i.e. cost increase >20%	(**-3**) Major decline
(**-1**) Minor delay i.e. time increase ≤10%	(**-1**) Minor cost overrun i.e. cost increase ≤10%	(**-1**) Minor decline
(**0**) No delay	(**0**) No impact	(**0**) No impact
(**1**) Minor acceleration i.e. time reduction ≤10%	(**1**) Minor cost saving i.e. cost reduction ≤10%	(**1**) Minor improvement
(**3**) Major acceleration i.e. time reduction >20%	(**3**) Major cost saving i.e. cost reduction >20%	(**3**) Major improvement

Impact of Design Changes caused by Changes in Client's Requirements

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Changes Requested by Other Stakeholders

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Changes recommended by the Contractor

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Complexity of Design/Project

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Unclear or mis-interpretation of Client Needs

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Changes in Market Conditions

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Design changes due to Unrealistic Design/Project's Periods

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○

Impact on Cost							
Impact on Quality							

Design changes to Reduce Project Duration

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Value Engineering

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Budget Constraints (Omissions due to lack of funds)

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Errors or Deficiencies made during Design Phase; example: Unclear/Incomplete/Inadequate/Inconsistent/Poor/Unrealistic Design, Conflicting Specifications, Outdated Design Criteria...

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Errors/Omissions during Construction/Fabrication/Transportation Phase

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Poor Communication

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Poor Coordination

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Incompetent Designer or Design Team

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Incompetent Contractor Technical Team

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Consultant NOT AWARE of the Current Regulations

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Unforeseen Site/Underground Condition

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Utilities Requirements

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Construction Conflict

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Sustainability Requirements (LEED/Estidama)

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Change in Government Policies/Regulations

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Mistakes/Discrepancies/Omissions in Tender/Contract Documents

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Changes to Materials and/or Specifications

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Field conditions or Change in Site Conditions

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Changes in Construction/Permanent Works Method/Technology

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to additional Factor 1

Please rate the design changes caused by the additional Factor 1

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to additional Factor 2

Please rate the design changes caused by the additional Factor 2

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Utilities Requirements

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Construction Conflict

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Sustainability Requirements (LEED/Estidama)

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Change in Government Policies/Regulations

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Mistakes/Discrepancies/Omissions in Tender/Contract Documents

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Changes to Materials and/or Specifications

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Field conditions or Change in Site Conditions

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to Changes in Construction/Permanent Works Method/Technology

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to additional Factor 1

Please rate the design changes caused by the additional Factor 1

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to additional Factor 2

Please rate the design changes caused by the additional Factor 2

	-3	-2	-1	0	1	2	3
Impact on Time							
Impact on Cost							
Impact on Quality							

Design changes due to additional Factor 3

Please rate the design changes caused by the additional Factor 3

	-3	-2	-1	0	1	2	3
Impact on Time	○	○	○	○	○	○	○
Impact on Cost	○	○	○	○	○	○	○
Impact on Quality	○	○	○	○	○	○	○

Quit | Previous Page | Next Page

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Design Changes

Answers marked with a * are required.

6. General feedback: Is there anything else you'd like to tell us about?

Please enter your feedback (if any) in the below box

Quit | Previous Page | Next Page

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Design Changes

Answers marked with a * are required.

7. End of Survey

Thank you for your valuable time for filling up this questionnaire. Your opinions will be considered anonymously.

Have a nice day.

Warm regards
Joseph Salameh, PMP

Quit | Previous Page | Finished - Thank you

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