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إدارة المشروعـات الهندسيـــــــة

# Factors Causing Variation Orders in Construction Projects in Gaza Strip (Case Study: Qatar Projects)

# العوامل المسببة للأوامر التغييرية في المشاريع الإنشائية في قطاع غزة
## دراسة حالة: المشاريع القطرية

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**A thesis submitted in partial fulfilment of the requirements for the degree of Master of of Science in Civil Engineering – Engineering Projects Management**

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إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

# Factors Causing Variation Orders in Construction Projects in Gaza Strip (Case study: Qatar Projects)

# العوامل المسببة للأوامر التغييرية في المشاريع الانشائية في قطاع غزة
# دراسة حالة: المشاريع القطرية

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# نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ محمد عدنان محمد البحيصي لنيل درجة الماجستير في كلية *الهندسة* قسم الهندسة المدنية – إدارة المشروعات الهندسية وموضوعها:

## العوامل المسببة للأوامر التغييرية في المشاريع الإنشائية في قطاع غزة

## دراسة حالة: المشاريع القطرية

## Factors Causing Variation Orders in Construction Projects in Gaza Strip Case study: Qatar Projects

وبعد المناقشة التي تمت اليوم الاثنين 12 جمادى الآخر 1437هـ، الموافق 2016/03/21م الساعة الثانية مساءً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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*واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.*

والله ولي التوفيق،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

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# Dedication

Firstly, this research is lovingly dedicated to my beloved Father and my beloved Mother who have been my constant source of inspiration. They have given me the drive and discipline to tackle any difficulty in this life with enthusiasm and determination. Without their prayers, love, encouragement and support, this work would not have been made possible. Their constant love has sustained me throughout my life. Thank you for giving me a chance to prove and improve myself through all my walks of life

And without doubt, I dedicate this thesis to my beloved brothers, sisters, uncles, aunts, cousins and best friends as well as the entire special people who have supported me throughout the process to make this thesis real. Their love, prayers and encouragement have had a great impact to give me the power to achieve this work.

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Thank you,
Mohammed Adnan Albhaisi

# Abstract

- **Purpose:** Change orders have long been an inherent part of the construction industry around the world and especially in Gaza Strip where construction projects suffers from variation orders. These variation orders are high especially in Qatar projects. This research investigates the main causes of variation order (VO) in worldwide projects through the literature and conclude which of them are affecting locally.
- **Aim and Objectives:** The aim of this research is to improve the control on variation order issue to the minimum in construction projects in Gaza Strip. To achieve the aim of this research many objectives exist, these objectives can be summarized as to investigate the factors causing variation order from the literature, extracting real causes of variation order through analyzing a case study of one of the completed projects of Qatar projects, and propose appropriate solutions to decrease the variation orders to minimum as much as possible.
- **Methodology:** First, review the literature to extract the causes of variation order around the world and then determine which of them is applicable in Gaza Strip. This was fulfilled using questionnaire and case study. A questionnaire will be developed to assess the perception of owners, consultants, and contractors on the factors causing variation orders in the construction industry in Gaza Strip especially the Qatar projects. Finally, a case study on one of the finished projects of Qatar projects to compare the real causes of VO with the result from analyzing the questionnaire.
- **Results:** The most influential factors causing VO are change of schedule by owner, design complexity and difficulty to understand, lack of contractor's involvement in design, delays in secure site, equipment or materials, and site safety considerations
- **Conclusions:** It was concluded that there are some similarities and differences between real data and questionnaire result. The differences between the study and real data is mainly because the study of the completed project has a special nature where this project faced several difficulties such as war and closure of the crossings. Not to forget to mention that the study included two projects (roads and buildings) but the case study included only road project which certainly caused differences in factors causing variation orders between the study and the real data.


- **Keywords:** Variation Order, Qatar projects, Gaza Strip, Construction Industry, Owner, Consultant, Contractor.

## الملخص

**خلفية عن الموضوع مع استعراض للمشكلة:** كانت الأوامر التغييرية منذ فترة طويلة جزءاً لا يتجزأ من صناعة البناء والتشييد في جميع أنحاء العالم وخاصة في قطاع غزة حيث تعاني مشاريع البناء من الأوامر التغييرية ولكن ترتفع نسبة الأوامر التغييرية بشكل خاص في المشاريع القطرية. يدرس هذا البحث الأسباب الرئيسية للأوامر التغيرية في المشاريع في جميع أنحاء العالم من خلال الأبحاث السابقة واستنتاج منها ما تؤثر محلياً.

**الأهداف المرجوة من موضوع الرسالة:** الهدف من هذا البحث هو تحسين التحكم في قضية الأوامر التغييرية إلى الحد الأدنى في مشاريع الإنشاءات في قطاع غزة. لتحقيق الهدف العام من هذا البحث توجد العديد من الأهداف التي يمكن تلخيصها على النحو التالي: تقصي العوامل المسببة للأوامر التغييرية من الابحاث السابقة ، استخراج الأسباب الحقيقية للأوامر التغييرية من خلال تحليل أحد المشاريع المنجزة من المشاريع القطرية و أخيراً وضع بعض الحلول و المقترحات للتقليل من حدة الأوامر التغييرية قدر الإمكان.

**طريقة ومنهجية العمل لتحقيق الأهداف:** أولاً، مراجعة الأبحاث السابقة لاستخراج أسباب الأوامر التغييرية في جميع أنحاء العالم ومن ثم تحديد قابليتها للتطبيق في قطاع غزة ، وقد تحقق ذلك من خلال استبيان ودراسة حالة وتم وضع الاستبيان لتقييم تصور المالكين والاستشاريين والمقاولين عن العوامل المسببة للأوامر التغييرية في صناعة البناء والتشييد في قطاع غزة وخاصة المشاريع القطرية. وأخيراً ، دراسة أحد المشاريع المنفذة من المشاريع القطرية للمقارنة بين الأسباب الحقيقية للأوامر التغييرية مع نتيجة تحليل الاستبيان.

**النتائج و إلى أي مدى تم تحقيق الأهداف:** أكثر العوامل تأثيراً والتي تتسبب بأوامر تغييرية هي تغير الجدول الزمني من قبل المالك ، تعقيد التصميم وصعوبة فهمه ، عدم إشراك المقاول في التصميم ، التأخر في تأمين الموقع والأدوات أو المعدات ، و اعتبارات السلامة في الموقع.

**الخلاصة:** استنتج أن هناك بعض أوجه التشابه والاختلاف بين البيانات الحقيقية ونتائج الاستبيان. الاختلاف الناتج بين الدراسة و البيانات الحقيقية سببه أن بيانات الخاصة بالمشروع المنفذ تتسم بطبيعة خاصة حيث واجه هذا المشروع عقبات عدة مثل الحرب والإغلاق المستمر للمعابر. لا ننسى ذكر أن الدراسة شملت نوعين من المشاريع (مباني و طرق) في حين أن الحالة المدروسة للمشروع المنفذ عبارة عن مشروع طرق مما تسبب حتماً في اختلاف العوامل المسببة للأوامر التغييرية بين الدراسة الحالية و البيانات الحقيقية.



**كلمات مفتاحية:** الأوامر التغييرية ، المشاريع القطرية ، قطاع غزة ، صناعة الإنشاءات ، المالك ، الاستشاري ، المقاول.

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# List of Abbreviations

| | |
|---|---|
| ANOVA | Analysis of Variance |
| CCD | Construction Change Directives |
| CII | Construction Industry Institute |
| CMR | Construction Management at Risk |
| Cα | Cronbach's Coefficient Alpha |
| DB | Design-Build |
| DBB | Design-Bid-Build contract |
| IBM | International Business Machines |
| NGO's | Non-Governmental Organizations |
| PPMCC | Pearson Product-Moment Correlation Coefficient |
| PWD | Public Works Department |
| RII | Relative Important Index |
| SPSS | Statistical Package for Social Science |
| VO | Variation Order |
| WBS | Work Breakdown Structure |

# Chapter 1: Introduction

This chapter presents a general introduction to the research providing a background about variation order in construction projects. Also, it provides problem statement, aim, objectives and hypotheses. Also, mentions the justification of the study, limitations and the structure of the thesis.

## 1.1 Background

The nature of the construction process means that variations are inevitable (Sunday, 2010). It's always important to remember the fact that there are variations in projects. A variation (sometimes referred to as a variation order or change order) is an alteration to the scope of work in a construction contract in the form of an addition, substitution or omission from the original scope of works. Almost all construction projects vary from the original design, scope and definition. Whether small or large, construction projects will have to depart from the original tender design, specifications and drawings prepared by the design team. This is possible because of technological advancement, statutory changes or enforcement, changes in conditions, geological anomalies, non-availability of specified materials, or simply because of the continuous development of the design after the contract has been awarded. In large civil engineering projects variations can be very significant, whereas on small building contracts they may be relatively minor. Variation orders affect the progress of any construction project and may be one of the main factors that might cause failure in delivering a project successfully. It is relatively difficult to deliver a project without any variation orders during the design stage, or even the construction stage. Therefore, it's necessary to identify and evaluate the factors causing variation orders.

## 1.2 Statement of problem

Change orders have long been an inherent part of the construction industry around the world and especially in Gaza Strip where construction projects suffers from variation orders (Memon *et al.*, 2014). Therefore, as the Qatar projects are the largest projects in Gaza Strip in this period of time it was necessary to spotlight this issue since Qatar projects suffers from a high percentage of VO that is caused due to some problems (Alaryan *et al.*, 2014). The Qatar projects are the largest projects in Gaza Strip that is funded by the State of Qatar. The Ministry of Public Works and Housing who is in charge to administrate and monitor these projects is facing a bigger problem. Dramatic changes of the original plans occur. These changes led to a high variation order as a consequence. The Ministry is conscious about these great changes but because of its busyness it couldn't determine the main causes of variation orders and appropriate solutions. This research investigates the main causes of variation order in worldwide projects through the literature and concludes which of them are affecting locally.

### 1.3 Research aim, objectives and hypotheses

The aim of this research is to improve the control on variation order issue to the minimum in construction projects in Gaza Strip.

**Research objectives**

To achieve the aim of this research many objectives exists, these objectives can be summarized as bellow :

1. To investigate the factors causing variation order from the literature.
2. To extract real causes of variation order through analyzing a case study of one of the completed projects of Qatar projects.
3. To propose recommendations to decrease the variation orders to minimum as much as possible.

**Research hypotheses**

**$H_1$**: There is an inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond on owner-related factors.

**$H_2$**: There is an inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond on consultant-related factors.

**$H_3$**: There is an inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond on contractor-related factors.

**$H_4$**: There is an inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond on External environment-related factors.

**$H_5$**: There is an inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond on other factors.

### 1.4 Justification of the study

Construction industry in Gaza Strip suffers from variation orders that result in time and cost overrun, quality defects and other negative impacts (Enshassi *et al.,* 2010). Construction projects especially in Qatar projects reaped the highest rates among the projects in the Gaza Strip which prompts the need for a research to identify the causes of variation orders the have great impact on Qatar projects. Furthermore, this study can be used as a guideline for future development to increase awareness of VO issue.

### 1.5 Limitations

The development of the research was based on the quantitative method through questionnaire and qualitative method through the case study. The findings were limited to the Qatar projects in Gaza Strip. The study included owners, consultants and

contractors in Qatar projects.

### 1.6 Thesis structure

This research was organized into the following six chapters:

**Chapter 1: Introduction**

This chapter has a general introduction to the subject of the thesis. It describes the rationale of the research, research objectives, and the outline of the research methodology. The research scope and outline contents are also stated.

**Chapter 2: Literature review**

This chapter presents an extensive literature about variation order and related studies to the subject of the thesis.

**Chapter 3: Methodology**

This chapter defines the process of the methodology that was applied through the questionnaires to enhance the results of survey.

**Chapter 4: Results and discussion**

This chapter presents the results achieved and their analysis using many methods and discussing them in detail.

**Chapter 5: Case Study**

This chapter contains a case study of one of the completed projects in Qatar projects which was analyzed and compared with result from analyzing the questionnaire of this study.

**Chapter 6: Conclusions and Recommendations**

This chapter states the conclusions and recommendations.

# Chapter 2: Literature review

The literature review is aimed to establish an understanding of the concept of the variation order (VO) and the causes of overall cost increment, time delays and limiting proper implementation. The sources have mainly been refereed academic research journals, dissertation/theses, publications, conferences and websites.

## 2.1 Variations and variation orders' definition

Olsen *et al.* (2012) (Cited in Webster, 1997) and Nachatar *et al.* (2010) quoted the definition of a famous 'guru' of construction industry Prof. Vincent Powell-Smith as any change to the works as the detailed or described in the contract documents. Another definition by PWD 203/203A (Rev. 2007) Condition of Contract, Clause 24.2 as the term variation means a change in the contract document which necessitates the alteration or modification of the design, quality or quantity of the works as described by or referred to therein and affects the contract sum.

Fong (2004) and Mohammad *et al.* (2010) defining variation for the purpose of the contract as the alteration or modification of the design, quality and quantity of works shown upon the Contract Drawings, Bills of Quantities and/or the Specification. It also includes the addition, omission or substitution of any work, alteration of the kind or standard or any of the materials or goods to be used for the Works and the removal off the Site of any work, material or goods executed or brought to the site expect if the work, material or goods are not in accordance with the Contract. Memon *et al*. (2014), Fisk (1997) and O'Brien (1998) defined variation as any deviation from an agreed well-defined scope and schedule. Hegazy *et al.* (2001) Stated differently that it is a change in any modification to the contractual guidance provided to the contractor by the owner or owner's representative. In another view, Wambeke *et al.* (2011) defined variation as the difference in what was planned and what actually happened (in terms of either task starting time or task duration).

In addition to the term variation, another generic term in construction projects is needed to be defined which is known by variation order. Fisk (1997) and O'Brien (1998) defined variation order as the formal document that is used to modify the original contractual agreement and becomes part of project's documents. Prof. Vincent Powell-Smith represented variation order to be an instructions of the engineer to effect a change to the works as defined in the contract documents, it is commonplace for a variation simply to be issued as engineer's instruction; it being evident from the content and that it is a variation. From another point of view, Clough and Sears (1994) said that a variation order is written order issued to the contractor after execution of the contract by the owner, which authorize a change in the work or an adjustment in the contract sum or even the contract time. O'Brien (1998), Arain & Pheng (2005) and Halwatura & Ranasinghe (2013) (Cited in FIDIC, 2005) stated that a variation order

is the formal document that is used to modify the original contractual agreement provided to the contractor by the client or the client's representative and becomes part of the project's documents. Desai *et al.* (2015) defined change order as a document describing the scope of the change and its impact on both cost and / or time. (Memon *et al.*, 2014) also defined change order as an addendum to the contract conditions and is signed by all the parties involved in the contract. Also, Halwatura & Ranasinghe (2013) pointed out that variation order is an official document that states the changes made into the original agreement between the client and the contractor. Bin Ali (2008) defined a variation order as the alteration or modification of the design, quality of works, as shown upon the contract drawings, bill of quantities, and/or specifications and include the addition omission, or substitution of any works. Memon *et al.* (2014) added another definition of variation order as the written agreement between the contracting parties that represent an addition, deletion, or revision to the contract documents, identifies the change in price and time and describes the nature of the work involved. Alsuliman *et al.* (2012) defined variation orders as any change that can occur to the basis that is different from the agreed and signed contract.

Variability is another term defined by Rilett (1998) as the variance associated with a component or end product specification in construction projects. Howell *et al.* (2004) focused on work-flow variability between what should be done and what is already done. They emphasized on reducing variation to improve performance and combining it with planning results in higher productivity. Another definition (Koskela, 2000) as random variation in the processing times or arrival of inputs.

### 2.2 Types of variations

Nachatar *et al.* (2010) and Al-Dubaisi (2000) defined two types of variations that are essential for legal aspects; direct and constructive changes. The differences between these two categories that direct change is easy to identify, happens when the owner orders the contractor to perform a different work of that listed in the contract and problems revolve around monetary damages whereas constructive changes is informal act, considered the ground of variation order and the claim must be written in time to be considered. CII (1990), Fisk (1988) and Cox (1997) added another one to the previous two which was the cardinal change which is outside the scope of contract and may comprise multiple change that leads to net scope change.

CII (1990) and Fisk (1988) had other classification of changes based on net effect on scope as the following; (1) Additive change which add work to the scope, (2) Deductive change which delete work from the scope, (3) Rework due to shortage in quality and (4) Force majeure change which affects depending upon the condition of the contract.

Wambeke et *al.* (2011) discussed another classification of the types of variation. It's divided into starting time variation and task duration variation. They studied which of the two categories affected the variation.

Mohammad *et al.* (2010) and Ibbs *et al.* (2001) had another idea, where they said that variation is divided into beneficial and detrimental. Beneficial variations that improve quality, reduce cost, schedule or difficulty are good to any project whereas detrimental variations that should be cautious of because of its negative impact on the project or owner's value.

Abdel Rashid *et al.* (2012) classified changes into change orders and minor change. Minor changes don't have any effect on time or cost. Nevertheless, change orders are a must when subjected to Construction Change directives (CCD's) process and contractor is obliged to perform the change even if he disagree in terms of time and cost. Contractor should prepare documents such as bulletins, quotes and negotiation to reach an agreement between all the parties.

### 2.3 Elements of a valid variation order

Harbans (2002) outlined three principles to consider variation order being valid. First, as an instruction. Second, the person who unleash such instructions should be authorized. Third, instruction must make a change and that change must be defined in the contract document. Fong (2000) had a different idea, where he said that validity of a variation order is summarized in two factors: the legal nature of the proposed change and the formalities governing the change. Al-Dubaisi (2000) presented that the spark which may inaugurate the change order could be from one of the following parties; owner, engineer, project manager and contractor.

### 2.4 The need of variation order

Nachatar *et al.* (2010) and Fisk (1997) summarized the target spent by variation orders as follows:

1. Change contract plans or specify the method and amount of payment.
2. Change contract specifications.
3. Effect agreements concerning the order of the work.
4. Establish the method of extra work payment and funds for work already stipulates in the contract.
5. Authorize an increase in extra work funds necessary to complete previously authorized change.
6. Cover adjustments to contract unit prices for overruns and under runs.
7. Effect cost reduction incentive proposal (value engineering proposals).
8. Effect payment after settlement of claims.

## 2.5 Variations and Change Orders on Construction Projects

El Karriri (2012) reported the issue of variation order in construction projects related to UNRWA as one of the clients that support the industry in Gaza Strip. He discussed that owner, consultant and contractor endeavor to minimize the adverse effects of variation especially on the duration, cost and labor productivity. He recognized that numerous causes or different sources at any stage of the project could originate variation.

Ssegawa *et al.* (2002) demonstrated that it's hard even impossible to finish any project without having to change plans or processes itself. According to Revay, (2002), there will be changes to scope, time, cost and/or quality on most, if not all, construction projects.

O'Brien (1998), Hester *et al.* (1991) and Keane *et al.* (2010) demonstrated that contracts are complex in nature and change is a fact in any project. The project team cooperate to manage these changes and by managing meaning having the capability to foresee the effects and control or at least monitor the correlating impacts which requires an extensive knowledge of the root causes and effects of variations.

Love & Edwards (2004) reported that construction industry in Australia suffers from lack of coordination and communication, lacks of formal customer-supplier focus, relies heavily upon price-based selection and is slow to adopt information technology practices which caused proliferating errors and misunderstanding, nonessential cost and wasting time and therefore rework generated (Abdul-Rahman, 1997; Josephson and Hammarlund, 1999).

Moselhi *et al.* (2005) reported that variation or change order may affect positively or negatively on any project. On one hand, it can be beneficial as it may satisfy owners' needs during the project delivery process and respond to design errors or omissions at utmost effective pattern. On the other hand, it can cause significant problems due to insufficient understanding and shortage of acknowledgement of the influence of impact on project performance.

Jawad *et al.* (2009) focused on legal aspect of variation order such as variation in contract, clause interpretation, substantiation and management of claims which somehow depends on the owner and project requirement. They also mentioned the extra cost and time incurred when providing new materials, tools and equipment. Jawad *et al.* (2009) spotted the light on one of the well-known and effective ways to evaluate the resulting impact which is Work Breakdown Structure (WBS). They presented the most used feature in the Work Breakdown Structure that it is used in large-scale projects where the project is divided hierarchically and the resources are distributed to all elements where it is easy to add an item not previously recognized (a variation) and linked it to the hierarchy. Jawad *et al.* (2009) emphasized on determining the scope of work as the first priority to compare original scope with variation scope which requires technical skills. Also, the scope must be clear and well-

defined as the poor scope may cause confusion wither the variation is from within or outside the scope.

Asamaoh & Nyako (2013) and Mohammad *et al.* (2010) viewed that despite the owner is one who places the goals and vision of the project, but he is the one who initiates changes in the construction phase in terms of cost and aesthetic appearance and indirectly through the consultant. Also, different parties should be included in the first stages of design or construction to eliminate the effect of variation order. They highlighted that the consultant should pay attention to the degree of accuracy of the drawings and blueprints are clear and easy to be interpreted (Fugar, F. & Agyakwah-Baah, 2001). Moreover, the contractor should cooperate with the consultant when problems emerged. However, some believed that the cause of variation is due to the dereliction of contractor that may be a result of poor workmanship, unfamiliarity with local conditions, poor management and lack of efficient communication. Once the contractor or the subcontractor notice differences in the task from what is originally mentioned in the contract they prepare a variation order and submit it to the consultant for revision considerations (Levy, 2002).

Akinsola, 1997 and Al-Hazmi *et al.* (2006) stated that in any project each party knows its duty and profit which are clearly explicit in the contract. Bhadmus *et al.* (2015) as well explored the cost variation as it is considered well-recognized in construction projects and the reason for hassle between different parties of the project.

Construction industry in Malaysia has grown rapidly. However, this growth included the emerge of more problems causing variation orders. These changes caused a dramatic effect on the duration of many projects in Malaysia (Memon *et al.*, 2014; Mohammad *et al.*, 2010).

Hwang & Low (2012); Oladapo (2007); Alsuliman *et al.* (2012) (Arain and Pheng, 2007; Motawa, 2004; Clough and Sears, 1994; Ndihokubwayo, 2008) agreed on the fact that major change orders in construction projects arose during design phase and dealing with design at the early stage is much easier, save money and time, and don't require demolition to the executed work.

Alsuliman *et al.* (2012) presented that the use of a system to manage variation helps the project team to make proper changes before conducting a project which minimize cost overrun, delays and negative impacts of variation.

Abdel Rashid *et al.* (2012) presented that there is no such a thing as a perfect project. The most projects susceptible to variation or change order are construction projects. Each party of the project feels that the change is other party's responsibility or needs extra effort. So, all the parties agree that any project is better with "no change order" phrase. Change order generates extra work that requires extra effort, cost, time and resources that would cause negative relations between parties, obstruction of

workflow, lack of quality and work under tension causing blunder errors. Abdel Rashid *et al.* (2012) clarified that change order is a method to give a contractors his rights.

### 2.6 Variation order and project performance

Memon *et al.* (2014) linked the poor construction performance with variation order. It has been agreed on that it even influenced the most organized projects. (Fisk, 1997; Ibbs *et al.*, 2001; O'Brien, 1998) It has major impact on project performance, time and cost (Ibbs, *et al.* 1998; Ibbs, 1997). Also, they elucidated that performance is extremely affected by performance of the team. Memon *et al.*, (2014) defined project performance as the set of measures used for evaluating the success of the project. They presented that there's no criteria defined the performance as it undergoes to the desire of the client. Time and cost are measured indicators to performance. Although, there are other indicators but they are immeasurable because of differ respondents' comprehension.

Zaneldin (2000) demonstrated variation is a consequence of poor performance which may be caused due to design changes and these changes in design involve multi-disciplinary situations not only a single source.

Osman (2009), Ijaola (2012) & Arain (2004) explained that variation order generated from the complexity of the construction process which include changing, adding, eliminating, substitution in terms of quality, quantity and time schedule; not to mention that administrative problems, designing flaws and problems due restraining resources delivery all leads to this variation to occur.

Ssegawa *et al.* (2002) pointed out that there must be obstacles and alterations within any project component which affects the quality of work. Also they highlighted that this alterations either useful of disastrous.

### 2.7 Variation order and change management

Hwang & Low (2012) verified that change management is an essential element for the construction project. Change management differs from project to another in terms of size, type, complexity, nature, etc. In spite of that, convenient measures may settle problems with no losses and guarantee a successful management. They stated that the source of project change can be either internal or external and both can affect the project performance and have to be minimized (Love *et al.*, 2002).

Zhao *et al.* (2009) showed that change management is important not only in minimizing changes, but also predicting the changes, identifying the already occurred changes and taking corrective actions. Motawa *et al.* (2007); Lee and Peña-Mora (2005); Charoenngam *et al.* (2003) & Isaac and Navon (2008) reported that a validate change management is substantial to prevent disputes that may generate due to unstable management. Several models and change management systems were

established to control and manage problems, evaluate negative impact of errors and identifying the sources of changes.

Ibbs (2012) summarized that change is inevitable in any project. Changes are numerous such as deletion or addition to the scope or to the contract which is a common thing in any project which can cause rework of tasks.

### 2.8 Change order and its impact on productivity

Hanna *et al.* (2002) (Cited in Webster's, 1986) defined impact as the force of impression of one thing on another. They clarified that variation orders have an impact on labor efficiency hence productivity. Measuring this impact results in hostility between the owner and the contractor. Each party claiming that loss is a fault of the other parties and vice versa. But, there are other variances that controls the loss in productivity and change order.

Change orders affects productivity of any project. Hanna & Gunduz (2004) showed that billions of dollars have been spent to compensate for change orders and claims. Change orders not just limited to large projects it also affects small projects as this was addressed by a Construction Industry Institute (CII) in 1991. The researchers chose small projects for the lack of several reasons; no schedule for cost and labor, fast-tracking, planning and management. Thomas & Napolitan (1995) explored in greater detail how change affects labor productivity. They presented that the change itself was considered indirect factor and didn't cause productivity loss. However, the disturbance caused as a consequence of change is responsible for the loss in productivity. Thomas & Napolitan (1995) concluded that change in the scope and complexity of work and environment are the main reasons for loss of productivity. Hanna *et al.* (2002) indicated that change orders are unavoidable and may cause disturbance to the work which may lead to loss of productivity.

Ibbs (2012) asserted that this phenomena (i.e. variation) has a negative effect on labor productivity where an increment to the overall project cost and duration may occur. There is always a dispute between the owner and the contractor on the reason of variation, and accumulation of discord cause the accumulation of VO in term called cumulative impact that cause losses to productivity. Finke (1997) defined productivity as the craft hours necessary to produce a unit of finished product. Loss of productivity may be caused by the contractor because of the slow pace in the implementation of work, and therefore may harm the owner in terms of cost and time. To find the main reasons and obtain appropriate solutions, the necessary data must be acquired from cost control.

### 2.9 Changes and their impact on Construction Cost and duration

Memon *et al.* (2014) defined project time as the time required or accomplishing the project activities. It is hard to commit to the time schedule for the construction project because of its complexity thus, it needs a careful preparation to stick to the plan.

Hwang *et al.* (2009) spotted the light on a costly problem which is re-doing the work because of a number of causes that are causing variation as well because of its impact on cost and schedule. Defining the causes and a method of prevention as addressing a system to determine those causes were established. Halwatura & Ranasinghe (2013) connected the change that occur due to variation order with the change on the cost of a project. These variations consumes time and hence presents additional cost to the owner (Mohamed, 2001). They also presented variation must be addressed carefully or it will disrupt the work in progress, cause cost and time overrun, decrease in productivity and deterioration in quality (Charoenngam *et al.*, 2003). Several studies made on variation order came up with a conclusion that it causes increment on cost compared to the original cost and time extension from a project's specified duration. Nevertheless, prevention methods can be established to make complete neat design to minimize the cost and time (Arain & Pheng, 2005; Mohamed, 2001; Charoenngam *et al.*, 2003; Arain, 2005; Koushki *et al.*, 2005).

Variation orders are not limited to time and cost but also the quality, health and safety. Variation orders cannot be avoided fully but can be reduced to the minimum by finding out the reasons clearly. Optimal implementation of the work in the best way reduces the potential for variation orders (Arain & Pheng, 2005; Mohamed, 2001; Al-Momani, 2000).

Bhadmus *et al.* (2015) clarified that a great percentage of the completed projects suffered from cost overrun due to many factors related to the nature of the project, site, material, bidding, governmental policies and general delays. They presented that this variation in cost differed dramatically than the signed price in the original contract between the owner and the contractor. Mohamed (2001) discussed the influence of variation on projects that make them consume time and cost as they became overabundant. The disadvantage in the subject of the variation is that the client changes his decision without considering any requirements of the project (Sunday, 2010).

Bubshait and Almohawis (1994) defined cost performance as the measure of the degree which indicates the probability of project completion within the budgets cost. Cost is a measure of performance and owners are satisfied when they meet their scope with the stipulated cost in the contract. Cost is something substantial for any client as it includes expenses at all stages of the project, and additional cost from claims and change orders. Nevertheless, additional cost occur and cost performance is not achieved (Ali and Kamaruzzaman, 2010; Azis, 2013).

Kazaz *et al.* (2012) illustrated that the variation in time schedule is the most repeated problem that every construction project faces. For example this variation in time schedule caused by finishing the project later than agreed upon and not obtaining the income from the product in the right time. They explained that not only finishing the project late can be a problem but finishing the project early means there is an excess in human resources. They also pointed out that the owner, contractor, subcontractors,

or some technical, legal, and natural difficulties are the reasons that the time delay cannot be controlled and contained (Enshassi *et al.*, 2010).

Further studies by (Kaming *et al.*, 1997) classified the influencing factors on the impact on time such as design change, poor productivity, inadequate planning and resource shortage and on cost such as material cost increment. Osman *et al.* (2009) emphasized on the impression of variation on duration and direct or indirect cost and how considering it individually affected harmfully on the project.

Jawad *et al.* (2009) included a compensation system to cost aspect of variation as: (1) direct cost impact; (2) direct schedule impact and (3) indirect impact.

Yates *et al.* (2003) mentioned that decreasing costs and improving quality is a beneficial variations unlike the disastrous variations that creates hassle and differences in construction industry which directly affect the labor production.

### 2.10 Consultants, contractors and discrepancies between design and construction

Arain *et al.* (2004) viewed the relation between the most two influencing parties in construction; consultants and contractors. They discussed that the success of any project is a result of coordination between these two parties and conflicts caused in any construction project is not only because of contractor, some of these are caused due to a flaw in the design phase. So, discrepancies between consultant and contractor should get a high priority. (Mendelsohn, 1997).

Arain *et al.* (2004) had the same idea, where they showed a similar situation in Saudi Arabia's projects where consultants got an already made design from abroad due to lack of knowledge in environmental, social and culture factors. In addition, contractors had issues in the familiarity of resources and other problems. Another summarized the cause of the two parties in poor management. (Wang, 2000).

Arain *et al.* (2006) stated that with proper coordination, cooperation, and communication between the parties; a successful construction projects would be established. They also highlighted that this kind of projects require two very important experts in the industry which are the designer and the contractor. Moreover, they mentioned that any conflict between these two parties caused delay, that's why the communication between the designer and the contractor is an important asset to finish the project successfully. Clough and Sears (1994) pointed out that there are many sources that affect the construction process like performance of construction parties, resource availability, environmental conditions, involvement of other parties, and contractual relations which can postpone the project.

Mendelsohn (1997) presented that the problems caused by the contractors are patrimonial from the design phase which most of the problems come from. Arain *et al.* (2006) illustrated that there is no way to have the right design for the project because of the different needs of the design for each of project, clients, and design construct

delivery team. (Mendelsohn, 1997) noted that the contractor and the designer are very different. From another point of view, they supported the idea and added that the reason of having this kind of conflicts is from the maladministration and he illustrated minimizing this problem by committing to the contract (Wang, 2000).

Oladapo (2007) and Ssegawa *et al.* (2002) pointed out that the design phase and the construction phase are two individual jobs, the construction have more complexity in its nature unlike the design phase and both design and construction provoke variation. In addition, to not be shocked by variation there must be advanced preparation. Other researchers (Karim and Adeli (1999) & Motawa *et al.* (2007)) had different concept that VO occur at any stage of the project not design and construction stages.

Kwakye (1997) stated that the classifications of the construction helps with maintaining a good design without any worries, Constructability, economy and continuation of costly mistakes from one project to another.

### 2.11 Variation and quality deviation

Burati *et al.* (1992) discussed the relation between cost of construction industry and quality problems. Quality problems led to heavy financial losses putting manufacturers faced with two choices; either reduce cost of poor quality or increase sales which the prior choice was the preferred one. Reducing the cost of poor quality would put construction industry on lead of manufacturing industry and increase profit (Shilstone, 1983). Researches on construction industry verified that industrial projects was the most known for quality problems especially in concrete, piping, welding, roofing, painting and electrical work (Ledbetter, 1983). Examining several claims concluded that design errors were the most common cause of claims (Diekmann & Nelson, 1985).

### 2.12 Construction claims; types and causes

Semple *et al.* (1994) defined a claim as a request for compensation for damages incurred by any party to a contract. Ho & Liu (2004) illustrated that claims issue raised as a result of rivalry between contractors that made them bid as low as possible to get into business and implementation of up-to-the-minute projects with limited resources and revenue. Abdul-Malak *et al.* (2002), Singh & Sakamoto (2001) and Scott (1997) viewed that claims are inevitable in any project and contractors must provide evidence and proper documents to support their situation when submitting a claim. Also, owners should be aware of the claims and properly manage them. Ren *et al.* (2003) pointed out that claims between owners and contractors either resolved as a change orders or became a dispute which may be settled by negotiation, mediation, arbitration, or litigation. Analyzing causes of delay is necessary to determine time, impact and contribution of each cause and assist the different parties to resolve the current situation without resorting to the court which comparing to the other methods is the more expensive and long-lead time consuming (Vidogah and Ndekugri, 1997).

Zaneldin (2005) admitted that legal advice in the subject of disputes' resolution either not obtainable or costly that's why no one cares about it.

### 2.13 Rework and its relation with cost

Many researchers defined the phrase rework relating it to quality. Others defined it as being non-conformance to the requirements (Burati *et al.*, 1992; Abdul-Rahman, 1997). On the other hand, others excluded the definition of rework if it is caused by scope changes and change orders from owners.

Love & Edwards (2004) clarified that rework is the main cause of escalating project cost because it did not take into consideration the change in the schedule as well as the judicial and poor quality costs. They identified from previous studies that direct rework cost ranged from 3 to 15 percent of the project's contract value and in some cases could reach 23 percent (Barber *et al.*, 2000; Abdul-Rahman, 1997; Burati *et al.*, 1992; Josephson and Hammurlund, 1999).

However, indirect cost cannot be underestimated whereas demonstrated that it could be worth five times the cost of work correction. Love & Wyatt (1997) stated that rework costs for refurbished projects are higher than new building projects due to complexity and uncertainty in this kind of projects. In another point of view, Love & Edwards (2004) correlated the rework cost with the size and type of project. They adopted that larger projects suffered less quality failure cost. On the other hand, project types such as commercial and road construction projects had higher values for quality cost rather than industrial because of the orderly site operations and the occurrence of sophisticated staff that integrated design and planning with site operations. Two researchers had a different idea, one of them imputed the cause of rework cost to poor documentation by design consultants (Burroughs, 1993). The other assigned the cause of rework cost to the limited time the design documents have to be completed which affects their quality (Gardiner, 1994).

### 2.14 Variation order and communication

Charoenngam *et al.* (2003) illustrated that providing communication in work environment among various staff members and stakeholders and the use of technology such as the internet which is accurate and approachable that lead to managing variation. Good documentation, proper coordination and communication are relevant to the easiness of variation order management (Chan and Yeong, 1995).

### 2.15 Variations in government contract

Nachatar *et al.* (2010) explored the term variation that is caused by any party of the contract. They agreed with Asamaoh & Nyako (2013) that variation is mentioned implicitly in the form of contract as a clause for instructing the work differently to what is stated in the contract. Variation comes in many forms provided in those clauses and also contains mechanism for financial variation. The absence of such clauses

doesn't obligate the contractor to perform any change from the original contract. They clarified that variation is affected by complexity of the project and means of variations. Their effect is unavoidable and considered a challenge to tackle by stakeholders. The continuous dealing with variation generated experience yet stakeholders are always cautious of variation to deliver the project at the right time, cost and quality or else they will cause disputes impeding the course of the project.

Singh H. (2002) pointed out that variation should be valid to be defensible at law. If the variation is not valid then it can't be compulsory and the contractor won't be obligated to perform the varied tasks which would forbid him from getting his rights from additional cost or time. The only norm of change is that it's applied on a valid variation order.

### 2.16 Change orders in Highway Projects

Wu *et al.* (2005) presented that change orders are unique and have specific causes to exist and require experience to fully understand and link their relationship to project management. They classified the causes of change for highway projects in two categories; internal and external factors. Internal factors include owner, consultant, contractor and other party related factors. External factors such as environment, policy, government, economic, etc.

### 2.17 Change order and delivery methods

Soares (2012) clarified that the contract signed between parties of the project in the principle of good faith. But, in the case of changes the circle of trust narrows and each party sticks to his convictions and values and this happens mostly between owners and contractors especially in the Design-Bid-Build contract (DBB) where the owner delegate the contractor to perform all the work so he would avoid change orders and the contractor doesn't perform any variation if he didn't get paid for it and the architect tries to keep the safety of the project without facing any cost increment. Soares (2012) suggested using project delivery systems such as design-build (DB) and construction management at risk (CMR) to minimize change order conflicts. He also pointed out that two-steps project delivery system such as DBB resulted in lack of integration between design and construction hence a change order occurs. In DBB system, adjustments to the project is switched to change orders. Although, DBB system has some downsides such as lack of accountability for errors, omissions, re-work, over-run and delays. Soares (2012) emphasized on the need to new delivery methods to guarantee the integration between design and construction particularly the ones that include one contract and one entity such as design-build (DB) that considered changes as a refinement to the project and return the concept of building as it was. Soares (2012) verified one of the benefits of DB system as it includes no increase in cost due to change orders in addition to the exclusion of judicial proceedings caused by variation orders. He represented that the concept of integration between design and construction

required the existence of one entity that controls both concepts. So, any adjustment will not be considered as a change but a natural phenomenon for improvements. However, methods such as DDB that separates design from construction that will generate adjustments which will turn to change orders to compensate the crack due to disintegration.

### 2.18 Causes of variation order

Keane *et al.* (2010) and Arain *et al.* (2006) distributed the causes based on the contracting party into three categories and an additional category for causes none relating to any of the contracting parties. The categories are owner-related, consultant-related, contractor-related and other variations. From another principle, other researchers classified causes of variation in three categories; design errors and omissions, design changes and unforeseen conditions (Ibbs, 1997; Diekmann and Nelson, 1985).

Another classification by Burati *et al.* (1992) and Thomas and Napolitan (1994) was based on the purpose and basis of classification. Other point of view demonstrated that the classification was based on the cause which was claimed to be most appropriate for cost impacts of changes. Al-Dubaisi (2000); Burati *et al.* (1992) showed that design, construction, fabrication, transportation were the main causes of change and provided that design changes contribute to 52.5% of the total changes.

Osman *et al.* (2009) presented two important factors causing variation; changes to the market conditions and new technologies. These two factors affect designs made by architectures and hence influence engineers' design. Variation's effect trespasses the design to contract price, drawings, contract documents and generates disputes between contractual parties. (O'Brien, 1998; Arain and Low, 2005).

Table (2.1) was tabulated by identifying the various causes of variation order distributed in separate categories or clauses as reviewed from the literature.

**Table (2.1)**: Causes of variation order

| # | Factors | Sunday (2010) | Memon et al. (2014) | Ismail et al. (2012) | Memon et al. (2014) | Sun and Meng (2009) | Ndihokubwayo and Haupt (2009) | Oladapo (2007) | Alsuliman et al. (2012) | Bröchner & Badenfelt (2011) | Hwang & Low (2012) | Aziz (2012) | Alaryan et al. (2014) | Mohammad et al. (2010) | Arain et al. (2004) | Hwang et al. (2009) | Halwatura & Ranasinghe (2013) | Keane et al. (2010) | Burati et al. (1992) | Abdel Rashid et al. (2012) | Al-Dubaisi (2000) | Olsen et al. (2012) | Alnuaimi et al. (2010) | Arain et al. (2006) | Pourrostam & Ismail (2011) | Desai et al. (2015) | Karthick et al. (2015) | Asamaoh & Nyako (2013) | Bhadmus et al. (2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Owner related variations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1. | Change of plans or scope by owner | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | ✓ | ✓ | | | | | ✓ | | ✓ | |
| 2. | Change of schedule by owner | ✓ | ✓ | | ✓ | | | | | | | | ✓ | | | ✓ | | | | ✓ | ✓ | | | | | ✓ | ✓ | | |
| 3. | Changes in owners' interests/requirements | | | | | | | ✓ | | | | | | | | ✓ | | | | | | | ✓ | | | | | | |
| 4. | Owner's financial problems | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | ✓ | ✓ | |
| 5. | Inadequate project objectives | ✓ | | | | | | | | | | | ✓ | | | | | ✓ | | | | | | | | | | ✓ | ✓ |
| 6. | Replacement of materials or procedures | ✓ | | | | | | | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | |
| 7. | Impediment in prompt decision making process | ✓ | ✓ | | | ✓ | | | | | | | | | | | | ✓ | | | | | ✓ | | ✓ | | | ✓ | |
| 8. | Improper preliminary advice by consultants | | | | ✓ | | | ✓ | | | | | | | | | | | | | | | | | | | | | |
| 9. | Obstinate nature of owner | | ✓ | | ✓ | | | | | | | | | | | | | ✓ | | | | | | ✓ | | | | ✓ | ✓ |
| 10. | Change in specifications by owner. | ✓ | ✓ | | ✓ | | | ✓ | | | | | | | | ✓ | | ✓ | | | | | | | | | | ✓ | |
| 11. | Owner instructs additional works | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |

**Table (2.1)**: Causes of variation order

| # | Factors | Sunday (2010) | Memon et al. (2014) | Ismail et al. (2012) | Memon et al. (2014) | Sun and Meng (2009) | Ndihokubwayo and Haupt (2009) | Oladapo (2007) | Alsuliman et al. (2012) | Bröchner & Badenfelt (2011) | Hwang & Low (2012) | Aziz (2012) | Alaryan et al. (2014) | Mohammad et al. (2010) | Arain et al. (2004) | Hwang et al. (2009) | Halwatura & Ranasinghe (2013) | Keane et al. (2010) | Burati et al. (1992) | Abdel Rashid et al. (2012) | Al-Dubaisi (2000) | Olsen et al. (2012) | Alnuaimi et al. (2010) | Arain et al. (2006) | Pourrostam & Ismail (2011) | Desai et al. (2015) | Karthick et al. (2015) | Asamaoh & Nyako (2013) | Bhadmus et al. (2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12. | Owner instructs modification to design | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| **Consultant related variations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13. | Change in design by consultant | | ✓ | | | | | | | | | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ | | | |
| 14. | Errors and omissions in design | ✓ | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| 15. | Conflicts between contract documents | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ | ✓ | | ✓ | ✓ | | | | | | ✓ | ✓ | |
| 16. | Improper briefing by client | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | |
| 17. | Inadequate scope of work for contractor | ✓ | | | | | | | | | | | | | | | ✓ | | | ✓ | ✓ | | | | | | | | |
| 18. | Technology change | | | | | | | ✓ | | | | | ✓ | | | | ✓ | ✓ | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| 19. | Lack of coordination | ✓ | | | | | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | | | ✓ | |
| 20. | Design complexity | ✓ | ✓ | | ✓ | | | ✓ | | | | | | | ✓ | | | ✓ | | | | | | ✓ | | | | ✓ | ✓ |
| 21. | Value engineering | | | | | | | | | | | | | | | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | | | | |
| 22. | Insufficient time for preparation of contract documents | | | | | | | ✓ | | | | | | | ✓ | | | | | | | | | | | | | | |

**Table (2.1)**: Causes of variation order

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23. | Failure by the consultant to provide adequate and clear information in the tender documents | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 24. | Modifications to the drawings | | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | |
| 25. | Inadequate working drawing details | ✓ | ✓ | | ✓ | | | | ✓ | | | | ✓ | | ✓ | | | ✓ | | | | | | ✓ | | ✓ | | ✓ | |
| 26. | Inadequate shop drawing details | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | | |
| 27. | Consultant's lack of judgment and experience | ✓ | | | | | | | ✓ | | | | | | ✓ | | ✓ | | | | | | ✓ | ✓ | ✓ | | | ✓ | |
| 28. | Lack of consultant's knowledge of available materials and equipment | ✓ | | | | | | | ✓ | | | | | | ✓ | | ✓ | ✓ | | | | | | ✓ | | | ✓ | ✓ | |
| 29. | Consultant's lack of required data | ✓ | | | | | | | | | | | | | ✓ | | | ✓ | | | | | | | | | | | |
| 30. | Obstinate nature of consultant | | | | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 31. | Over inspection | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | |
| 32. | Ambiguous design details | | | | | | | | ✓ | | | ✓ | | | ✓ | | | ✓ | | | | | | ✓ | | | | | |

**Table (2.1)**: Causes of variation order

| # | Factors | Sunday (2010) | Memon et al. (2014) | Ismail et al. (2012) | Memon et al. (2014) | Sun and Meng (2009) | Ndihokubwayo and Haupt (2009) | Oladapo (2007) | Alsuliman et al. (2012) | Bröchner & Badenfelt (2011) | Hwang & Low (2012) | Aziz (2012) | Alaryan et al. (2014) | Mohammad et al. (2010) | Arain et al. (2004) | Hwang et al. (2009) | Halwatura & Ranasinghe (2013) | Keane et al. (2010) | Burati et al. (1992) | Abdel Rashid et al. (2012) | Al-Dubaisi (2000) | Olsen et al. (2012) | Alnuaimi et al. (2010) | Arain et al. (2006) | Pourrostam & Ismail (2011) | Desai et al. (2015) | Karthick et al. (2015) | Asamaoh & Nyako (2013) | Bhadmus et al. (2015) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33. | Delay in preparing construction documents | | | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | | | | |
| **Contractor related variations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 34. | Complex design and technology | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | | ✓ | | | | | |
| 35. | Lack of strategic planning | | ✓ | | | ✓ | | | ✓ | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | | ✓ | | | | |
| 36. | Contractor's lack of required data | ✓ | | | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 37. | Lack of contractor's involvement in design | | | | | | | | | | | | | | ✓ | | | ✓ | | | | | | ✓ | | | | ✓ | |
| 38. | Lack of modern equipment | | ✓ | | ✓ | | | | | | | | ✓ | ✓ | | | | ✓ | | | ✓ | | | | ✓ | ✓ | | ✓ | |
| 39. | Unfamiliarity with local conditions | | | | | | | | | | | ✓ | | | | | | ✓ | | | | | | | | | | ✓ | |
| 40. | Lack of a specialized construction manager | | | | | ✓ | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | ✓ | |
| 41. | Fast track construction | | | | | | | | ✓ | | | | | | ✓ | | | ✓ | | | | | | ✓ | | | | | |
| 42. | Poor procurement process | | ✓ | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | |
| 43. | Lack of communication | ✓ | | | | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | | | ✓ | ✓ | ✓ | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44. | Contractor's lack of judgment and experience | ✓ | | | | ✓ | | | | | | | | | ✓ | | ✓ | | | | | | | ✓ | ✓ | | | | |
| 45. | Shortage of skilled manpower | ✓ | ✓ | | ✓ | | | | | | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ | |
| 46. | Contractor's financial difficulties | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ |
| 47. | Contractor's desired profitability | ✓ | | | | | | | | | | | | ✓ | | | ✓ | ✓ | | | ✓ | | | | | | ✓ | ✓ | ✓ |
| 48. | Differing site conditions | ✓ | | ✓ | | | | | | | | | | ✓ | | | ✓ | ✓ | | ✓ | | | | | ✓ | | ✓ | ✓ | |
| 49. | Defective workmanship | ✓ | ✓ | | ✓ | ✓ | | | | | | | | ✓ | | | ✓ | ✓ | | | ✓ | | | | | ✓ | | | |
| 50. | Procurement delay | | | | | | | | | | | | | | ✓ | | | ✓ | | | | ✓ | | ✓ | | | | | |
| 51. | Poor site management and supervision | | | | | ✓ | | | | | ✓ | ✓ | | | | | | | | | | | | | ✓ | | | | |
| 52. | Changes in construction method | | | | | ✓ | | | | | | | | | | | | | ✓ | ✓ | | | | | | | | | |
| 53. | Material approval | | | | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 54. | Shortage of materials | | | | | | | | | | | | | | | | ✓ | | | | | | | ✓ | | | | | |
| 55. | Poor scheduling | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 56. | Improper control over site resource allocation | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57. | Delays in subcontractors' work | | | | | ✓ | | | | | | | | | | | | | | | | ✓ | | | | | | | |
| 58. | Unsuitable management structure and style of contractor | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 59. | Unsuitable leader style of contractor construction manager | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 60. | The contractor misuses variations instructions | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 61. | Poor project management by contractor | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| **Other variations** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 62. | Weather conditions | | | ✓ | | ✓ | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| 63. | Force majeure | | | | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | | | | |
| 64. | Safety considerations | | | | | ✓ | | | | | | | ✓ | | | | ✓ | ✓ | | | ✓ | | | | | | | ✓ | |
| 65. | Political pressure | | | | | ✓ | | | | | | | | | | | ✓ | | | | | | | | | | | | |
| 66. | Change in government regulations | ✓ | | | | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | | | ✓ | ✓ | | | ✓ | |
| 67. | Change in economic conditions | ✓ | | | | | | | | | | | | | ✓ | | ✓ | ✓ | | | | | | ✓ | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68. | Third party permits | | | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | |
| 69. | ex ante unknown state of the system (IT, geotechnical conditions, etc.) | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | |
| 70. | changes suggested to client by a subcontractor with technology change | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | |
| 71. | changes in provider technology | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | |
| 72. | Changes in the competing market | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | | |
| 73. | Socio-cultural factors | | | | | | | | | ✓ | | | | | | | | ✓ | | | | | | | | | | ✓ | |
| 74. | Unforeseen problems | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | | ✓ | | | | ✓ | | ✓ | | | | | |
| 75. | Expected geological conditions | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 76. | Change of decision-making authority | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 77. | Adjustment of PC and provisional sums | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78. | Financial and Decision Management | | ✓ | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | |
| 79. | Human and Equipment Resource | | ✓ | | | | | | | | ✓ | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 80. | Unrealistic contract durations imposed by client | | | | | ✓ | | | | | | | | | | | ✓ | | | | | | | | | | | | |
| 81. | Better understanding of client needs | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | | |
| 82. | Client Requirements | | ✓ | | | | | | | | | | | | | | | | | ✓ | | | | | | | | | |
| 83. | Project construction complexity | | | | | ✓ | | | | | ✓ | ✓ | | | | | | | | | | | | | | | | | |
| 84. | Client-initiated variations | | | | | ✓ | | | | ✓ | | | | | | | ✓ | | | | | | | | | | | | |
| 85. | vendor error/omission | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | |
| 86. | vendor change | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | |
| 87. | Additional preliminaries due to time extension | | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | |
| **Project-related** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 88. | Site restrictions | | | | | ✓ | | | | | | | ✓ | | | | | | | ✓ | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89. | Buildability | | | | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 90. | Building codes | | | | | | | | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| 91. | Nonavailability of records of similar projects | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 92. | Nonavailability of overall project planning | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 93. | Inaccurate cost estimating | | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | |
| 94. | Construction errors at job site | | | | | | | | | | | | | | ✓ | | | | ✓ | ✓ | | | | ✓ | | | | | |
| 95. | Nonavailability of construction manuals and procedures | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 96. | Nonavailability of engineering licensing for engineers | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 97. | Delays in secure site, equipment or materials | | | | | ✓ | | | | | | | | | | | | | | ✓ | | ✓ | | | ✓ | | | | |
| 98. | Slow information flow between project team members | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 99. | Inappropriate overall structure linking all design teams Disputes/conflicts | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 100. | Unrealistic construction schedule | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 101. | Site safety considerations | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | | |
| 102. | Site security considerations | | | | | | | | | | | | | | | ✓ | | | | | | | | | | | | | |
| **Design-related** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 103. | Time limitation in the design phase | | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | |
| 104. | Necessary variations of works | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 105. | Defects in design and planning | | | | | ✓ | | | | | | | | | | | | | | ✓ | | | ✓ | ✓ | | ✓ | | | |
| 106. | Design changes in respond to site conditions | | | | | ✓ | | | | | | | | | | | | | ✓ | | | | | | | | | | |
| 107. | Delay in design information | | | | | ✓ | | | | | | | | | | | | | | | | ✓ | | | | | | | |
| 108. | Unrealistic design periods | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 109. | Errors and omissions in quantity estimations | | | | | ✓ | | | | | | | | | | | ✓ | | | | | | | | | | | | |
| 110. | Erroneous or incomplete design information | | | | | ✓ | | | | | | | | | | | | | ✓ | | | | | | | | | | |
| 111. | Long waiting time for approval of drawings | | | | | ✓ | | | | | | | | | | | ✓ | | | | | | | | ✓ | | | | |
| 112. | The design and construction criteria are outdated and do not suit the present construction technology | | | | | | | | | | | | | | | | | | | | | | ✓ | | | | | | |
| 113. | Inconsistency between drawings and site conditions | | | | | ✓ | | | | | | | | | | | | | | | | | | | | | | | |
| 114. | Insufficient site investigation prior to design | | | | | ✓ | | | | | | ✓ | | | | | ✓ | | | | | | | | | | | | |
| 115. | Mistakes and discrepancies in design documents | | | | | ✓ | | | | | | | | | | | | | | | | | | | ✓ | | | | |
| 116. | Citation of inadequate specification | | | | | ✓ | | | | | | | | | ✓ | | | | | | | | | | | | | | |
| 117. | Design changes | | | | | ✓ | | | | | | ✓ | | | | | | | ✓ | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 118. | Inadequate design team experience | | | | | ✓ | | | | | | | | | | | | | | | | | ✓ | | | | ✓ | | |
| 119. | poor project definition by owners | | | | | | | | | | ✓ | | | | | | | | | | | | | | | | | | |
| 120. | inadequate project change management | | | | | ✓ | | | | | ✓ | | | | | | | | | | | | | | | | | | |

# Chapter 3: Research Methodology

This chapter discusses the methodology that have been used in the research. The research methodology was chosen to comply with the aim and objectives which assist finalizing this research study. This chapter included information about the research design, sample size, data collection technique, the design of questionnaire and evaluation, face-validity of the questionnaire, pre-testing the questionnaire, pilot study, final format and content of the questionnaire, and analytical methods for the data.

## 3.1 Research aim and objectives

This research was designed to improve the control on variation order issue to the minimum in construction projects in Gaza Strip in general and Qatar projects in particular. In achieving this aim, three main objectives have been outlined which includes:

1. To investigate the factors causing variation order from the literature.
2. To extract real causes of variation order through analyzing a case study of one of the completed projects of Qatar projects.
3. To propose recommendations to decrease the variation orders to minimum as much as possible.

## 3.2 Research design

The design of the research is describing several points in the research as defining the problem, the previous studies, designing the questionnaire, validity, testing the questionnaire, pilot study, analyzing, and deriving results. In order to explore these stages, a quantitative survey approach involving different institutions and positions to whom involved in the study from the construction industry in Gaza Strip. The research technique was chosen as a questionnaire research to measure objectives. To support the study, a case study analysis on one of the completed projects was conducted to compare the results of analyzing the questionnaire and give conclusions and recommendations. The detailed methodology of this study was illustrated in Figure (3.1).

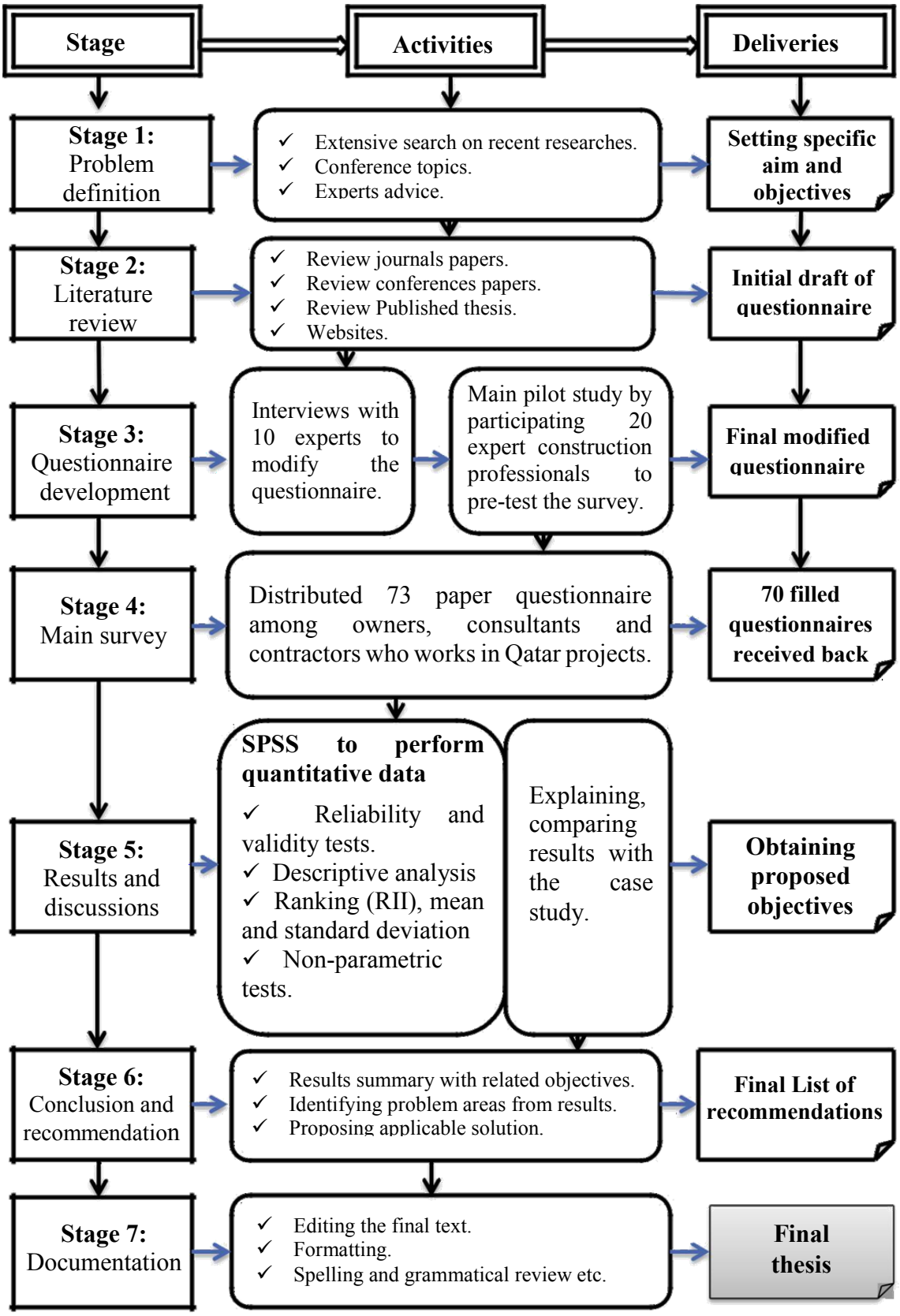


**Figure 3.1**: Framework of the research methodology

**First stage: Problem identification**

The inception was to define the problem and the related definitions, demonstrate the aim, objectives, hypotheses, and promote a research approach and a suitable technique.

**Second stage: Literature Review**

Several studies were reviewed form the literature and raised the knowledge of the subject of VO, reading and taking notes from different sources such as:

- Refereed academic research journals
- Refereed conferences
- Dissertations/theses
- Conferences
- Websites

The literature review for this study revealed several interesting points; questionnaire survey is worthy when collecting data from a large sample but the issue that each respondent would be biased to the position they are in (Olsen *et al.,* 2012). Also, the concept of VO (definition and causes), and VO's relations with different aspects such as construction industry, highway, productivity, cost, time and quality.

To be precise, the researcher has accumulated 120 different causes of VO from the literature. They all were reviewed in the previous chapter in Table (2.1). Some of those causes have been modified; others have been merged; or have been deleted through the process of questionnaire evaluation as well as some items have been added.

**Third stage: Questionnaire design and evaluation**

Through this stage, the following points have been identified: types and distribution of questions, the questions suitability and the spot–on questions.

**Fourth stage: Pre-testing the questionnaire**

Pre-testing the questionnaire was done to create an effective survey by determining the effectiveness of the questionnaire. It is necessary to pre-test it before actually using it. Pre-testing can help determining the strengths and weaknesses of the questionnaire concerning question format, wording and order. The pre-testing was managed by 10 professionals and academics in Gaza Strip. The questions were rephrased, simplified, and modified based on the feedback from the experts, thus questions have become clear to be answered in a way that helps to achieve the target of the study.

**Fifth stage: Pilot study**

A small-scale rehearsal of the larger research is conducted before the intended study. Pilot studies are usually executed as planned for the intended study, but on a smaller scale. Although a pilot study cannot eliminate all systematic errors or unexpected

problems, it reduces the likelihood of making a Type I or Type II error. 20 copies of the questionnaire were distributed, retrieved and analyzed. After analysis, pilot study test proved that the questionnaire design (the internal consistency, and the structure of the questionnaire) is valid and that data collected were reliable. Based on that, the 20 successful copies were included in the whole sample.

**Sixth stage: Sampling of the questionnaire**

After piloting, the questionnaire was adopted and distributed to the whole sample (Judgment sampling). There are no strict rules to follow, and the researcher must rely on logic and judgment. The population is defined in keeping with the objectives of the study. Sometimes, the entire population will be sufficiently small, and the researcher can include the entire population in the study. This type of research is called a census study because data is gathered on every member of the population.

**Seventh stage: Analysis and presentation of the results**

After collecting data, quantitative analysis was adopted by Statistical Package for Social Science (SPSS) IBM version 20. It was done by converting the ordinal data to scale data. The following quantitative measures were used for the data analysis:

A. Descriptive Statistics (Burati *et al.*, 1992; Osman *et al.*, 2009)
    1. Frequencies and Percentile (results can be presented in the form of tabulation, a bar chart, a pie chart or a graph).
    2. Measures of central tendency (the mean)
    3. Measurement of dispersion based on the mean (standard deviation)
    4. Relative Important Index (RII)
    5. Normal distribution

B. The inferential statistics (bivariate)
    1. Pearson product-moment correlation coefficient/ Pearson's correlation coefficient (a parametric test )
    2. The sample independent *t*-test to find whether there is a significant differences in the mean between two groups (a parametric test)
    3. Analysis of variance (one way ANOVA) test (a parametric test)
    4. Scheffé's method for multiple comparisons

**Eighth stage: Case study**

A case study of one of the completed projects to be analyzed and compared with the results of the study.

**Ninth stage: conclusion and recommendations**

The final stage of the research included the conclusions and recommendations.

### 3.3 Target population and sampling of the questionnaire

The questionnaire survey was carried out in December 2015. Research population involving engineers from different institutions and positions in the construction industry in Gaza Strip and engineers working in projects belonging to the State of Qatar. The target group was limited only to Qatar projects. Judgment sample was chosen as the type of sample. Judgmental sampling is a non-probability sampling technique where the researcher selects units to be sampled based on their knowledge and professional judgment. Judgmental sampling design is usually used when a limited number of individuals possess the trait of interest. It is the only viable sampling technique in obtaining information from a very specific group of people. The sample was chosen carefully to provide adequate reliability and ensure its validity.

To determine the sample size for the whole population the following equation was used (Estimating a Proportion for a Small, Finite Population, 2016):

$$n = \frac{m}{1+\frac{m-1}{N}}$$

Where;

*m*: is the sample size necessary for estimating the proportion for a large population, which can be calculated from this formula:

$$m = \frac{(Z_{\alpha/2})^2 * p(1-p)}{\varepsilon^2}$$

*n*: is the sample size necessary for estimating a population proportion p of a small finite population.

*N*: Total population.

$\varepsilon$: Margin of error (e.g. 4%).

$Z_{\alpha/2}$: Z value (e.g. 1.96 for 95% confidence level).

*p*: Sample proportion.

The sample size for the whole population can be calculated from the previous equations as follows:

$m = (1.96)^2 * (0.5*0.5) / (0.04)^2 = 600.25$

$n = \frac{600.25}{1+\frac{600.25-1}{400}} = 240$ (owners, consultants and contractors).

The available sample was less than the required sample size and so it was used all. 73 copies of the questionnaire were distributed and 70 copies of the questionnaire were returned from the respondents and completed for quantitative analysis. The totals of 70 questionnaires were satisfactorily completed, making the total response rate

(70/73)*(100) = (95.9 %). Personal delivery, colleague's assistant and cooperation of the respondents helped to increase the rate of response for the sample.

### 3.4 Questionnaire design and evaluation

The type of questionnaire used was a self-administered questionnaire. There are three fundamental stages that should be taken into account when constructing a questionnaire:

1. Identifying the first thought questions.
2. Formulating the final questionnaire.
3. Wording of questions.

Before constructing the questionnaire, literature should be reviewed and start formulating the list of questions which took a massive effort to prepare the questions related to be best-fit to the current situation of VO. After that, a number of sections or categories for the questionnaire should be introduced and be given titles. The questionnaire is constructed with three sections to correspond with the objectives. The first section of the questionnaire was named 'General Information or Factual questions'. The second section was named 'Information about projects the respondents worked in' and the third section was named 'Causes of VO'. Then, questions were rectified properly.

The questionnaire consisted of closed-ended questions which are easy to ask and quick to answer, they require no writing by either respondent, and their analysis is straightforward. But, the main drawback is that respondents are required to choose a response that does not exactly reflect their answer; the researcher cannot further explore the meaning of the responses.

In addition, the questionnaire was prefixed with a covering letter elucidating the main goal of the research, and confidentiality of information in order to reassure the respondents that the research was merely for scientific purposes. Also, the questions were set to achieve the objectives and conclude results to come up with proper suggestions and recommendations.

After answering the factual questions and information about projects the respondents administrated/worked in, respondents were asked to rate each cause in the third part by giving it a quantitative value using a Likert scale that required a ranking (1– 5), where 1 represented "*lowest scale*" and 5 represented "*highest scale*", as the case might be. A five-level Likert item was used as shown in Table (3.1):

**Table (3.1):** Likert items for the numerical rating scale

| **Severity (Influence)** | extremely influential | very influential | somewhat influential | slightly influential | not at all influential |
|---|---|---|---|---|---|
| **Occurrence (frequency)** | A great deal | A Moderate amount | Occasionally | Rarely | Never |
| **scale** | 5 | 4 | 3 | 2 | 1 |

To start with the questionnaire, a draft was reconsidered through three primary stages, which are: *pre-testing the questionnaire*, and *pilot study*. With every stage, the questionnaire was changed and refined in an incredible increment. Concerning details of every stage, it will be demonstrated in the accompanying parts.

### 3.5 Pre-testing the questionnaire

Pre-testing the questionnaire was done to create an effective survey by determining the effectiveness of the questionnaire. It was necessary to pre-test it before actually using it. Pre-testing can help determining the strengths and weaknesses of the questionnaire concerning question format, wording and order. The pre-testing was managed by 10 professionals and academics in Gaza Strip. The questions were rephrased and simplified based on the feedback from the experts, thus questions have become clear to be answered in a way that helps to achieve the target of the study. There were adjustments in the wording of the questions, and the choices in some of the questions. Necessary questions have been added. Also, a number of factors from the third stage of the questionnaire were merged, deleted or modified. For more details, review Table (3.2).

**Table (3.2):** Results of pre-testing the questionnaire

| **Expert #** | **Outcome** |
|---|---|
| 1 | ✓ Added a two important questions in the general information section.<br>✓ Wording of some questions in the first and second section.<br>✓ Amendment on the scale of answers in the second section.<br>✓ Reformulation the factors causing variation orders.<br>✓ Delete duplicated factors in the third section<br>✓ Clarify some of the ambiguous sentence in third section.<br>✓ Adding other suitable factors in the third section.<br>✓ Group similar points in a sequential order of the processes.<br>✓ Suggestion to a new title for sub-list in the third section. |

| | |
|---|---|
| | ✓ Sort factors that are not in place and replace them under the possible clause. |
| 2 | • Change the scale/range of answers in the first section.<br>• Delete repeated questions from the first section.<br>• Re-wording of the question and answers in the first section.<br>• Add a paragraph guidelines for the respondent of the questionnaire.<br>• Numbering factors should not be cumulative, but to be unique for each clause.<br>• Modify the title of the clause in the third section.<br>• Rephrasing some of the factors in the third section.<br>• Factors not appropriate to the condition of the study should be omitted.<br>• Clarifying vague phrases in third section.<br>• Additional clause for an open-ended question related to the third section. |
| 3 | ▪ Distinguish or add factors related to the client/donor rather than owner-related factors in the third section of the questionnaire.<br>▪ Delete poorly understood/inappropriate factors in the third section.<br>▪ Merge similar factors in the third section. |
| 4 | ➢ Add a separate clause for donor related factors in the third section.<br>➢ A number of questions repeated directly and indirectly need to be merged or deleted.<br>➢ Clarify unclear factors in third section.<br>➢ Modify inexpedient factors.<br>➢ Move some factors to other convenient clauses.<br>➢ Standardization of terminology in third section. |
| 5 | - The hypotheses and research aim must be attached to the study to pre-test the questionnaire. |
| 6 | ✓ Re-wording questions in first section<br>✓ Illustrate vague questions in second and third section.<br>✓ Delete repeated factors in the third section.<br>✓ Move some factors to their suitable clause. |
| 7 | • Modify the choices of intervals/numbers in the first section to not be interfered.<br>• Add a separate clause for other factors in the third section. |

| | |
|---|---|
| 8 | ▪ Wording of some questions in the first and second section.<br>▪ Reformulation the factors causing variation orders.<br>▪ Delete duplicated factors in the third section.<br>▪ Clarify some of the ambiguous sentence in third section. |
| 9 | ➢ Change the scale/range of answers in the first section.<br>➢ Delete repeated questions from the first section.<br>➢ Factors not appropriate to the condition of the study should be omitted.<br>➢ Clarifying vague phrases in third section. |
| 10 | • Delete repeated factors in the third section. |

### 3.6 Pilot study

A small-scale rehearsal of the larger research is conducted before the intended study and after a successful pre-testing. Pilot studies are usually executed as planned for the intended study, but on a smaller scale. Although a pilot study cannot eliminate all systematic errors or unexpected problems, it reduces the likelihood of making a Type I or Type II error. 20 copies of the questionnaire were distributed to the target group, retrieved and analyzed through Statistical Package for the Social Sciences IBM (SPSS) version 20. The conducted tests were as follows:

1. Statistical validity of the questionnaire.
2. Reliability of the questionnaire by Cronbach's Coefficient Alpha method.

#### 3.6.1 Statistical validity of the questionnaire

Onwuegbuzie *et al.* (2007) defined Validity as *"the extent to which scores generated by an instrument measure the characteristic or variable they are intended to measure for a specific population"*. "Items in the questionnaire must measure something, and a good questionnaire measures what you designed it to measure (this is called validity). So, validity basically means measuring what you think you are measuring". (Field, 2003). Two substantial tests are applied, the first is criterion-related/internal validity test (Pearson test) which measures the extent to which scores on an instrument are related to an independent external/criterion variable believed to measure directly the underlying attribute or behavior. The second is structure validity test (Pearson test) that shows "*the degree to which scores of a questionnaire are an adequate reflection of the dimensionality of the construct to be measured*" (Elbers *et al.*, 2012).

#### Internal validity test

Internal consistency of the questionnaire was measured by the pilot study sample which consisted of 20 questionnaires. It was done by measuring the correlation coefficients (Pearson test) between each item in one field and the whole filed.

**Structure validity test**

Structure validity defined as the degree to which scores of a questionnaire are an adequate reflection of the dimensionality of the construct to be measured. Structure validity is the second statistical test that used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. As shown in Table (3.3), the significance values are less than 0.01, which indicates that the correlation coefficients of all the fields are significant at α = 0.01. Thus, it can be said that the fields are valid to be measured what it were set for to achieve the main aim of the study.

**Table (3.3):** Structure validity of the questionnaire

| Fields | Pearson correlation coefficient | Sig. (2-tailed) at 0.01 level |
|---|---|---|
| Owner-related factors | 0.723 | 0.000 |
| Consultant-related factors | 0.723 | 0.000 |
| Contractor-related factors | 0.857 | 0.000 |
| Environment-related factors | 0.813 | 0.000 |
| Other factors | 0.737 | 0.000 |

### 3.7.2 Reliability test

Reliability is the degree to which an assessment tool (questionnaire for this study) produces stable and consistent results. The method correlate between different items on the same test. It measures whether several items that propose to measure the same general construct produce similar scores. This test is an indication of good internal consistency of the questionnaire which is usually measured by Cronbach's alpha test. For designing a reliable questionnaire, the reliability coefficient should be greater than 0.7. Cronbach's alpha coefficient test was used through the SPSS software.

**Cronbach's Coefficient Alpha ($C_\alpha$)**

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. The value of alpha (α) may lie between negative infinity and 1. However only positive values of α make sense. Generally, alpha coefficient ranges in value from 0 to 1. (Streiner & Norman, 1989).

Cronbach's coefficient alpha ($C_\alpha$) was calculated for the third section of the questionnaire as shown in Table (3.4), the. The results were superior as they were above 0.9. This range is considered acceptable as it is above 0.7 and excellent where it is greater than 0.9. Thus, the result ensures the reliability of the questionnaire.

**Table (3.4):** Cronbach's Coefficient Alpha for reliability (Cα)

| No. | Fields | Cronbach's alpha ($C\alpha$) |
|---|---|---|
| 1 | Influence | 0.969 |
| 2 | Occurrence | 0.971 |

As shown above, results of the statistical validity of the questionnaire as well as results of reliability tests (Cronbach's coefficient Alpha method) showed the success of the tests and thus the success of the questionnaire (valid and reliable). Thereby, the questionnaire was adopted and the 20 successful copies of the pilot study were included in the whole sample.

### 3.7 Final amendment to the questionnaire

The questionnaire was ascertain to be valid hence it was adopted and distributed to the whole sample. As mentioned previously, the questionnaire was prefixed with a covering letter elucidating the main goal of the research, confidentiality of the information in order to reassure the respondents that the research was merely for scientific purposes. The questionnaire was executed in Arabic language (Appendix 2). It would be more efficient than the English version (Appendix 1) because the target may have lack of knowledge about English language because their native language is Arabic. Otherwise, the questionnaire will alienate the respondents from positively responding to the study.

As recalled earlier in (3.2 Research design), section three of the questionnaire was meant for the causes of VO which were divided into five clusters that were reviewed in the previous chapter (literature review) in Table (2.1). The researcher has collected and briefly viewed it as 10 of owner-related causes, 12 consultant-related causes, 20 contractor-related causes, 7 environment-related causes and 3 other causes.

### 3.8 Quantitative data analysis

When facing a social or human problem and testing a hypothesis, a quantitative strategy is suitable where their exists variables, measurements, analysis and statistical procedures. The advantages is that it can be used with a large number of cases representing the population and recommend a final course of action.

Statistical analysis is substantial for all the attempts or trials that uses statistics as a methodology of a research. Almost, these trials exists in social sciences and several significant attempts in natural sciences and engineering that demand statistical analysis. Statistical analysis is very beneficial to gain indefinite solutions when the real procedures are complex or obscure in its true form.

### 3.9 Measurements

Analysis of the data was undertaken using IBM SPSS Statistics (Statistical Package for the Social Sciences) Version 20. The following quantitative measures were used for the data analysis:

A. Descriptive Statistics (Burati *et al.*, 1992; Osman *et al.*, 2009).
    1. Frequencies and Percentile.
    2. Measures of central tendency (the mean)

3. Measurement of dispersion based on the mean (standard deviation)
4. Relative Important Index (RII)
5. Normal distribution

B. The inferential statistics (bivariate).
   1. Pearson product-moment correlation coefficient/ Pearson's correlation coefficient (a parametric test).
   2. The sample independent t-test to find whether there is a significant differences in the mean between two groups (a parametric test).
   3. Analysis of variance (one way ANOVA) test (a parametric test).
   4. Scheffé's method for multiple comparisons.

### 3.9.1 Calculating of Relative Importance Index (RII) of Factors

The relative importance index method (RII) was used to determine the ranks of variables as comprehended by the respondents in part 3 of the questionnaire. The relative importance index was computed as (Pourrostam & Ismail, 2011; Halwatura & Ranasinghe, 2013; Alnuaimi *et al.*, 2010) = $\frac{\Sigma W}{A*N}$

Where:

$W$ = is the weight given to each factor by the respondents and ranges from 1 to 5, (where "1" is "strongly disagree" and "5" is "strongly agree")

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

$N$ = is the total number of respondents

The RII value ranges from 0 to 1, the higher the value of RII, the more impact of the attribute. However, RII doesn't reflect the relationship between the various items. RII was used to rank each factor in the questionnaire and compare the responses. But, this type of analysis doesn't mean anything significative. So, additional analysis is accompanied to the RII analysis such as the mean, standard deviation and principle component analysis that can reduce the factors and study their effect. (Muhwezi *et al.*, 2014).

### 3.9.2 Normal distribution

Many statistics counts the sample as normally distributed when sample size above 30 ($n \geq 30$). Wherefore, as the sample size increase it takes the shape of a normal distributed sample. To check the assumption, a normality analysis (called One-Sample Kolmogorov-Smirnov Test) is done using SPSS. According to Table (3.5) the sample is normally distributed hence, the collected data can be used in parametric tests.

**Table (3.5):** One-Sample Kolmogorov-Smirnov Test for normality check

| | | TOTAL_AVG |
|---|---|---|
| sample number | | 70 |
| Normal Parameters[a,b] | Mean | 2.7257 |
| | Std. Deviation | 0.63325 |
| Most Extreme Differences | Absolute | 0.064 |
| | Positive | 0.064 |
| | Negative | 0.06- |
| Kolmogorov-Smirnov Z | | 0.54 |
| Asymp. Sig. (2-tailed) | | 0.933 |
| a. Test distribution is Normal | | |

### 3.9.3 Parametric tests

When the information about the population is completely known by means of its parameters and specific assumptions can be made then statistical test is called parametric test. Whereas, when the population or parameters are not known but still is required to test hypotheses of population it is called nonparametric tests. As the information about population is known and certain assumptions are made then it is a parametric test.

#### 3.9.3.1 Pearson product-moment correlation coefficient/ Pearson's correlation coefficient

Pearson product-moment correlation coefficient (sometimes referred to as the PPMCC) is the most common measure of correlation. It is an index of relationship between two variables. It reflects the degree of linear relationship between two variables. Pearson correlation is symmetric, i.e. the correlation between x and y is the same between y and x and ranges between +1 and -1, where +1means a perfect positive linear relationship between variables while -1 means a perfect negative linear relationship between variables. Also, a correlation of 0 means no linear relationship between two variables.

#### 3.9.3.2 Sample Independent *t*-test

The independent samples *t*-test is probably the most widely used test in statistics. It's used to compare differences between separate groups. Differences between groups can be explored with independent *t*-test in one condition, that the members of each group are reasonably representative of the population.

#### 3.9.3.3 One way ANOVA (F-test)

One-way analysis of variance (abbreviated one-way ANOVA) is used to estimate and

compare the effects of the differences in mean in more than two groups based on one factor (Day & Quinn, 1989)

#### 3.9.3.4 Scheffé's method (Multiple-Comparison procedure)

In statistics, Scheffé's method, named after the American statistician Henry Scheffé, is a statistical test that is used to make unplanned comparisons, rather than preplanned comparisons among group of means in an ANOVA experiment.

## 3.10 Summary

This chapter describes the details of methodology used in the research. It encompasses the preliminary design of the research, sample size and response rate to the questionnaire. The questionnaire appraisal was detailed where it include types and distribution of questions, format and the sequence of questions and the covering letter. The three fundamental steps were validity, pre-testing the questionnaire and pilot study. These steps were used on the final adjustment on the questionnaire and were described in detail in this chapter. Also, quantitative data analysis techniques have been used that involved Relative Important Index, normality, pearson correlation analysis and other methods using analytical tool such as SPSS. The results were displayed through tables, bar charts, pie charts and graphs. To ensure the test validity, reliability and adequacy of methods used in the analysis, various statistical tests were utilized and explained in details.

# Chapter 4: Results and discussion

This chapter presented the analysis and discussion of results that have been gathered from survey represented by the questionnaire and the outcome from the conducted focus group. 70 copy from the total number have been successfully returned with a response rate of 95.9%. The quantitative analysis was carried out using IBM (SPSS) v20 including descriptive and inferential statistical tools. This chapter included glimpses on respondents' profile and the way of implementing their work, quantitative analysis of the questionnaire, and finally the summary of the results.

## 4.1 Respondents' profiles

The target respondents of the questionnaire survey were engineers from different institutions and positions in the construction industry in Gaza Strip and engineers working in projects belonging to the State of Qatar. This section analyzed the personal characteristics of the 70 respondents.

Among the respondents, a large majority had "*more than 15 years*" of working experience in the construction industry, with 35.2%. The experience for the rest of the respondents were "*from 10 years to less than 15 year* ", "from *5 years to less than 10 years*" and "*less than 5 years*" with 23.9%, 25.4% and 15.5%, respectively. With respect to the nature of their positions there were 9 owners (12.7%), 26 contractors (36.6%), 34 consultants (47.9%) and 2 others (2.8%).

In terms of job description, a majority of the respondents were working as project Managers/vice with 47.9%, 42.3% were working as site engineers, 7% had other job descriptions such as: electrical engineer, mechanical engineer, office engineer, consultant engineer and supervisor engineer, and 2.8% of them were institution manager/vice.

Respondents for this study had a good understanding of consulting and construction work in the construction industry, and could thus provide reliable answers to the questionnaire. In terms of the nature of their workplace, a majority of the respondents were working in a consulting office with 45.1%, 38% were working in Contracting, 14.1% of them were working in the governmental sector, and 2.8% of them were working in the NGOs. Table (4.1) presents the characteristics of the respondents as follows:

**Table (4.1)**: The respondent's profile

| General information about respondents | Categories | Frequency | Percentage |
|---|---|---|---|
| Nature of the workplace | Consulting Office | 32 | 45.1 |
| | Contracting | 27 | 38.0 |
| | Governmental | 10 | 14.1 |
| | International NGO's | 2 | 2.8 |
| Nature of their position | Consultant | 34 | 47.9 |
| | Contractor | 26 | 36.6 |
| | Owner | 9 | 12.7 |
| | Other | 2 | 2.8 |
| Job description | Project Manager /Vice | 34 | 47.9 |
| | Site engineer | 30 | 42.3 |
| | Other | 5 | 7 |
| | Institution manager /Vice | 2 | 2.8 |
| Years of experience | more than 15 year | 25 | 35.2 |
| | from 5 years to less than 10 years | 18 | 25.4 |
| | from 10 years to less than 15 year | 17 | 23.9 |
| | less than 5 years | 11 | 15.5 |

### 4.2 Information about the projects have been managed by respondent

This section analyzed the characteristics of projects managed/directed by respondents. Table (4.2) summarized the six points in this part. According to respondents, 56.33% of the projects were building type while 43.66% were road type. In terms of percentage of projects including change orders that obstruct the work, a majority of the respondents agreed that the percentage of projects included variation was less than 20% with 47.89%. A percentage of 21.13% that there are no projects included variation. A Similar result with 15.49% that the percentage of projects included variation were 20 – 50% and more than 50%.

Ratio of projects that exceeded the value of the contract because of change orders were as follows: Less than 20% of the projects exceeded the value of the contract with a percentage of 52.11%. 20 – 50% of the projects exceeded the value of the contract with a percentage of 21.13%. More than 50% of the projects exceeded the value of the contract with a percentage of 14.08% and none of the projects exceeded the value of the contract with a percentage of 12.68%.

**Table (4.2)**: The characteristics of projects managed/directed by respondents

| Information about projects | Categories | Percentage |
|---|---|---|
| Type of project | Building/residential | 56.33% |
| | Road | 43.66% |
| Size of projects that were directed in the last five years | Less than 1 million dollars | 14.71% |
| | From 1 to less than 5 million dollars | 17.65% |
| | From 5 to less than 10 million dollars | 25% |
| | More than 10 million dollars | 42.65% |
| Percentage of projects included change orders causing obstructing the work | None | 21.13% |
| | Less than 20% | 47.89% |
| | 20 – 50% | 15.49% |
| | More than 50% | 15.49% |
| Time-delay rate in projects where several change orders occurred | None | 9.86% |
| | Less than 20% | 53.52% |
| | 20 – 50% | 25.35% |
| | More than 50% | 11.27% |
| Ratio of projects that exceeded the value of the contract because of change orders | None | 12.68% |
| | Less than 20% | 52.11% |
| | 20 – 50% | 21.13% |
| | More than 50% | 14.08% |
| The ratio which exceeded the project contract value compared to the value of the original contract | Less than 5% | 35.71% |
| | From 5 to less than 10% | 28.57% |
| | From 10 to less than 15% | 17.14% |
| | From 15 to less than 20% | 2.857% |
| | From 20 to less than 25% | 4.286% |
| | More than 25% | 11.43% |
| To what degree Variation Orders cause obstruction to projects | Very large degree | 9.86% |
| | Large degree | 12.68% |
| | Moderate | 45.07% |
| | Small degree | 28.17% |
| | Very Small degree | 4.23% |

### 4.3 Factors responsible for variation order

Factors responsible for variation orders have been divided after thorough review of the literature into 5 groups as follows: owner-related, consultant-related, contractor-related, related to the external environment of the project, and other causes. 52 causes have been taken from literature and adapted by modifying, merging or adding new

factors according to the results of pretesting of the questionnaire as mentioned in chapter 3. The conducted analysis was divided according to these five groups in the third section of the questionnaire. Each group of factors is analyzed separately. The factors in each group were subjected to the views of respondents, and the outcomes of the analysis were shown in detail. The descriptive statistics, i.e. means, standard deviations (SD, relative importance indices (RII), ranks, *t*-value (two-tailed) and analysis of variance (ANOVA) were established and presented.

### 4.4 Analysis of the influence/occurrence of each group of factors

Any construction project involves several parties such as owner, consultant and contractor. In this study, the analysis has been implemented according to the different parties participating in the study. So, descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), ranks, *t*-value (two-tailed) and analysis of variance (ANOVA) were established and presented.

#### 4.4.1 Influence of Owner-related factors

In this category, the influence of owner-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.3).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.3) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (W2, W5 and W8); (W3 and W6) and (W4 and W5), ranking will depend on the lowest SD.

**Table (4.3)**: The influence of owner-related factors on VO

| No | Owner-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Change of plans or scope by owner* | 46.67 | 8 | 51.52 | 4 | 50.40 | 3 |
| 2 | *Change of schedule by owner* | 57.78 | 4 | 58.82 | 1 | 59.23 | 1 |
| 3 | *Changes in owners' interests / requirements* | 31.11 | 10 | 50.30 | 8 | 52.31 | 2 |
| 4 | *The long waiting time to get approval on drawings* | 60.00 | 1 | 54.71 | 3 | 46.15 | 8 |
| 5 | *Inadequate project objectives* | 57.78 | 3 | 54.71 | 2 | 46.15 | 7 |
| 6 | *Replacement of materials or procedures* | 55.56 | 5 | 50.30 | 7 | 49.23 | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | *Impediment in prompt decision making process* | 51.11 | 6 | 50.00 | 9 | 40.77 | 10 |
| 8 | *Lack of previous experience in related projects* | 57.78 | 2 | 48.82 | 10 | 42.31 | 9 |
| 9 | *Obstinate nature of owner* | 48.89 | 7 | 51.18 | 5 | 47.69 | 6 |
| 10 | *Change in specifications by owner* | 44.44 | 9 | 50.91 | 6 | 48.46 | 5 |

It's shown from Table (4.3) that *"Change of schedule by owner"* (W2) is the most influential owner-related factor on variation order. It has been ranked as the first position for both; the consultant and contractor with (RII = 57.78%). This result agreed with (Memon *et al*., 2014) who found that this factor was in first position in the related category. However, *"Change of schedule by owner"* is ranked as the fourth position based on owners' point of view because this is something that touches them and it's psychologically considered not affecting VO. This emphasizes that as clear and consistent the schedule as VO fades. Change of schedule requires the contractor to provide additional resources for extra work or set some of them inactive which cause reallocation of resources producing additional costs, time loss and disturb the performance of work creating variation orders (Memon *et al*., 2014; Sunday, 2010; Alaryan *et al*., 2014; Karthick *et al.*, 2015).

Whereas, "*The long waiting time to get approval on drawings*" is ranked as the first position for owners with (RII = 60.00%) and third position to consultants. The importance of this factor that it causes delays in the adoption of drawings and hence generate variations.

### 4.4.2 Occurrence of Owner-related factors

In this category, the occurrence of owner-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.4).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.4) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (W1 and W9); (W2 and W5); (W3 and W7) and (W5; W7 and W8), ranking will depend on the lowest SD.

**Table (4.4)**: The occurrence of owner-related factors on VO

| No | Owner-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Change of plans or scope by owner* | 53.33 | 7 | 56.47 | 5 | 58.46 | 2 |
| 2 | *Change of schedule by owner* | 66.67 | 2 | 62.94 | 1 | 63.85 | 1 |
| 3 | *Changes in owners' interests / requirements* | 44.44 | 9 | 54.71 | 7 | 49.23 | 7 |
| 4 | *The long waiting time to get approval on drawings* | 68.89 | 1 | 62.35 | 3 | 57.69 | 3 |
| 5 | *Inadequate project objectives* | 62.22 | 4 | 62.94 | 2 | 47.69 | 10 |
| 6 | *Replacement of materials or procedures* | 48.89 | 8 | 52.94 | 10 | 50.77 | 6 |
| 7 | *Impediment in prompt decision making process* | 60.00 | 5 | 54.71 | 6 | 47.69 | 9 |
| 8 | *Lack of previous experience in related projects* | 64.44 | 3 | 54.12 | 8 | 47.69 | 8 |
| 9 | *Obstinate nature of owner* | 53.33 | 6 | 61.76 | 4 | 55.38 | 4 |
| 10 | *Change in specifications by owner* | 42.22 | 10 | 53.53 | 9 | 53.08 | 5 |

It's shown from Table (4.4) that *"Change of schedule by owner"* (W2) is the most occurred factor on variation order. It has been ranked as the first position for both; the consultant and contractor with (RII = 63.85%) and ranked as the second position for owners' point of view. This denotes that delays which occur in Qatar projects from consultant and contractor point of view is caused by change of schedule by owner. This result agreed with (Memon *et al*., 2014) who found that this factor was in first position in the related category. In addition, *"The long waiting time to get approval on drawings"* is ranked as the first position of owners and third position for both the consultant and specifically contractor especially when the rank for this factor increased to third position indicating its importance for contractors because in Qatar projects consultants are responsible for this waiting time because any change in the schedule leads to the need for additional time to finish the project (Memon *et al*., 2014), where it prevents the contractor to begin work without the approval of the drawings, so work remains stalled until adopted, and this leads to a delay in the project, forcing the contractor to raise a claim and for this reason variation occur.

### 4.4.3 Influence of Consultant-related factors

In this category, the influence of consultant-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.5).

RII was calculated to weight each factor of VO according to the numerical scores

obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.5) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (C1, C2 and C4); (C7 and C10); (C3 and C6); (C5 and C11); (C6 and C10) and (C1 and C10), ranking will depend on the lowest SD.

**Table (4.5)**: The influence of consultant-related factors on VO

| No | Consultant-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Change in design by consultant* | 31.11 | 10 | 54.71 | 10 | 45.38 | 7 |
| 2 | *Errors and omissions in design* | 31.11 | 10 | 55.88 | 7 | 42.31 | 11 |
| 3 | *Conflicts between contract documents* | 48.89 | 4 | 53.53 | 12 | 49.23 | 5 |
| 4 | *Inadequate design team experience* | 31.11 | 10 | 54.71 | 11 | 44.62 | 9 |
| 5 | *Consultant's lack of judgment and experience* | 44.44 | 6 | 55.88 | 8 | 41.54 | 12 |
| 6 | *Lack of consultant's knowledge of available materials and equipment* | 48.89 | 3 | 60.59 | 4 | 49.23 | 6 |
| 7 | *Design complexity and difficulty to understand* | 60.00 | 1 | 65.29 | 1 | 60.00 | 1 |
| 8 | *Insufficient time for preparation of contract documents* | 40.00 | 8 | 56.47 | 6 | 52.31 | 3 |
| 9 | *Modifications to the drawings* | 37.78 | 9 | 55.29 | 9 | 43.85 | 10 |
| 10 | *Inadequate working drawing details* | 60.00 | 2 | 60.59 | 3 | 45.38 | 8 |
| 11 | *Consultant's lack of required data* | 44.44 | 5 | 58.82 | 5 | 50.00 | 4 |
| 12 | *Failure to observe all other parties' requirements (water, electricity, etc.)* | 42.22 | 7 | 64.12 | 2 | 54.62 | 2 |

It's shown from Table (4.5) that there is a high degree of compatibility between the three parties as they agree on *"Design complexity and difficulty to understand"* (C7) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 65.29%). This entails sometimes additional work that is not clear in design and thus it requires a VO. To elaborate, the consultant put prices but, there is ambiguity or misinterpretation of drawings. Also, the contractor takes his time to

understand these drawings. In addition, skilled professionals and construction methods may be requisite compared to simple activities that are easy to handle. So, the more complexity in design, more discrepancies emerge and more chance that variations occur (Karthick *et al.*, 2015; Asamaoh & Nyako, 2013; Memon *et al*., 2014; Keane *et al.,* 2010).

*"Failure to observe all other parties' requirements (water, electricity, etc.)"* (C12) is ranked as the second position with (RII = 64.12%) in consultant and contractor's point of view. This factor requires a high degree of coordination between all disciplines (architectural, civil, electrical, etc.) and therefore such coordination consumes time and may acquire a VO.

From owner's point of view, *"Inadequate working drawing details"* (C10) was ranked as the second position. This coincides with (Asamaoh & Nyako, 2013) and (Arain *et al.,* 2004) as they gave it a rank of second position. Designers and contractors communicate through drawings. Working drawings must be clear, brief, and complete so work can be efficient. The lack of these terms in working drawings may lead to misunderstanding and deviate from the work plan and cause variations (Memon *et al.,* 2014; Asamaoh & Nyako, 2013; Arain *et al.,* 2004; Keane *et al.,* 2010; Bhadmus *et al.,*2015).

### 4.4.4 Occurrence of Consultant-related factors

In this category, the occurrence of consultant-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.6).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.6) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (C2 and C3); (C1; C9 and C12); (C6 and C7); (C10 and C11); (C5 and C11) and (C1 and C4), ranking will depend on the lowest SD.

**Table (4.6)**: The occurrence of consultant-related factors on VO

| No | Consultant-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Change in design by consultant* | 40.00 | 8 | 58.82 | 10 | 46.15 | 10 |
| 2 | *Errors and omissions in design* | 42.22 | 7 | 60.00 | 8 | 49.23 | 8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | *Conflicts between contract documents* | 42.22 | 6 | 56.47 | 12 | 48.46 | 9 |
| 4 | *Inadequate design team experience* | 35.56 | 11 | 62.35 | 6 | 46.15 | 11 |
| 5 | *Consultant's lack of judgment and experience* | 51.11 | 4 | 62.94 | 5 | 45.38 | 12 |
| 6 | *Lack of consultant's knowledge of available materials and equipment* | 57.78 | 2 | 68.82 | 2 | 53.85 | 5 |
| 7 | *Design complexity and difficulty to understand* | 57.78 | 1 | 70.00 | 1 | 60.77 | 1 |
| 8 | *Insufficient time for preparation of contract documents* | 33.33 | 12 | 59.41 | 9 | 57.69 | 3 |
| 9 | *Modifications to the drawings* | 40.00 | 9 | 57.65 | 11 | 55.38 | 4 |
| 10 | *Inadequate working drawing details* | 51.11 | 5 | 61.76 | 7 | 51.54 | 6 |
| 11 | *Consultant's lack of required data* | 51.11 | 3 | 62.94 | 4 | 50.00 | 7 |
| 12 | *Failure to observe all other parties' requirements (water, electricity ... etc.)* | 40.00 | 10 | 67.06 | 3 | 59.23 | 2 |

It's shown from Table (4.6) that there is a high degree of compatibility between the three parties as they also agree on *"Design complexity and difficulty to understand"* (C7) to be the most occurring factor on variation order. It has been ranked as the first position with (RII = 70%). This emphasizes that, this is the most important factor that affect all the parties in any project and produce VO. Skilled professionals and construction methods may be requisite compared to simple activities that are easy to handle. So, the more complexity in design, more discrepancies emerge and more chance that variations occur (Karthick *et al.*, 2015; Asamaoh & Nyako, 2013; Memon *et al*., 2014; Keane *et al.,* 2010).

On the other hand, owners and consultants united in opinion that *"Lack of consultant's knowledge of available materials and equipment"* was ranked as the second position with (RII = 68.82%) as resulted from Bhadmus *et al.* (2015). Its importance illustrated that owner should be knowledgeable and specific in the tender about the availability of materials and equipment in the country. There is no material standardization in construction industry, hence pre-selection may be difficult and lack of knowledge of available material can cause numerous variation orders due to contradiction between design and construction. (Asamaoh & Nyako, 2013; Sunday, 2010; Arain *et al.,* 2004).

### 4.4.5 Influence of Contractor-related factors

In this category, the influence of contractor-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about

this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.7).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.7) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (R2; R3; R7 and R10); (R11 and R12); (R6 and R9); (R16 and R18); (R1; R2 and R12) etc., ranking will depend on the lowest SD.

**Table (4.7)**: The influence of contractor-related factors on VO

| No | Contractor-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Fast track construction* | 37.78 | 19 | 55.88 | 10 | 56.15 | 15 |
| 2 | *Lack of strategic planning* | 55.56 | 11 | 55.88 | 8 | 55.38 | 17 |
| 3 | *Complex design and technology* | 55.56 | 9 | 60.00 | 4 | 62.31 | 4 |
| 4 | *Lack of contractor's involvement in design* | 73.33 | 1 | 70.59 | 1 | 59.23 | 9 |
| 5 | *Unsuitable management structure and style of contractor* | 57.78 | 7 | 55.29 | 11 | 62.31 | 5 |
| 6 | *Lack of communication* | 53.33 | 14 | 57.65 | 6 | 56.92 | 13 |
| 7 | *Poor site management and supervision* | 55.56 | 12 | 54.71 | 13 | 60.77 | 7 |
| 8 | *Lack of a specialized construction manager* | 42.22 | 18 | 51.76 | 18 | 57.69 | 11 |
| 9 | *Contractor's lack of required data* | 53.33 | 13 | 50.59 | 19 | 53.85 | 18 |
| 10 | *Shortage of materials* | 55.56 | 10 | 52.94 | 17 | 56.15 | 16 |
| 11 | *Improper control over site resource allocation* | 60.00 | 6 | 54.12 | 14 | 61.54 | 6 |
| 12 | *Contractor's lack of judgment and experience* | 60.00 | 5 | 55.88 | 9 | 56.92 | 13 |
| 13 | *Shortage of skilled manpower* | 66.67 | 2 | 55.29 | 12 | 63.85 | 2 |
| 14 | *Defective workmanship* | 64.44 | 3 | 57.06 | 7 | 65.38 | 1 |
| 15 | *Changes in construction method* | 62.22 | 4 | 60.59 | 3 | 63.08 | 3 |
| 16 | *Differing site conditions* | 48.89 | 16 | 65.88 | 2 | 56.92 | 12 |
| 17 | *Contractor's financial difficulties* | 57.78 | 8 | 52.94 | 16 | 60.77 | 8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | *Contractor's desired profitability* | 48.89 | 17 | 50.00 | 20 | 47.69 | 20 |
| 19 | *Poor scheduling* | 51.11 | 15 | 57.65 | 5 | 57.69 | 10 |
| 20 | *Inadequate shop drawing details* | 35.56 | 20 | 52.94 | 15 | 53.08 | 19 |

It's shown from Table (4.7) that owner and consultant agreed on *"Lack of contractor's involvement in design"* (R4) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 73.33%). From the practical side, this is somehow difficult because in designing phase we don't know the contractor yet until the tender is awarded. However, this factor necessarily affects work causing VO. Including a contractor who is characterized by good practical experience, in the design stage can decrease issues between him and the consultant or the designer (Memon *et al.,* 2014; Karthick *et al.,* 2015).

Contractor respondents placed *"Defective workmanship"* at first rank while owner and consultant consider this factor less important. This result matched with (Memon *et al.,* 2014) who ranked it in first position for contractors responses. Poor workmanship waste material, time, and increase cost when wrecking executed activities and re-implement them (Karthick *et al.,* 2015; Memon *et al.,* 2014; Keane *et al.,* 2010).

On the other hand, owners and contractors shared the same opinion that *"Shortage of skilled manpower"* was ranked as the second position with (RII = 66.67%) which corresponded with (Sunday, 2010) as he ranked it a second position. Technological projects require skilled manpower to execute the work skillfully. The shortage of skilled manpower can introduce flaws and delay the work and variations arose (Memon *et al.,* 2014; Keane *et al.,* 2010; Arain *et al.,* 2004).

### 4.4.6 Occurrence of Contractor-related factors

In this category, the occurrence of contractor-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.8).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.8) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (R7 and R11); (R3 and R12); (R2 and R13); (R9 and R16); (R5 and R17) etc., ranking will depend on the lowest SD.

**Table (4.8)**: The occurrence of contractor-related factors on VO

| No | Contractor-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Fast track construction* | 53.33 | 15 | 65.29 | 7 | 66.92 | 8 |
| 2 | *Lack of strategic planning* | 68.89 | 3 | 61.18 | 12 | 63.08 | 14 |
| 3 | *Complex design and technology* | 66.67 | 5 | 65.29 | 6 | 67.69 | 6 |
| 4 | *Lack of contractor's involvement in design* | 82.22 | 1 | 71.76 | 1 | 63.08 | 12 |
| 5 | *Unsuitable management structure and style of contractor* | 64.44 | 8 | 64.12 | 9 | 68.46 | 5 |
| 6 | *Lack of communication* | 55.56 | 13 | 67.65 | 3 | 59.23 | 19 |
| 7 | *Poor site management and supervision* | 60.00 | 9 | 62.35 | 11 | 66.92 | 9 |
| 8 | *Lack of a specialized construction manager* | 53.33 | 14 | 60.59 | 15 | 70.00 | 2 |
| 9 | *Contractor's lack of required data* | 44.44 | 20 | 60.00 | 16 | 58.46 | 20 |
| 10 | *Shortage of materials* | 57.78 | 12 | 58.24 | 17 | 60.77 | 18 |
| 11 | *Improper control over site resource allocation* | 60.00 | 11 | 66.47 | 5 | 65.38 | 11 |
| 12 | *Contractor's lack of judgment and experience* | 66.67 | 4 | 69.41 | 2 | 66.15 | 10 |
| 13 | *Shortage of skilled manpower* | 68.89 | 2 | 63.53 | 10 | 67.69 | 7 |
| 14 | *Defective workmanship* | 82.22 | 1 | 60.59 | 13 | 68.46 | 4 |
| 15 | *Changes in construction method* | 60.00 | 10 | 66.47 | 4 | 68.46 | 3 |
| 16 | *Differing site conditions* | 44.44 | 19 | 64.71 | 8 | 63.08 | 13 |
| 17 | *Contractor's financial difficulties* | 64.44 | 6 | 57.65 | 19 | 72.31 | 1 |
| 18 | *Contractor's desired profitability* | 46.67 | 17 | 57.06 | 20 | 63.08 | 15 |
| 19 | *Poor scheduling* | 51.11 | 16 | 60.59 | 14 | 62.31 | 16 |
| 20 | *Inadequate shop drawing details* | 46.67 | 17 | 57.65 | 18 | 60.77 | 17 |

It's shown from Table (4.8) *"Lack of contractor's involvement in design"* (R4) to be the most occurring factor on variation order. It has been ranked as the first position with (RII = 82.22%) in owner and consultant's point of view. This factor necessarily affects work causing VO. Including a contractor who is characterized by good practical experience, in the design stage can decrease issues between him and the consultant or the designer (Memon *et al.,* 2014; Karthick *et al.,* 2015).

On the other hand, for contractors *"Contractor's financial difficulties"* (R17) was ranked as the first position with (RII = 72.31%) which disagree with owners and consultants who gave it a rank of sixth and nineteenth position respectively. Contractor is responsible for executing the work using his skilled and unskilled labors. And for those resources to be available the contractor must pay wages on time whether he got paid or not. If the contractor is facing financial difficulties, this will affect the availability of manpower and may require variation or extension of time. (Memon *et al*., 2014; Sunday, 2010; Pourrostam & Ismail, 2011; Keane *et al.,* 2010).

### 4.4.7 Influence of External environment-related factors

In this category, the influence of external environment-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.9).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.9) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (V3 and V4), ranking will depend on the lowest SD.

**Table (4.9)**: The influence of external environment-related factors on VO

| No | External environment-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Weather conditions* | 66.67 | 1 | 60.59 | 3 | 58.46 | 5 |
| 2 | *Force majeure* | 46.67 | 6 | 47.65 | 7 | 40.77 | 7 |
| 3 | *Site security considerations* | 55.56 | 4 | 58.82 | 4 | 62.31 | 2 |
| 4 | *Change in government regulations* | 55.56 | 3 | 63.53 | 2 | 61.54 | 3 |
| 5 | *Change in economic conditions* | 40.00 | 7 | 54.71 | 6 | 55.38 | 6 |
| 6 | *Changes in the competing market* | 48.89 | 5 | 57.06 | 5 | 59.23 | 4 |
| 7 | *Delays in secure site, equipment or materials* | 64.44 | 2 | 64.71 | 1 | 66.92 | 1 |

It's shown from Table (4.9) that *"Delays in secure site, equipment or materials"* (V7) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 66.92%) for consultant and contractor. However, the owner

ranked this factor at second position but, it still indicated the importance of this factor. However, *"Change in government regulations"* was ranked as the second position with (RII = 63.53%) for consultant and third position for both; owner and contractor. This result agreed with (Sunday, 2010) and (Bhadmus *et al.,* 2015) as they ranked it as third position. The importance is represented in the extent of the application of government regulations made by local authorities that must be enrolled in the design or the execution of the project will be troublesome (Arain *et al.,* 2004). On the other hand, *"Weather conditions"* was ranked as first position for owners' point of view. This result agreed by (Karthick *et al.*, 2015) who ranked it the first position which shows that it has an effect on projects causing variation orders.

### 4.4.8 Occurrence of External environment-related factors

In this category, the occurrence of external environment-related factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.10).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.10) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (V2 and V3) and (V6 and V7), ranking will depend on the lowest SD.

**Table (4.10)**: The occurrence of External environment-related factors on VO

| No | External environment-related factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Weather conditions* | 55.56 | 3 | 68.24 | 3 | 64.62 | 3 |
| 2 | *Force majeure* | 37.78 | 6 | 55.88 | 7 | 46.92 | 7 |
| 3 | *Site security considerations* | 55.56 | 2 | 64.12 | 4 | 65.38 | 2 |
| 4 | *Change in government regulations* | 53.33 | 4 | 68.24 | 2 | 63.08 | 4 |
| 5 | *Change in economic conditions* | 37.78 | 7 | 59.41 | 5 | 61.54 | 5 |
| 6 | *Changes in the competing market* | 48.89 | 5 | 58.82 | 6 | 60.77 | 6 |
| 7 | *Delays in secure site, equipment or materials* | 57.78 | 1 | 70.00 | 1 | 69.23 | 1 |

It's shown from Table (4.10) that there is a high degree of compatibility between the three parties as they agree on *"Delays in secure site, equipment or materials"* (V7) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 70%). *"Site security considerations"* is ranked as the second position for owner and contractor's point of view with (RII = 65.38%).

### 4.4.9 Influence of other factors

In this category, the influence of other factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.11).

RII was calculated to weight each factor of VO according to the numerical scores obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.11) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (V3 and V4), ranking will depend on the lowest SD.

**Table (4.11)**: The influence of other factors on VO

| No | Other factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Site safety considerations* | 53.33 | 1 | 59.41 | 1 | 63.85 | 1 |
| 2 | *Interventions of beneficiaries* | 35.56 | 3 | 56.47 | 2 | 53.85 | 2 |
| 3 | *Intervention of others in the decision-making process* | 44.44 | 2 | 47.06 | 3 | 48.46 | 3 |

It's shown from Table (4.11) that there is a high degree of compatibility between the three parties as they agree on *"Site safety considerations"* (O1) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 63.85 %). This emphasizes that, this is an important factor. Because in developed countries, safety considerations are not considered in project delivery. Safety should be considered along with cost, quality and time to measure success of projects.

### 4.4.10 Occurrence of other factors

In this category, the occurrence of other factors have been analyzed. Responses of owners, consultants and contractors have been sorted and analyzed about this group. The descriptive statistics, i.e. means, standard deviations (SD), relative importance indices (RII), and ranks were established and presented in Table (4.12).

RII was calculated to weight each factor of VO according to the numerical scores

obtained from the questionnaire responses and results have been ranked from the highest degree (the most influential factor on VO) to the least degree (the lowest influential factor on VO). Table (4.12) provides RIIs and ranks of VO causes. The numbers in the "rank" column represent the sequential ranking. It's worth mentioning that ranking of VO factors was based on the highest mean, RII, and the lowest SD. If some factors have similar means and RIIs, as in the case of (O1 and O3), ranking will depend on the lowest SD.

**Table (4.12)**: The occurrence of other factors on VO

| No | Other factors | Result for each party | | | | | |
|---|---|---|---|---|---|---|---|
| | | Owner | | Consultant | | Contractor | |
| | | RII | Rank | RII | Rank | RII | Rank |
| 1 | *Site safety considerations* | 55.56 | 1 | 68.24 | 1 | 65.38 | 1 |
| 2 | *Interventions of beneficiaries* | 40.00 | 3 | 60.00 | 2 | 58.46 | 2 |
| 3 | *Intervention of others in the decision-making process* | 55.56 | 2 | 50.59 | 3 | 48.46 | 3 |

It's shown from Table (4.12) that there is a high degree of compatibility between the three parties as they agree on *"Site safety considerations"* (O1) to be the most influencing factor on variation order. It has been ranked as the first position with (RII = 68.24%). This emphasizes that, this is an important factor. Safety in construction sites deals with physical and psychological well-being of workers on construction sites. Safety therefore is an economic as well as humanitarian concern that requires proper management control.

### 4.5 Test for research hypotheses

Hypothesis was used to compare the means of two or more groups. The difference is examined between two groups; consultants and contractors. This test was implemented to compare the means of responses between consultants and contractors as they form the majority of the respondents (neglecting owners which counts for only 7 respondents). Five hypotheses were tested through applying the statistic *t*-test to compare; the null hypothesis ($H_0$) which states that the means of the two groups are equal and the alternative hypothesis ($H_1$) which states that the means of the two groups are unequal (i.e., reject the null hypothesis) (Hanna *et al.,* 2002). From the *t*-distribution, a *P*-value was determined. The *p*-value was compared to a significance level of 0.05, to determine whether the null hypothesis should be rejected or not. Variables represent parts of the questionnaire, where the questionnaire was built from the following five parts:

- **Part one:** *Owner related factors.*
- **Part two:** *Consultant related factors.*
- **Part three:** *Contractor related factors.*

- **Part four:** *External environment related factors.*
- **Part five:** *Other factors.*

### 4.5.1 Relation between respondents' means of consultant and contractor on owner-related factors

> **H0**: There are no inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond.

In order to test the hypothesis, independent *t*-test was used to measure the difference between means of two groups. From the *t*-distribution, a *p*-value was determined. The *p*-value is compared to a significance level of 0.05, to determine whether the null hypothesis should be rejected or not. According to results of the test that shown in Table (4.13) with a Sig. (2-tailed) (*p*-value = 0.300), the significance value is greater than 0.05 (*P*-value > 0.05), and thus the relationship is statistically insignificant at $\alpha \leq 0.05$. Consequently, the hypothesis $H_0$ can't be rejected and so the means of consultants and contractors are equal.

**Table (4.13)**: The independent t-test for owner-related factors

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| owner_related | Equal variances assumed | 2.856 | .096 | -1.045 | 58 | .300 | -.19115 | .18284 | -.55714 | .17484 |
| | Equal variances not assumed | | | -1.083 | 57.994 | .283 | -.19115 | .17657 | -.54460 | .16230 |

### 4.5.2 Relation between respondents' means of consultant and contractor on consultant-related factors

> **H0**: There is no inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond.

In order to test the hypothesis, independent *t*-test was used to measure the difference between means of two groups. From the *t*-distribution, a *p*-value was determined. The *p*-value is compared to a significance level of 0.05, to determine whether the null hypothesis should be rejected or not. According to results of the test that shown in Table (4.14) with a Sig. (2-tailed) (*p*-value = 0.03), the significance value is less than 0.05 (*P*-value < 0.05), and thus the relationship is statistically significant at $\alpha \leq 0.05$. Consequently, the hypothesis $H_0$ is rejected and so the means of consultants and contractors are unequal.

**Table (4.14)**: The independent t-test for consultant-related factors

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| consultant_related | Equal variances assumed | 3.056 | .086 | -2.225 | 58 | .030 | -.48954 | .22005 | -.93002 | -.04907 |
| | Equal variances not assumed | | | -2.338 | 57.329 | .023 | -.48954 | .20938 | -.90876 | -.07033 |

### 4.5.3 Relation between respondents' means of consultant and contractor on contractor-related factors

**$H_0$**: There is no inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond.

In order to test the hypothesis, independent *t*-test was used to measure the difference between means of two groups. From the *t*-distribution, a *p*-value was determined. The *p*-value is compared to a significance level of 0.05, to determine whether the null hypothesis should be rejected or not. According to results of the test that shown in Table (4.15) with a Sig. (2-tailed) (*p*-value = 0.647), the significance value is greater than 0.05 (*P*-value > 0.05), and thus the relationship is statistically insignificant at $\alpha \leq 0.05$. Consequently, the hypothesis $H_0$ can't be rejected and so the means of consultants and contractors are equal.

**Table (4.15)**: The independent t-test for contractor-related factors

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| contractor_related | Equal variances assumed | .417 | .521 | .460 | 56 | .647 | .11084 | .24075 | -.37143 | .59311 |
| | Equal variances not assumed | | | .457 | 51.861 | .650 | .11084 | .24257 | -.37594 | .59762 |

### 4.5.4 Relation between respondents' means of consultant and contractor on External environment-related factors

**$H_0$**: There is no inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond.

In order to test the hypothesis, independent *t*-test was used to measure the difference between means of two groups. From the *t*-distribution, a *p*-value was determined. The *p*-value is compared to a significance level of 0.05, to determine whether the null

hypothesis should be rejected or not. According to results of the test that shown in Table (4.15) with a Sig. (2-tailed) (*p*-value = 0.926), the significance value is greater than 0.05 (*P*-value > 0.05), and thus the relationship is statistically insignificant at $\alpha \leq 0.05$. Consequently, the hypothesis $H_0$ can't be rejected and so the means of consultants and contractors are equal.

**Table (4.15)**: The independent t-test for contractor-related factors

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Environment_related | Equal variances assumed | 2.591 | .113 | -.093 | 57 | .926 | -.02198 | .23604 | -.49464 | .45068 |
| | Equal variances not assumed | | | -.096 | 56.969 | .924 | -.02198 | .22874 | -.48003 | .43608 |

### 4.5.5 Relation between respondents' means of consultant and contractor on other factors

> **$H_0$**: There is no inverse relationship, statistically insignificant at $\alpha \leq 0.05$, between means for consultants respond and means for contractors respond.

In order to test the hypothesis, independent *t*-test was used to measure the difference between means of two groups. From the *t*-distribution, a *P*-value was determined. The *P*-value is compared to a significance level of 0.05, to determine whether the null hypothesis should be rejected or not. According to results of the test that shown in Table (4.15) with a Sig. (2-tailed) (*P*-value = 0.695), the significance value is greater than 0.05 (*P*-value > 0.05), and thus the relationship is statistically insignificant at $\alpha \leq 0.05$. Consequently, the hypothesis $H_0$ can't be rejected and so the means of consultants and contractors are equal.

**Table (4.16)**: The independent t-test for contractor-related factors

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| O_AVG | Equal variances assumed | .023 | .879 | .394 | 57 | .695 | .08139 | .20656 | -.33223 | .49501 |
| | Equal variances not assumed | | | .392 | 52.627 | .697 | .08139 | .20769 | -.33526 | .49804 |

### 4.6 Analysis considering all parties in the project

ANOVA (*F*-test) provides a parametric statistical test of whether the means of several groups (more than two) are equal or not. Thus, ANOVA was used to test the differences among opinions of respondents with respect to their position (Owner, consultant and contractor).

According to the results of the test as shown in table (4.17), the significance value for owner related factors equals 0.711, which is greater than 0.05 (*P*-value > 0.05). Thus, there are no statistically significant differences between the three parties on this category. The same result occurred for contractor and environment related factors with *P*-value = 0.421 & *P*-value = 0.342 for contractor and environment related factors, respectively. But, in the case of consultant related factors and other factors, the *P*-value = 0.022 & *P*-value = 0.034, respectively, which is less than 0.05 (*P*-value < 0.05) Thus, there are statistically significant differences between the three parties on this category. To clarify in more detail the spots were the differences are, Scheffe test is used.

**Table (4.17)**: One way ANOVA results regarding all parties

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| owner_related | Between Groups | .543 | 2 | .272 | .611 | .546 |
| | Within Groups | 30.226 | 68 | .444 | | |
| | Total | 30.769 | 70 | | | |
| Consultant_related | Between Groups | 5.999 | 2 | 3.000 | 4.773 | .012 |
| | Within Groups | 42.110 | 67 | .629 | | |
| | Total | 48.109 | 69 | | | |
| Contractor_related | Between Groups | .245 | 2 | .123 | .151 | .860 |
| | Within Groups | 53.575 | 66 | .812 | | |
| | Total | 53.820 | 68 | | | |
| Environment_related | Between Groups | .022 | 2 | .011 | .013 | .987 |
| | Within Groups | 57.054 | 67 | .852 | | |
| | Total | 57.076 | 69 | | | |
| Others | Between Groups | .458 | 2 | .229 | .336 | .716 |
| | Within Groups | 45.649 | 67 | .681 | | |
| | Total | 46.107 | 69 | | | |

Thus, Scheffe test was used for multiple comparisons between the means of the opinions of respondents with respect to their position to make unplanned comparisons, rather than pre-planned comparisons among group of means in an ANOVA experiment. According to the results of the test as shown in table (4.18), there is a difference between the averages of the opinions of 'owners and consultants' and 'contractors and consultants with (*P*-value <0.05) indicating the existence of significance between them.

**Table (4.18)**: Results of Scheffe test for multiple comparisons regarding all parties

| Dependent Variable | | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Owner related | Owner | Contractor | .08563 | .23980 | .938 | -.5145 | .6858 |
| | | Consultant | -.10553 | .23126 | .901 | -.6843 | .4732 |
| | Contractor | Owner | -.08563 | .23980 | .938 | -.6858 | .5145 |
| | | Consultant | -.19115 | .17369 | .549 | -.6258 | .2435 |
| | Consultant | Owner | .10553 | .23126 | .901 | -.4732 | .6843 |
| | | Contractor | .19115 | .17369 | .549 | -.2435 | .6258 |
| Consultant related | Owner | Contractor | -.25921 | .29500 | .681 | -.9977 | .4793 |
| | | Consultant | -.74875* | .28519 | .038 | -1.4627 | -.0348 |
| | Contractor | Owner | .25921 | .29500 | .681 | -.4793 | .9977 |
| | | Consultant | -.48954 | .20654 | .067 | -1.0066 | .0275 |
| | Consultant | Owner | .74875* | .28519 | .038 | .0348 | 1.4627 |
| | | Contractor | .48954 | .20654 | .067 | -.0275 | 1.0066 |
| Contractor related | Owner | Contractor | .02509 | .32406 | .997 | -.7865 | .8367 |
| | | Consultant | .13593 | .31490 | .911 | -.6527 | .9246 |
| | Contractor | Owner | -.02509 | .32406 | .997 | -.8367 | .7865 |
| | | Consultant | .11084 | .23788 | .897 | -.4849 | .7066 |
| | Consultant | Owner | -.13593 | .31490 | .911 | -.9246 | .6527 |
| | | Contractor | -.11084 | .23788 | .897 | -.7066 | .4849 |
| Environment related | Owner | Contractor | .05228 | .33191 | .988 | -.7787 | .8832 |
| | | Consultant | .03030 | .32128 | .996 | -.7740 | .8346 |
| | Contractor | Owner | -.05228 | .33191 | .988 | -.8832 | .7787 |
| | | Consultant | -.02198 | .24199 | .996 | -.6278 | .5838 |
| | Consultant | Owner | -.03030 | .32128 | .996 | -.8346 | .7740 |
| | | Contractor | .02198 | .24199 | .996 | -.5838 | .6278 |
| Others | Owner | Contractor | -.24301 | .29689 | .717 | -.9863 | .5003 |
| | | Consultant | -.16162 | .28738 | .854 | -.8811 | .5578 |
| | Contractor | Owner | .24301 | .29689 | .717 | -.5003 | .9863 |
| | | Consultant | .08139 | .21645 | .932 | -.4605 | .6233 |
| | Consultant | Owner | .16162 | .28738 | .854 | -.5578 | .8811 |
| | | Contractor | -.08139 | .21645 | .932 | -.6233 | .4605 |

**Table (4.19)**: Homogeneous Subsets of Scheffe test

| | Subset for alpha = 0.05 | |
|---|---|---|
| | 1 | 2 |
| Owner | 2.1508 | |
| Contractor | 2.4100 | 2.4100 |
| Consultant | | 2.8995 |
| Sig. | .622 | .190 |

Means for groups in homogeneous subsets are displayed.

Based on previous findings of the hypotheses, it was appeared that the hypotheses have been rejected in respect of the consultant-related factors section for both the independent *t*-test and ANOVA. While the same hypotheses have been accepted in respect of the owner-related, contractor-related, environmental-related and other factors in both ANOVA and independent *t*-test. According to results of Scheffe test, there is differences in consultant related factors between owners and consultant where Sig. value = 0.038 < (*p*-value = 0.05). As shown in Table (4.19), means of consultants (mean = 2.8995) are greater than means of owners (mean = 2.1508) which may be because almost half of the respondent on the questionnaire are consultants which put in favor for consultants in consultant related factors.

# Chapter 5: Case Study

This chapter highlights a practical study on one of the finished projects of Qatar projects to compare the real causes of VO with the ones concluded from the quantitative method (i.e. questionnaire). The case study analysis was carried out and the project to be studied was re-creation part of the coastal Al Rasheed Street (third stage). Variation orders from this project were analyzed and compared to the questionnaire results from the research.

## 5.1 Variation order No. 1

This variation in particular for civil works is related to electric work. The problem here is that this clause was not detailed in the contract as it includes multiple tasks which should be listed separately. Also, the requested quantities on reality were more than the quantities in drawings. Hence, the causes of variations were: *shortage of materials* and *missing clauses in the contract.*

## 5.2 Variation order No. 2

This variation occurred due to a problem in rain water drainage where concrete pipes are not practical because slopes vary from point to another where the soil cover or depth is low and subsequently the concrete pipes that should be buried underground will appear on surface. So, an alternative was to use box culvert instead of concrete pipes. The advantage of using box culvert is that they are casted in any dimension and will control the issue of slopes, and durable because it is composed of reinforced concrete and it is not discrete like concrete pipes and is easy to implement. Hence, the cause of variation was: *differing site conditions.*

## 5.3 Variation order No. 3

This clause concerns the new modified irrigation network. This kind of variation is because some clauses where not mentioned in the contract (the contract is incomplete). Hence, the cause of variation was: *missing clauses in the contract.*

## 5.4 Variation order No. 4

This variation pertain to rooms for municipality and security. This came up due to demolition of existed rooms of municipality and security. So, new rooms are required to be built in compensation for the old rooms. This additional construction process was not taken into account. Hence, the cause of variation was: *missing clauses in the contract.*

## 5.5 Variation order No. 5

This variation occurred irrigation lines must be connected with the feeder source that is located about 300 meters away. The irrigation pipes must be extended in the median

island of the road, this hinders using an excavator because of the pavement around the median island, casted concrete on the sides and an aluminum fence along the road. So, workers will be needed for manual excavation. Another variation caused by a mistake from the designer or the owner because the wet pit should be detailed in the contract instead of mentioning it in the end of the minutes of preliminary. Also, electrical works were not available in the contract. Hence, the causes of variations were: *differing site conditions*, *insufficient time for preparation of contract documents*, *missing clauses in the contract* and *errors and omissions in design.*

### 5.6 Variation order No. 6

This variation includes electrical and miscellaneous works. Electrical works don't exist in the contract and the change occurred because the diameter of the sidewalk curve became smaller. Consequently, the overhead power column is located in the right of way (or road reserve). Miscellaneous work included alteration in the design of retaining wall. The retaining wall is located near the coast. The stem of the retaining wall will stand out from the sea side, so a T-beam is executed underneath the retaining wall and also there is a difference in levels from a point to another which requested a new design and material for the retaining wall. Hence, the causes of variations were: *differing site conditions*, *Changes in the design,* and *missing clauses in the contract.*

### 5.7 Variation order No. 7

This variation related to municipality transportation. The contractor and consultant both have private cars. The Ministry of Public Works and Housing requested one as well to secure the movement of the Owner's staff. So, the contractor pledged to bring a private car. When the war occurred, the contractor reneged on his promise and then an argument raised. Hence, the cause of the variation was: *Obstinate nature of owner.*

### 5.8 Variation order No. 8

This variation occurred due to the siege that is imposed on Gaza Strip. The closure of borders with Egypt has impacted greatly on the entry of construction materials, especially base course. So, the Qatar committee proposed an alternative which is Kurkar. Hence, the causes of variation were: *Force majeure, Delays in securing the materials* and *Replacement of materials.*

### 5.9 Variation order No. 9

This variation occurred due to the demolition of existed room and rebuilding it with special specifications for marine police such as the interior, window and steel protection, shed and a gate. Hence, the cause of variation was: *Modifications to the drawings* and *Site safety considerations*.

### 5.10 Variation order No. 10

This variation occurred because the owner requested to plaster some of the exterior walls and paint them for aesthetic purposes. In addition, excavation for electrical work was done manually. In pipe lines, two inch gate valves were used instead of four inch because of unavailability and over design. Finally, special trees were requested to bear the sea weather. Hence, the causes of variations were: *Missing clauses in the contract*, *Changes in owners' interests / requirements, inadequate design team experience,* and *Differing site conditions.*

### 5.11 Variation order No. 11

This variation occurred because special trees were requested to bear the sea weather. Hence, the cause of variation was: *missing clauses in the contract.*

### 5.12 Comparison between real data and the study

After reviewing and analyzing the previous variation orders and concluding their causes. Table (5.1) compares the different factors concluded from both the study and the real data.

**Table (5.1)**: Comparison between factors of the study and real data

| Case study (real data) | Questionnaire |
|---|---|
| *Missing clauses in the contract* | *Change of schedule by owner* |
| *Shortage of materials* | *the long waiting time to get approval on drawings* |
| *Change in design by consultant* | *Lack of previous experience in related projects* |
| *Force majeure* | *Inadequate project objectives* |
| *Changes in owners' interests / requirements* | *Changes in owners' interests / requirements* |
| *Differing site conditions* | *Differing site conditions* |
| *Insufficient time for preparation of contract documents* | *Design complexity and difficulty to understand* |
| *Errors and omissions in design* | *Inadequate working drawing details* |
| *Modifications to the drawings* | *Failure to observe all other parties' requirements (water, electricity, etc.)* |
| *Obstinate nature of owner* | *Lack of consultant's knowledge of available materials and equipment* |
| *Delays in securing materials* | *Lack of contractor's involvement in design* |
| *Replacement of materials or procedures* | *Contractor's financial difficulties* |
| *Site safety considerations* | *Site safety considerations* |
| *Inadequate design team experience* | *Defective workmanship* |

| | |
|---|---|
| - | *Shortage of skilled manpower* |
| - | *Change of plans or scope by owner* |
| - | *Lack of a specialized construction manager* |
| - | *Weather conditions* |
| - | *Change in government regulations* |
| - | *Delays in secure site, equipment or materials* |
| - | *Contractor's lack of judgment and experience* |

From Table (5.1), it is obvious that there are some similarities and differences between real data and questionnaire result. The differences between the study and real data is mainly because the study of the completed project has a special nature where this project faced several difficulties such as war that made the work stop for a long time which caused severe delays, major destruction to machinery, material and affected the staff of engineers and workers. Furthermore, the closure of the crossings hindered the entrance of material from outside of Gaza Strip and even prevented the entry of materials fully which caused delays and lack of proper material that where strongly needed for different construction projects of Qatar projects.

Not to forget to mention that the study included two projects (roads and buildings) but the case study included only road project which certainly caused differences in factors causing variation orders between the study and the real data.

### 5.13 Summary

This chapter included an analysis of a completed project of Qatar projects that have been provided from The Ministry of public Works and Housing. Real causes of variation have been extracted and compared to the results of the questionnaire. Similarities and differences have been shown and a reasonable explanation for these differences have been provided.

# Chapter 6: Conclusions and recommendations

This chapter summarizes the research and aims to provide recommendations and conclusions for the issue of variation orders in construction industry in Gaza Strip and suggests some recommendations to minimize VO in future. By revisiting the objectives and findings, an overview will be discussed to assess the extent to which the research objectives were met.

## 6.1 Summary

An investigation into the factors causing variation orders which were divided into groups of factors was conducted. An extensive review of literature was conducted to develop a clear understanding about VO and all necessary information and identify the different factors that cause those numerous variation in construction industry in Gaza Strip especially in Qatar projects. The results of a 70 collected questionnaires were analyzed quantitatively and then presented by using an "interpretive-descriptive" method for qualitative data analysis. Finally, recommendations for issue of variation order in construction industry in Gaza Strip specifically Qatar projects were outlined.

## 6.2 Achievement of objectives

To achieve the aim of the research, three main objectives have been outlined and achieved through the findings of the analyzed collected questionnaires. The outcomes were found as following:

### 6.2.1 Outcomes related to objective one

- ***The objective was****: To investigate the factors causing variation order from the literature.*

The study findings indicated that multi-source factors responsible for variation orders. The most important factors according to owners' point of view are:

1. The long waiting time to get approval on drawings.
2. Design complexity and difficulty to understand.
3. Lack of consultant's knowledge of available materials and equipment.
4. Lack of contractor's involvement in design.
5. Shortage of skilled manpower.
6. Weather conditions.
7. Site security considerations.
8. Changes in owners' interests / requirements.

The most important factors according to consultants' point of view are:

1. Change of schedule by owner.
2. Design complexity and difficulty to understand.
3. Failure to observe all other parties' requirements (water, electricity, etc.).

4. Lack of consultant's knowledge of available materials and equipment.
5. Lack of contractor's involvement in design.
6. Delays in secure site, equipment or materials.

The most important factors according to consultants' point of view are:

1. Change of schedule by owner.
2. Design complexity and difficulty to understand.
3. Failure to observe all other parties' requirements (water, electricity, etc.).
4. Shortage of skilled manpower.
5. Defective workmanship.
6. Contractor's financial difficulties.
7. Delays in secure site, equipment or materials.
8. Site security considerations.

### 6.2.2 Outcomes related to objective two

- ***The objective was****: To extract real causes of variation order through analyzing a case study of one of the completed projects of Qatar projects.*

The analysis of case study concluded the factors affecting variation orders which are the following:

- Shortage of materials.
- Differing site conditions.
- Missing clauses in the contract.
- Insufficient time for preparation of contract documents.
- Errors and omissions in design.
- Changes in the design.
- Obstinate nature of owner.
- Force majeure.
- Delays in securing the materials.
- Replacement of materials
- Modifications to the drawings.
- Site safety considerations.
- Changes in owners' interests / requirements.
- Inadequate design team experience.

### 6.2.3 Outcomes related to objective three

- ***The objective was****: To propose recommendations to decrease the variation orders to minimum as much as possible.*

Proper recommendation are given as shown below.

## 6.3 Recommendations

### 6.3.1 Recommendations to owners

Owners should consider the following factors:

- Owners are recommended to determine project duration by experts or their consultants because they are more familiar with the duration of the implementation of the project and thus avoid a change in the schedule.
- Owners are recommended not to change the original drawings, because any change in the original drawings require a new effort in the preparation of new drawings.
- Owners are recommended to hire a consultant who specializes in the nature of work.
- Owners are recommended to request everything they need in the contract from the beginning and avoid any requirements after implementation of works and develop a clear vision for projects.
- Owners are recommended to give contractors a period of two to three weeks for reviewing the drawings and give their notes and feedback.
- Owners are recommended to develop criteria for the selection of contractor according to the nature of the project and to have a good reputation and great experience.
- Owners are recommended to rush in the adoption of alternative materials when some of the materials described in the contract are not available due to the blockade or non-existent in the country or closer of crossings.
- Owners are recommended to provide the consultant sufficient time to prepare bidding documents to avoid any mistakes or misunderstanding.

### 6.3.2 Recommendations to consultants

Consultants should consider the following factors:

- Consultants are recommended to provide more details in drawings. Also, train contractors on certain types of drawings especially that complex ones. Also, consultants should explain on site the complex details to the contractor.
- Consultants are recommended to provide complete and detailed drawings (architectural, civil, electric, and mechanical).
- Consultants are recommended to get the approval of all stakeholders or specialized departments before implementation. Also, keep in touch with other parties (such as water, electricity, communication, etc.) to avoid conflicts.

- Consultants are recommended to search and explore the equipment and materials that are available in the country and how to deal with it.
- Consultants are recommended to re-design the project according to the request from the owner, so that the contractor must get variation (cost and time) for additional work which happens from re-design.
- Consultants are recommended to choose engineers who with high efficiency to perform the work meticulously to avoid any error in the future and review and audit the design by several engineers.

### 6.3.3 Recommendations to contractors

Contractors should consider the following factors:

- ✓ Contractors are recommended to search for and hire new skilled crew. Also, the general contractor must provide all documents (i.e. certificates) and experience for the staff and get approval on all subcontractors.
- ✓ Contractors are recommended that before studying the tender and pricing, they must make site visit of the site to see all obstacles and take into account in the bid (financially and chronologically).
- ✓ Contractors are recommended to use qualified workers, engineers, and project manager with good experience to avoid any problems at work.
- ✓ Contractors are recommended to choose a site engineer with strong personal leadership and be able to control the site and direct the work in the best way.
- ✓ Contractors are recommended to take into consideration the days when work stop due to the bad weather and take approval to stop work from consultant on the site. As well, make up for the days when work stop over time or work in holidays to avoid change in schedule especially in road projects.
- ✓ Contractors are recommended to be financially prepared before entering the tender, have strong financial aspects and cash flow during the project. Also, buy approved original materials with any price.
- ✓ Contractors are recommended to keep safety first in the site for all people and the project. In addition, make training courses for workers and should set a safety officer to be always on site.
- ✓ Contractors are recommended to purchase the whole quantity of certain material in ordinary situations to avoid shortage of material due to closure. But, contractors can't be forced to buy the whole quantity if prices differs dramatically from the contract price unless it is mentioned in the contract that owner doesn't bear the increment in prices.

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# Appendix 1:
# Questionnaire in English

Islamic University of Gaza
Dean of Graduate Studies
College of Engineering - Master's program
Engineering project management

## Questionnaire about

Factors causing Variation orders in the construction industry in the Gaza Strip: Case Study (Qatar projects)

**Gentlemen**

Peace, mercy and blessings of Allah

This questionnaire aims to study the factors causing Variation orders and their impact on the construction industry in the Gaza Strip, and is part of a supplementary research required for a master's degree in engineering project management of the Islamic University of Gaza.

Please kindly we request your assistance in mobilizing the required data with level of accuracy and honesty as usual in your work, knowing that the information will be used for scientific research only, and also please read intimations contained the top of each part of the questionnaire.

**And you all are thanked and appreciated for your contribution in supporting the scientific research**

Researcher
Mohammed Adnan Albhaisi

**Questionnaire components:**

This questionnaire consists of three parts which are as follows:

• Part I: General Information.

• Part II: Information about the projects that you managed.

• Part III: Factors influencing the reasons for Change Orders and their impact on the construction industry in the Gaza Strip.

## Important disclaimer:

**Please tick √ against the option that is convenient for you and please take into account and place in front of only one option.**

**Part I: General Information**

1. **The institution type, which works in who fills out the questionnaire:**

☐ governmental ☐ NGO's ☐ Consulting office

☐ Contracting ☐ Others

2. **Entity:**

☐ Owner/Client ☐ Contractor ☐ Consultant ☐ Others

3. **Job Title for whom fills out the questionnaire :**

☐ The institution director/vice ☐ Project manager/vice

☐ Site engineer ☐ Others(explain) …….

4. **Years of experience in the construction sector for whom fills out the questionnaire:**

☐ Less than 5 years ☐ from 5 years to less than 10 years

☐ From 10 years to less than 15 years ☐ 15 years and over

**Part II: Information about the projects that you managed**

1. **Type of project**

☐ Road ☐ Building/residential

2. **The size of projects that were a director in the last five years:**

☐ Less than $ 1 million ☐ From 1 to less than $ 5 million

☐ From 5 to less than $ 10 million ☐ $ 10 million and more

3. **Percent of projects that included variation orders caused obstructing the work (during the last five years):**

☐ None ☐ Less than 20% ☐ 20-50% ☐ more than the 50%

4. **Time-delay rate in the projects in which several variation orders happened (during the last five years):**

☐ None ☐ Less than 20% ☐ 20-50% ☐ more than the 50%

5. **Projects that exceeded the value of the contract due to Change Orders ratio (last five years):**

☐ None ☐ Less than 20% ☐ 20-50% ☐ more than the 50%

6. **Select the ratio which the project contract value exceeded the value of the original contract:**

☐ Less than 5% ☐ From 5 to less than 10%

☐ From 10 to less than 15% ☐ From 15 to Less than 20%

☐ From 20 to less than 25% ☐ 25% or more

7. **To what degree can Variation Orders cause in the obstruction of projects:**

☐ Very large degree ☐ Large degree ☐ moderate degree

☐ Low degree ☐ Very low degree

**Part III: Factors causing the Change Orders**

**From your point of view (and regardless of your current job) select the degree of influence and the degree of occurrence that lead to the presence of change orders in the project, whether they are related to the owner / client or consultant or contractor or others.**

| # | Factors | Influence | | | | | Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Extremely influential | Very influential | Somewhat influential | slightly influential | Not at all influential | A great deal | A Moderate amount | Occasionally | Rarely | Never |
| **First: owner/client related factors** | | | | | | | | | | | |
| 1 | Change of plans or scope by owner | | | | | | | | | | |
| 2 | Change of schedule by owner | | | | | | | | | | |
| 3 | Changes in owners' interests / requirements | | | | | | | | | | |
| 4 | The long waiting time to get approval on drawings | | | | | | | | | | |
| 5 | Inadequate project objectives | | | | | | | | | | |
| 6 | Replacement of materials or procedures | | | | | | | | | | |
| 7 | Impediment in prompt decision making process | | | | | | | | | | |
| 8 | Lack of previous experience in related projects | | | | | | | | | | |
| 9 | Obstinate nature of owner | | | | | | | | | | |
| 10 | Change in specifications by owner | | | | | | | | | | |
| **Second: Consultant related factors** | | | | | | | | | | | |
| 1 | Change in design by consultant | | | | | | | | | | |
| 2 | Errors and omissions in design | | | | | | | | | | |
| 3 | Conflicts between contract documents | | | | | | | | | | |
| 4 | Inadequate design team experience | | | | | | | | | | |
| 5 | Consultant's lack of judgment and experience | | | | | | | | | | |

| # | Factors | Influence | | | | | Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Extremely influential | Very influential | Somewhat influential | slightly influential | Not at all influential | A great deal | A Moderate amount | Occasionally | Rarely | Never |
| 6 | Lack of consultant's knowledge of available materials and equipment | | | | | | | | | | |
| 7 | Design complexity and difficulty to understand | | | | | | | | | | |
| 8 | Insufficient time for preparation of contract documents | | | | | | | | | | |
| 9 | Modifications to the drawings | | | | | | | | | | |
| 10 | Inadequate working drawing details | | | | | | | | | | |
| 11 | Consultant's lack of required data | | | | | | | | | | |
| 12 | Failure to observe all other parties' requirements (water, electricity, etc.) | | | | | | | | | | |
| **Third: Contractor related factors** | | | | | | | | | | | |
| 1 | Fast track construction | | | | | | | | | | |
| 2 | Lack of strategic planning | | | | | | | | | | |
| 3 | Complex design and technology | | | | | | | | | | |
| 4 | Lack of contractor's involvement in design | | | | | | | | | | |
| 5 | Unsuitable management structure and style of contractor | | | | | | | | | | |
| 6 | Lack of communication | | | | | | | | | | |
| 7 | Poor site management and supervision | | | | | | | | | | |
| 8 | Lack of a specialized construction manager | | | | | | | | | | |
| 9 | Contractor's lack of required data | | | | | | | | | | |
| 10 | Shortage of materials | | | | | | | | | | |
| 11 | Improper control over site resource allocation | | | | | | | | | | |
| 12 | Contractor's lack of judgment and experience | | | | | | | | | | |
| 13 | Shortage of skilled manpower | | | | | | | | | | |
| 14 | Defective workmanship | | | | | | | | | | |

| # | Factors | Influence | | | | | Occurrence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Extremely influential | Very influential | Somewhat influential | slightly influential | Not at all influential | A great deal | A Moderate amount | Occasionally | Rarely | Never |
| 15 | Changes in construction method | | | | | | | | | | |
| 16 | Differing site conditions | | | | | | | | | | |
| 17 | Contractor's financial difficulties | | | | | | | | | | |
| 18 | Contractor's desired profitability | | | | | | | | | | |
| 19 | Poor scheduling | | | | | | | | | | |
| 20 | Inadequate shop drawing details | | | | | | | | | | |
| | | | | | | | | | | | |
| **Four: External environment related factors** | | | | | | | | | | | |
| 1 | Weather conditions | | | | | | | | | | |
| 2 | Force majeure | | | | | | | | | | |
| 3 | Site security considerations | | | | | | | | | | |
| 4 | Change in government regulations | | | | | | | | | | |
| 5 | Change in economic conditions | | | | | | | | | | |
| 6 | Changes in the competing market | | | | | | | | | | |
| 7 | Delays in secure site, equipment or materials | | | | | | | | | | |
| **Five: other factors** | | | | | | | | | | | |
| 1 | Site safety considerations | | | | | | | | | | |
| 2 | Interventions of beneficiaries | | | | | | | | | | |
| 3 | Intervention of others in the decision-making process | | | | | | | | | | |

**We appreciate and thank you for your cooperation**

# Appendix 2:
# Questionnaire in Arabic

الجامعة الإسلامية - غزة
عمادة الدراسات العليا
كلية الهندسة - برنامج الماجستير
إدارة مشاريع هندسية

## استبانة حول

## العوامل المسببة للأوامر التغييرية في صناعة البناء والتشييد في قطاع غزة دراسة حالة (المشاريع القطرية)

**السادة الكرام /**

السلام عليكم ورحمة الله وبركاته,

إن هذه الاستبانة تهدف إلى دراسة العوامل المسببة للأوامر التغييرية وانعكاساتها على صناعة الإنشاءات في قطاع غزة ، و هو جزء من البحث التكميلي اللازم لنيل درجة الماجستير في إدارة المشاريع الهندسية من الجامعة الإسلامية بغزة.

نرجو التكرم بالمساعدة في تعبئة البيانات المطلوبة بمستوى الدقة والأمانة المعهودة في عملكم علماً أن المعلومات ستستخدم للبحث العلمي فقط ، كما ونرجو قراءة التنويهات الواردة أعلى كل جزء من أجزاء الاستبانة.

**ولكم كل الشكر والتقدير على مساهمتكم في دعم البحث العلمي .**

الباحث

محمد عدنان البحيصي

**مكونات الاستبانة:**

تتكون هذه الاستبانة من ثلاثة أجزاء وهي كما يلي:

- **الجزء الأول:** معلومات عامة.
- **الجزء الثاني:** معلومات حول المشاريع التي قمت بإدارتها.
- **الجزء الثالث:** العوامل المؤثرة على أسباب الأوامر التغييرية وانعكاساتها على صناعة الإنشاءات في قطاع غزة.

**تنويه هام:**

**الرجاء وضع إشارة √ مقابل الخيار الذي ترونه مناسباً و نرجو مراعاة وضعها أمام خيار واحد فقط.**

**الجزء الأول: معلومات عامة:**

5. **نوع المؤسسة التي يعمل بها من يقوم بتعبئة الاستبيان :**

☐ حكومي ☐ مؤسسة دولية غير حكومية ☐ مكتب استشاري

☐ مقاولات ☐ غير ذلك

6. **الجهة التي تعمل بها :**

☐ مالك/ صاحب عمل ☐ مقاول ☐ استشاري ☐ غير ذلك

7. **المسمى الوظيفي لمن يقوم بتعبئة الاستبيان :**

☐ مدير المؤسسة/ نائبه ☐ مدير المشروع /نائبه

☐ مهندس موقع ☐ غير ذلك. وضح .....

8. **سنوات الخبرة في قطاع الإنشاءات لمن يقوم بتعبئة الاستبيان :**

☐ أقل من 5 سنوات ☐ من 5 سنوات إلى أقل من 10 سنوات

☐ من 10 سنوات إلى أقل من 15 سنة ☐ 15 سنة فأكثر

**الجزء الثاني : معلومات حول المشاريع التي قمت بإدارتها:**

8. **حجم المشاريع التي كنت مديراً لها خلال الخمس سنوات الأخيرة:**

☐ أقل من مليون دولار ☐ من 1 إلى أقل من 5 مليون دولار

☐ من 5 إلى أقل من 10مليون دولار ☐ 10 مليون دولار فأكثر

9. **نسبة المشاريع التي شملت أوامر تغييرية تسببت بعرقلة العمل (خلال السنوات الخمس الأخيرة):**

☐ لا يوجد ☐ أقل من 20% ☐ 20 -50% ☐ أكثر من 50%

10. **معدل التأخر الزمني في المشاريع التي حدث فيها عدة أوامر تغييرية (خلال السنوات الخمس الأخيرة):**

☐ لا يوجد ☐ أقل من 20% ☐ 20 -50% ☐ أكثر من 50%

11. **نسبة المشاريع التي تجاوزت قيمة العقد بسبب الأوامر التغييرية (خلال السنوات الخمس الأخيرة):**

☐ لا يوجد ☐ أقل من 20% ☐ 20-50 % ☐ أكثر من 50%

12. **حدد النسبة التي تجاوزت بها المشاريع قيمة العقد مقارنة بقيمة العقد الأصلي :**

☐ أقل من 5 % ☐ من 5 - أقل من 10% ☐ من 10 - أقل من 15%

☐ من 15- أقل من 20 % ☐ من 20 – أقل من 25% ☐ 25% فأكثر

13. **إلى أي درجة تتسبب الأوامر التغييرية في عرقلة سير المشاريع :**

☐ درجة كبيرة جداً ☐ درجة كبيرة ☐ درجة متوسطة

☐ درجة قليلة ☐ درجة قليلة جداً

**الجزء الثالث: العوامل المؤثرة على الأوامر التغييرية**

**من وجهة نظرك ( و بغض النظر عن موقعك الوظيفي الحالي) حدد درجة تأثير و درجة حصول العوامل التي تؤدي لوجود أوامر تغييرية في المشروع سواءً كانت متعلقة بالمالك/صاحب العمل أو الاستشاري أو المقاول أو جهات أخرى.**

| م | العوامل المؤثرة | درجة التأثير (في الأوامر التغييرية) | | | | | درجة الحصول (في الأوامر التغييرية) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | عالية جداً | عالية | متوسطة | منخفضة | منخفضة جداً | كبيرة جداً | كبيرة | متوسطة | ضعيفة | ضعيفة جداً |
| | **أولاً : العوامل المتعلقة بصاحب العمل أو مالك المشروع** | | | | | | | | | | |
| 1 | تغيير خطة العمل أو مجاله من قبل المالك | | | | | | | | | | |
| 2 | تغيير جدولة العمل من قبل المالك | | | | | | | | | | |
| 3 | تغير في رغبات/متطلبات المالك | | | | | | | | | | |
| 4 | طول وقت الانتظار للحصول على الموافقة على الرسومات | | | | | | | | | | |
| 5 | عدم وضوح أهداف العمل لدى المالك | | | | | | | | | | |
| 6 | تغيير نوع المواد المستخدمة أو طرق التنفيذ أثناء العمل من قبل المالك أو حسب رغبة المالك | | | | | | | | | | |
| 7 | ضعف قدرة المالك على اتخاذ القرارات | | | | | | | | | | |
| 8 | عدم خبرة المالك السابقة في مشاريع ذات علاقة | | | | | | | | | | |
| 9 | طبيعة المالك و إصراره على رأيه رغم تناقض الرأي مع رأي الاستشاري | | | | | | | | | | |
| 10 | تغيير في المواصفات من قبل المالك | | | | | | | | | | |
| | **ثانياً: العوامل المتعلقة باستشاري المشروع** | | | | | | | | | | |
| 1 | تغيير أو تعديل التصميم من قبل الاستشاري في مرحلة التنفيذ | | | | | | | | | | |
| 2 | وجود نقص او أخطاء في التصميم | | | | | | | | | | |
| 3 | تعارض او تضارب بين وثائق العقد | | | | | | | | | | |
| 4 | عدم كفاية خبرة فريق التصميم | | | | | | | | | | |
| 5 | ضعف خبرة الاستشاري | | | | | | | | | | |
| 6 | ضعف متابعة الاستشاري للتغيرات في أدوات و تقنيات التنفيذ | | | | | | | | | | |
| 7 | تعقيد التصميم وصعوبة فهمه | | | | | | | | | | |
| 8 | ضيق وقت تحضير وثائق العطاء | | | | | | | | | | |
| 9 | التعديلات المستمرة على المخططات | | | | | | | | | | |
| 10 | الرسم التفصيلي من قبل المصمم Design drawings للأعمال غير كامل | | | | | | | | | | |

| م | العوامل المؤثرة | درجة التأثير (في الأوامر التغييرية) | | | | | درجة الحصول (في الأوامر التغييرية) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | عالية جداً | عالية | متوسطة | منخفضة | منخفضة جداً | كبيرة جداً | كبيرة | متوسطة | ضعيفة | ضعيفة جداً |
| 11 | عدم توفر البيانات اللازمة للعمل لدى الاستشاري | | | | | | | | | | |
| 12 | عدم مراعاة متطلبات كافة الجهات الأخرى (المياه، الكهرباء ... الخ) | | | | | | | | | | |
| **ثالثاً : العوامل المتعلقة بمقاول المشروع** | | | | | | | | | | | |
| 1 | البدء بتنفيذ المشروع قبل الانتهاء من التصميم بشكل كامل | | | | | | | | | | |
| 2 | عدم وجود خطة واضحة ومفصلة للعمل لدى المقاول | | | | | | | | | | |
| 3 | تعقيد التصميم و التكنولوجيا على المقاول | | | | | | | | | | |
| 4 | عدم مشاركة المقاول في اعمال التصميم | | | | | | | | | | |
| 5 | عدم وجود تنظيم وهيكل اداري واضح للمقاول | | | | | | | | | | |
| 6 | ضعف التواصل بين المقاول وباقي اطراف المشروع | | | | | | | | | | |
| 7 | اشراف و ادارة ضعيفة لموقع العمل | | | | | | | | | | |
| 8 | عدم وجود مدير مشروع متخصص و ذو كفاءة | | | | | | | | | | |
| 9 | عدم توفر البيانات اللازمة للعمل لدى المقاول | | | | | | | | | | |
| 10 | قلة وضعف كفاءة موارد المقاول من مواد ومعدات | | | | | | | | | | |
| 11 | إدارة غير سليمة للموارد وتوزيعها | | | | | | | | | | |
| 12 | قلة خبرة المقاول بالسوق | | | | | | | | | | |
| 13 | عجز او نقص في العمال المهرة لدى المقاول | | | | | | | | | | |
| 14 | خلل أو عيب في المصنعية أو الأعمال المنجزة | | | | | | | | | | |
| 15 | تغييرات في طريقة البناء | | | | | | | | | | |
| 16 | اختلاف ظروف الموقع | | | | | | | | | | |
| 17 | ضعف القدرة المالية للمقاول | | | | | | | | | | |
| 18 | اهتمام المقاول بالربح على حساب باقي الأعمال | | | | | | | | | | |
| 19 | ضعف في جدولة الاعمال | | | | | | | | | | |
| 20 | اعتماد الرسم التفصيلي للأعمال المنفذة shop drawings بدون مراجعة كافية | | | | | | | | | | |
| **رابعاً : العوامل المتعلقة بالبيئة الخارجية للمشروع** | | | | | | | | | | | |
| 1 | سوء الاحوال الجوية والجيولوجية | | | | | | | | | | |
| 2 | ظهور العديد من القوى القاهرة | | | | | | | | | | |
| 3 | عدم مراعاة اعتبارات السلامة و الأمان | | | | | | | | | | |
| 4 | عدم وضوح و كفاية اللوائح والقوانين الحكومية | | | | | | | | | | |
| 5 | سوء الوضع الاقتصادي | | | | | | | | | | |
| 6 | ارتفاع المنافسة في سوق العمل | | | | | | | | | | |
| 7 | تأخيرات ناتجة عن تأمين الموقع او الادوات | | | | | | | | | | |

| م | العوامل المؤثرة | درجة التأثير (في الأوامر التغييرية) | | | | | درجة الحصول (في الأوامر التغييرية) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | لا يوجد تأثير | عالية | متوسطة | منخفضة | منخفضة جداً | كبيرة جداً | كبيرة | متوسطة | ضعيفة | ضعيفة جداً |
| **خامساً : عوامل أخرى** | | | | | | | | | | | |
| 1 | اعتبارات السلامة في الموقع | | | | | | | | | | |
| 2 | تدخلات المستفيدين | | | | | | | | | | |
| 3 | تدخل جهات أخرى في عملية اتخاذ القرار | | | | | | | | | | |

**نقدر و نشكر لكم تعاونكم**