# Change Orders in Construction Projects In Saudi Arabia

BY

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# ABSTRACT

This research discusses the change order process in construction of large building projects in Saudi Arabia. The focus is on the causes of change orders, the impact of changes on a project, and the control procedures adopted. The subjected is treated in two parts. The first part covers a review of literature discussing the subject of change orders. The review which includes major periodicals, research reports, and some text books, is summarized into four parts; the basic ideas, the legal aspects, the cost and pricing aspects, and the management and administration of change orders. The information and recommendations made in this part were used to develop and establish direction for the second part of the study.

The second part is a field survey for over 34 contractor and consultant involved in construction and consultancy of large building projects. The data gathered was streamlined and analyzed using a computer statistical package (STATSTICA).

The results of the survey is presented in five areas; the general characters of the companies and market, the causes, the effects, the controls of change order adopted, and the correlation and hypothesis testing. The study attempts in the last study area to establish a correlation between causes of change orders and the characteristics indicated in the first part. The research study shows that contractors and consultants agree to a large extent on the causes, effects, and controls of change orders.


## *CHAPTER ONE*

# INTRODUCTION

## 1.1 Significance of the Study

Saudi Arabia has in the last thirty years experienced a huge volume of work in the field of construction. This is because the wealth created by the oil industry and the economic impetus it has given the country. This has resulted in very rapid growth and transformations during that period. The high living standards of the people of Saudi Arabia have generated many manufacturing and building employment opportunities. The growth of towns has accelerated as a result of high population growth. Large and complex projects have been built, attracting contractors and construction companies from all over the world. Most of those contractors and their companies lack sufficient understanding of the social, cultural and physical environment of Saudi Arabia. This situation coupled with inexperienced owners has led to inadequate design resulting in many changes to plans, specifications, and contract terms.

These changes are inevitable in any construction project. Needs of the owner may change in the course of design or construction, market conditions may impose changes to the parameters of the project, and technological developments may alter the design and the choice of the engineer. The engineer's review of the design may bring about changes to improve or optimize the design and hence the operation of the project. Further, errors and omissions in engineering or construction may force a change. All these factors and many others necessitate changes that are costly and generally un-welcomed by all parties.

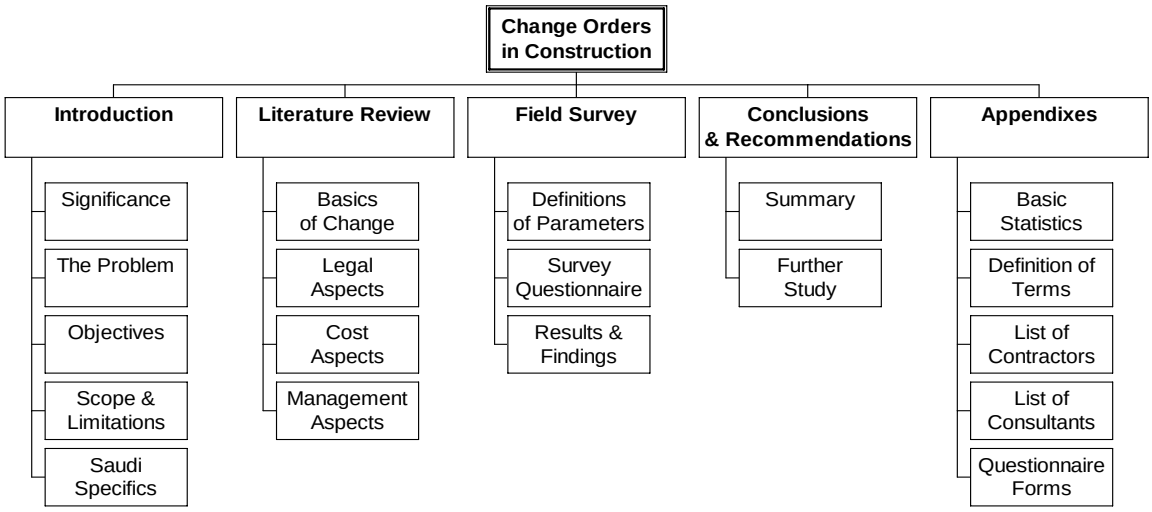
Consideration must be given to this construction phenomena from the early stages of the project until commissioning. A contract change clause is added to define the way that owner, consultant, and contractor will handle changes. A procedure must be set to process a change from its conceptual development until it materializes in the field. Given the fact that an adversarial atmosphere usually exists between the parties in the construction industry, a change must be managed well in order to minimize its cost, schedule and consequential effects that can lead to enormous cost and schedule overruns.

In this research, the aim is to study this construction issue in the Saudi construction industry, and to find out the causes, the severity, and the effects it has on the construction process. This research should pave the road for future research on the solutions of problems related to changes and change orders in a market that is increasingly competitive and has tight owner's budgets as oil prices fluctuate.

## 1.2 **Research Outline**

This research is arranged in six chapters. Chapter one is an introduction explaining the importance of this research study, its objectives and an introduction to the Saudi specific environment. Chapter two is the first part of this research study and contains the review of literature on the subject of change orders. The chapter is broken into four sections: the basics of changes, legal issues, cost and pricing issues, and management and administration aspects.

Chapter three is the start of the second part, which is the survey work. Chapter three defines the causes, effects, and the controls as they are used in the survey and the questionnaire. Chapter four defines research methodology, questionnaire design, and scoring technique. Chapter five shows the results and findings of the study. Results are presented in five sections: the general data on participant and overall change data, the causes, the effects, the controls, and hypothesis testing. Chapter six is the last chapter and presents the conclusions and recommendations. The block diagram below shows the thesis structure.



## 1.3 **Statement of the Problem**

A change order is a written order to the contractor, signed by the owner, and issued after execution of the contract, authorizing a change in the work or an adjustment in the contract sum or the contract time. Changes in drawings and contract documents usually lead to change in contract price or contract schedule. Changes also increase the possibility of contractual disputes. In general, changes present problems to all parties involved in the construction process.

There are many reasons for issuing construction change orders in large building construction contracts. It might be a result of further development of the owner's requirements. It can be a result of non-availability, slow delivery of required materials or correction of contract document errors and omissions. Identifying the causes of change orders is very important in order to avoid potential changes in future projects or minimize their effects. The aim of this research is therefore to study the causes and effects of construction change orders in large building projects in the Eastern Province of Saudi Arabia

This study will assist both owners and contractors to plan effectively before starting a project and during the design phase to minimize and control changes and change effects. This study will also lay the foundation for further research on the subject.

## 1.4 **Objective of the Study**

The main objectives of this research study are to:

- Identify the main causes of construction change orders in Saudi Arabia.
- Identify the severity of those causes.
- Test the hypothesis that consultants and contractors disagree on the severity of causes.

## 1.5 **Scope and Limitations**

The study will be limited to large building construction projects ( projects costing over 20 million Saudi Riyals , SR. 3.75 = $1) in the Eastern Province of Saudi Arabia executed by building contractors Grade 1 and 2 as classified by the Chamber of Commerce in Dammam. Grade 1 contractors are joint venture companies and Saudi companies with a working capital of more than 10 million SR. Grade 2 contractors are Saudi contractors with a working capital of not less than 5 million SR.

## 1.6 **The Saudi Environment**

Unlike other industrial products such as manufacturing products, the products of construction industry (projects) are affected to a large extent by the surrounding environment. It might be of great benefit before our review of literature, which was done on totally different settings and environments than ours, to highlight the specifics of the Saudi Arabian construction industry. This is very important for what this study is trying to accomplish.

### 1.6.1 **Climate**

Saudi Arabia has a long, hot and almost totally dry summer, with a short cool, winter season during which a little rain falls. The temperature in the summer can rise to 50°C and sometimes even more in the deserts. The climate of the Eastern Province of Saudi Arabia is directly affected by its geographical location. As it lies along the Arabian Gulf coast, relative humidity is generally high for most of the year, and especially in the summer due to the sea breeze that brings in moisture. The highest relative humidity (over 90%) is reached at the end of the summer season in late August and early September.

As can be noted from the above, Saudi Arabia has extreme climatic conditions that cause many problems for contractors. As a result, most contractors try to work in the cool hours of the early morning or evening, especially when pouring concrete, in order to slow the rate of water evaporation and avoid cracking in concrete. The high temperature and humidity reduces the productivity of laborers, and increases the maintenance cost of the equipment due to the high temperature of the engines and rusting problems resulting from the high relative humidity.

### 1.6.2 **Social and Cultural Impact**

The wealth created by the oil industry and the economic impetus it has given to Saudi Arabia has resulted in very rapid growth and change, much of which has occurred during the last two decades. Large and complex projects have been built, attracting contractors and construction companies from all over the world. Most of those contractors and their companies lack sufficient information and background on the social, cultural, and physical environment of Saudi Arabia. This has led to unacceptable or inadequate designs, resulting in many changes to building plans and contract terms.

### 1.6.3 **Materials and Equipment**

The availability of building materials in the Saudi market has improved a great deal since the start of the oil boom in the late seventies. This, however, did not eliminate the need to import many building materials from abroad. This market feature makes early planning and purchase of long lead items a requirement for the smooth construction of a project. The cost of a mis-planned job is normally delay, disruption and change orders. Poor storage and handling of materials are other factors that can cause changes. Furthermore, accuracy in the estimate of required quantities could play a role in decreasing the number of change orders originating due to lack of materials.

Building equipment and tools are almost all imported to the Kingdom. Although the main items of building equipment and tools are available in the local market, many major construction projects require special pieces of equipment. The inability to include this in the early planning of the project results in delays and changes to the original plans and construction methods. Equipment failure during construction is one of the major problems faced in the construction which might force a change to originally planned work.

### 1.6.4 **Manpower**

Almost all manpower used in the construction industry in Saudi Arabia is imported mainly from Asian countries. It is not uncommon to find in one construction site people from different countries who speak different languages. This mix of cultures, languages and backgrounds makes the Saudi construction industry unique in this regard. Misunderstanding of instructions due to language barries is quite common.

Misinterpretation of needs and requirements due to different background opens the door for rework, delay, and demolition.

Another important factor one needs to bear in mind is the high turnover rates of workers. Normally, workers are brought for a certain project and leave upon completion. This means that every time workers start from zero or close to zero on the learning curve. Changes are expected to be compounded by this problem.

In this work environment, mobilization and demobilization requires extra attention. Governmental procedures take time to complete. Many problems exist among governmental agencies due to the lack of information and coordination between agencies. These problems have increased the contractor difficulties in getting the needed government permits. For example, the process of application for labor work permits start after contract award and might take more than three months to get approved. This means that an error in technical skills selection cannot be corrected quickly resulting in either a delay to the original plan, acceptance of low workmanship or a change in procedures.

### 1.6.5 **Codes and Standards**

The Saudi Construction Industry uses the common international industry standards such as ASCI, AIA, ASTM and others. There are no national codes conditioned to the Saudi market with its own characteristics.

Due to the lack of applicable code requirements in the last few years, the number of change orders issued by owners or contractors has increased. In order to include the applicable code of technological improvements required by the governmental agencies, the owner or the contractor must provide for the maintenance of traffic, waste disposal,

environmental protection and construction safety. These new governmental regulations are the result of the revision of building codes.

### 1.6.6 **Finance in Construction Projects**

Construction projects are highly dependent on receiving payments made by owners. However, these payments may be slow. Delays for a month or more are common. Many construction firms in the kingdom are small and under financed and unable to finance payroll and material vendors if payment by owners is not made on time. This problem is more apparent in the last several years due to the decrease of oil revenues and delay of payment by many government agencies.

*PART ONE*

*CHAPTER TWO*

# LITERATURE REVIEW

## Introduction

There have been numerous articles written on changes, change orders and change management in construction. Most of the articles written discuss the legal aspects of changes such as claims and disputes. Many other articles were devoted to the discussion of the effects of changes on labor productivity. Most of the research on changes as a separate construction issue is done by or under the guidance of the Construction Industry Institute (CII) an American national organization. Although this review is by no means a comprehensive one, it covers the most important articles and subjects and can open the door for further research on the subject of changes.

The articles written on the subject of change orders deal with three aspects: legal, cost, and management. In this study, the literature review section is divided into four parts. The first part defines the basics of changes and their terminology. The second part covers the legal aspects of changes in literature. The third part covers the evaluation and cost aspects and the fourth part concentrates on control, administration and procedures of changes. A glossary of terms used in change management is included in Appendix B.

## 2.1 **Basics of Changes**

A change is defined in literature as any deviation from an agreed upon well-defined scope and schedule. Stated differently a change is any modification to the contractual guidance provided to the contractor by the owner or owner's representative (Fisk,1988 and Yu, 1996). This includes changes to plans, specifications or any other contract document. A change order is the formal document that is used to modify the original contractual agreement and becomes part of project's documents.

Initially, the contractor receives the contract package in the form of plans, drawings, equipment lists and other documents. This constitutes the basis of his proposal. Contractor will calculate labor cost, material cost, and schedule based on this original package. Obviously any changes to this set of documents will alter his plans and calculations.

Changes can be initiated by all parties in the construction process. All changes, however, must be approved by Owner before implementation. CII Publication 6-10 (1990) summarizes initiation of change orders as follows:

1. *Owner* may request/order a change, usually a scope change.
2. *Engineer* may originate a change because of differing site conditions or new governmental regulations etc.
3. *Project management firm/person* may originate a change, usually in schedule.
4. *Contractor* may initiate a change due to design errors, value engineering, or field requirement.

Changes can be classified in many different ways depending on the basis and the purpose of classifications. In this review, the most common classifications will be presented. Changes in a construction project can be classified based on the cause that forced them (Burati, Farrington & Ledbetter 1992, Thomas and Napolitan 1994). The cause or originator based classification is best suited for the assessment of cost impacts of changes. These causes can be numerous. In a study by J. Burati, et al (1992), deviations or changes in constructions are caused by design, construction, fabrication, transportation or operability. Design changes, which were found to constitute 52.5% of total changes, fall mainly into three categories:

1. Design changes caused by improvement through design process (DCI). Examples are changes resulting from design reviews, technological advances or constructability reviews.
2. Design changes originated by Owner (DCO). Examples are scope changes.
3. Design changes initiated by Engineer or Consultant familiar with the process (DCP). Examples are additions of pumps, valve or instrumentation that affect the operation of the facility.

Design errors and omissions mentioned in the study are also other possible causes of changes in construction. Hester et al (1991), summarizes the sources of changes from different studies. The lists show a consensus as to the sources of changes. Yu Kelving (1996) cites owner's change of mind as the prime source of changes in residential housing projects.

Second, changes can be classified in terms of net effect on scope (CII publication 6-10(1990), Fisk 1988) as follows:

1. *Additive change.* This involves addition of work to the original scope (adding a new module for example).
2. *Deductive change*: Unlike the previous type this change involves deletion of work or shrinking the scope of work – Contractors call this a negative change since it usually involves deduction in contract value.
3. *Rework* – due to quality deficiency. Although this type involves no scope change it could have a huge cost impact.
4. *Force majeure change*: Although this has the effect of a change, a force majeure caused change may entitle the contractor to schedule adjustment and (1) or cost adjustment depending on the conditions of contract.

Third, changes can be classified by the procedure used to introduce them (CII publication 6-10 (1990), Fisk 1988, Cox 1997). This classification is important in discussing the legal aspects of changes.

1. *Formal or directed change*: is a change introduced by the owner or his agent under the mechanism of the change clause.
2. *Constructive Change*: Is a change that resulted from a failure to do or not do on part of the owner or owner's agent. This type is not initially documented as a change and hence becomes a potential source of dispute. The failure of the owner or owner's agent may take the form of error in design or drawings, wrong Engineer's interpretation of contract documents, change in construction sequence imposed by a construction requirement etc. (Fisk 1988, Cox 1997).

3. *Cardinal change* is a change outside the scope of the contract and executed only after complete redefinition of the scope and re-negotiation of the contract. This can also be called a “scope change”. This is not necessarily a single change but can be the result of a number of changes that have the net effect of modifying the original scope.

A study by CII on effects of changes on labor productivity (Thomas and Napolitan 1994) presents several other listings and classifications of changes that show a great similarity. First changes are classified on the basis of the subject of change such as “ changes to process design”. In a second listing changes are classified in a form of a matrix showing type and originator. A third listing shows changes classified according to the account group responsible for the change (client, home office, and field). Many of the listings, as noted by the CII report, are usually developed for the purpose of cost accounting and back charging and add little in clarifying the impacts of changes.

## 2.2 **The Legal Aspects**

In this regard, we refer to literature discussing legal aspects such as contract change, clause interpretation, substantiation and management of claims. In this approach changes are looked at as a major source of construction claims and disputes. The major legal aspects are (CII publication 5-10 (1986), Cox 1997):

- Selecting the best delivery system (contract format)
- Drafting and interpreting change clauses
- Documenting change orders to be ready in case of litigation

Most of these issues can be found in literature discussing claims and disputes and deal with after the fact approach. However, there are few points that affect how a project will cope with changes and problems anticipated. As ascertained by Cox (1997), "An owner's management of change orders and claims must also anticipate and provide for dispute prevention and dispute resolution processes from the outset".

### Types of Construction Contracts

Of direct bearing on the legal subjects of change orders is the subject of the contract format used. There are numerous contract types used in construction depending on owner and project requirement. The more common types will be reviewed here.

Construction contracts are typically drafted by the Owner or his representative (consultant) and contain the subject matter and terms and conditions. The construction contract is typically compromised of (Ashly & Workman, 1986):

- Bid Form
- Agreement Form

- General Conditions or Standard Specifications
- Special Provisions
- Plans
- Addenda

Construction contracts must also include a compensation system and generally are classified according to the compensation system as follows:

**1. Fixed Price Contracts**

This category includes all contract types in which financial terms require the contractor to "establish a stipulated sum for the completion or execution of a defined quantity of work". Ibbs et al (1986). Under this category the following types are listed:

a. Lump Sum

The contractor in this type of contract is required to construct the project in accordance with plans and specification for a fixed sum. Contractor will be solely responsible for any cost exceeding the agreed amount. The scope may include or exclude materials, procurement or engineering as agreed.

The term Lump Sum Turn Key (LSTK) is often used to indicate a lump sum contract including design procurement and construction. Sometimes it is referred to as simply turn key contract. In building construction, in Saudi Arabia, lump sum contract for labor work LS-LBR is quite common especially for residential buildings. Sometimes the term Design and Build (D&B) is used

to indicate a lump sump contract as will be discussed later under contracting strategies. Another form of lump sum type contract used in industrial construction is the Lump Sum Procure and Build (LSPB).

b. Unit Price

This contract type contains a detailed list of estimated work quantities such as cubic meters of excavated land or concrete or a total length of different pipe sizes. The owner in this case will take the risk of variation in quantity. Actual price paid (fixed) is determined by actual units done as constructed. Most government contracts in Saudi Arabia are unit type format. Unit price contract allows owner the freedom to make changes in the volume of work and permit more control (Ayers, 1988)

c. Guaranteed Maximum

In this type of contracts the owner is guaranteed a maximum price for executing the work as defined in the contract. Normally the contract contains incentive clauses for cost under-runs and penalty clauses for cost overruns. Ashly and Workman (1986) discussed the effects of incentives in the contract and concluded that they promote an attitude of motivation on the contractual relationship and take the form of inducements, encouragement and threats. The study also indicates that incentives are a tool used by owners to adjust the contractor's fee. The study includes full details of finding on contractual motivation which is beyond our scope of this review.

According to Ayers (1988), about 90% of the contracts in construction are one form or another of fixed type contracts. Ayers (1988), believes that fixed type contracts insure by competition that owners get lowest prices possible. Fixed type contracts are, also characterized by well-defined scope and low risk for owners. According to Ayers (1988), the quality of work is usually poor.

**2. Cost-Reimbursable Contracts**

This category includes all contract types, in which financial terms allows the contractor price adjustment relative to project costs. Ibbs et al (1986) summaries the type of contracts which fall under this category as:

a. Cost Plus Fixed Fee

The contractor in this type of contract is paid whatever cost associated with the project plus a lump sum fee for corporate overhead and profit.

b. Cost Plus Percentage

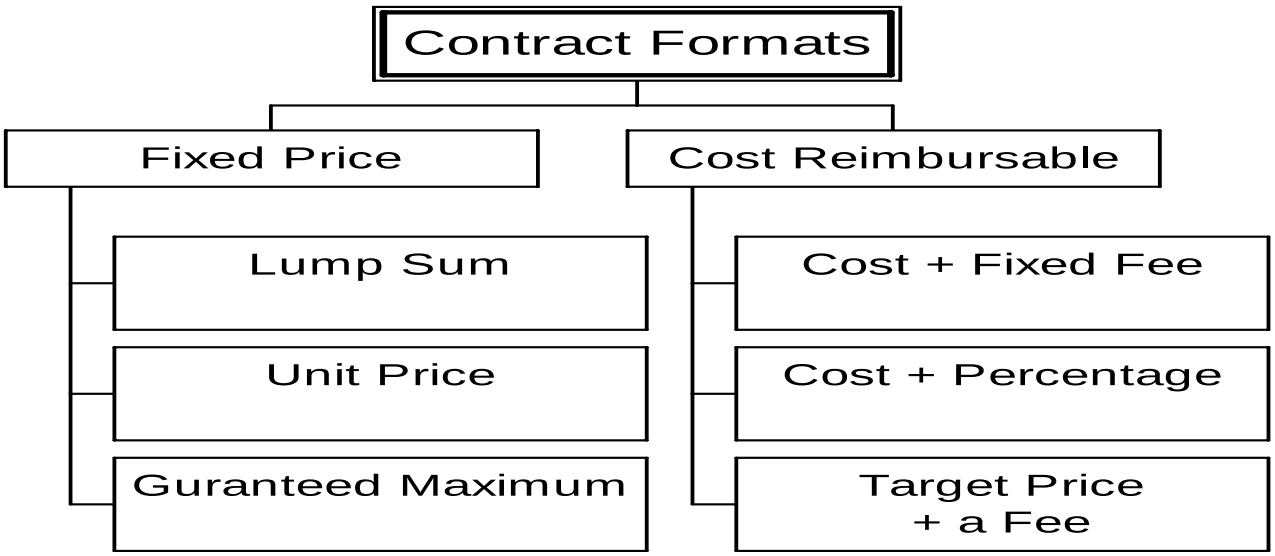
In this type of contract the contractor is paid all costs associated with the project plus a percentage of these costs rather than a fixed sum or fee.

c. Target Price Plus a Fee

In this type of contract, a target price is first established for the cost of the project based on contract documents or unit prices. "The contractor's fee will be based on this sum. Typically financial arrangements make

provision for the contractor to share any savings below the target price or participate in the liability of cost overruns".

According to Ayers (1988), cost plus contract insure better quality at higher costs to owners. The block diagram below depicts the contract format division:




There are other classifications or names used to describe certain contract formats based on scope or on contractual strategy such as the Engineer-Procure and Construct contract (EPC) which is quite common in industrial construction. There is the Design and Build type (D&B) as discussed earlier. Other type includes Build-Own-Operate-Transfer (BOOT) and Build-Operate-Transfer (BOT) contract methods.

John Webb (1995) studied the reward and risk in partnership-based contract and highlighted that "A large number of different contract models and leasing arrangement are

currently being used across the world, with the essential difference being the division and acceptance of risk by the different parties taking part in the structure". The paper discussed the rising interest in concession contract arrangements which include arrangement such as BOOT and BOT "Even in the UK, concession contracts in the form of Design-Build-Finance-Operate (DBFO) projects are emerging as the fast track method for major road improvement".

Ayers (1988), divides contracting strategies into single and partial. In single contracts, all the work is given to one single contractor. Partial contract is where more than one contractor is employed to do the work on a single project. Ayers (1988) also discussed the features of single contract versus partial contract. Those features include level of control, level of required coordination, and definition of contractor responsibilities.

Gilbreath (1992) divides contracting strategies into design-build, general contractor, few primes, multiple primes and force account. The features of each was discussed and the author concluded" only by thoroughly understanding the features and benefits of each approach can you (1) make a rational selection of any one approach over the others and (2) successfully implement the choice you have made"

The very basic idea mentioned in Webb's paper about the division and acceptance of risk is what differentiate contract types or contractual arrangements and deserve close evaluation for every case to determine the suitable format and its level of accepted risk for the different parties. Ibbs et al (1986) indicated that "the choice of the type of contract (fixed cost versus cost reimbursable) should be heavily influenced by four circumstances:

1. The extent to which the work is defined
2. The desired allocation of risk between owner and contractor
3. The availability of owner expertise and effort on the project
4. The need to accommodate fast-tracking of design and construction
5. The general marketplace conditions.

Ibbs et al (1986) summarized the commonly accepted ideas with respect to contract strategy as follows:

1. Risk allocation is considered to be, primarily, directed toward the contractor in fixed price contracts
2. Risk allocation is considered to be primarily directed toward the owner in cost reimbursable contracts.
3. More owner administrative time is required in cost reimbursable contracts.
4. Environment is less adversarial in cost plus contracts.
5. Documentation and scope definition effort is more critical in fixed price contracts.
6. Fixed price contracts provide less incentive for high quality work.
7. Cost plus contracts provide more flexibility to change in design or scope.
8. Cost reimbursable contracts assist in minimizing the schedule while fixed price contracts minimize costs.

Certainly not all types of contracts are equally sensitive to changes. If contracts are classified as either cost reimbursable or fixed cost, the latter will be the most sensitive to changes. For example, Resmond (1984) suggested that in a climate of intense competition, the winners of bid awards are not only willing to assume the risk of losing profits, but are also willing to improve their financial position through excessive use of

change orders. This premise was tested against a sample of actual data from the Western Division, USA Naval Facilities Engineering Commands.

In cost reimbursable projects there is a direct transfer of cost and schedule effects to the owner. Generally fixed price contracts are selected for projects in which the scope is well defined and the risk is low. Cost reimbursable contracts on the other hand are selected for ill-defined projects or for schedule acceleration. (Refer to Appendix B for definitions of terms). An interesting discussion on the degree of control required for each type of contract is presented by Lock (1992). In short, owners should consider changes when considering the type of contract for their project in terms of the ability of the contract to contain and minimize changes (CII publication 5-1,1986)

The most important clause in this regard is the change clause: “Change clauses are an important element of the contract because they provide mechanism for contract modification (either to react to unexpected events or because the owner desires change) and for appropriate compensation” (CII publication 5-1,1986). The change clause establishes the right of the owner to make changes within certain limitations and through a defined mechanism. As noted by Cox (1997), the change clause is “ the most frequently relied on by contractors and subcontractors when seeking recovery of extra money”.

Krone (1992) found in his interesting comparison between Construction Management styles in the US and Japan that change orders are uncommon in Japanese construction. Instead, Japanese contractors request additional money at the end of construction projects.

In a study done by the Construction Industry Institute (CII publication 5-1,1986) it was found that change clause is one of the most troublesome contract clauses. “Problems

most often encountered with construction change clauses involved definition and negotiation of costs, dispute resolution and time required for approval". According to Hester (1991) legal disputes over changes often focus on whether or not a compensatory change exists, the appropriate level of compensation, and the relative responsibility for a change. Hester further differentiated between the direct and indirect impacts from a legal point of view. Two terms came into discussion namely compensability and excusability of a change.

Krone (1991) conducted a study on a change order process that promotes efficient administrative performance and addresses the daily demands of changes in the construction process. The change order process has contributed to an increase in litigation and a decline in production. The process can cause localized problems on a construction site to spread into other areas. This study investigates the construction change order process through a review of construction case studies, literature covering the period between 1975 and 1990, and construction at the University of Maryland during 1987-1990. The analysis develops digraphs of the change order process to determine the cause and extent of possible damage resulting from it. A hypothetical process is tested through a comparison with the American Institute of Architects' change article. The contractual analysis technique (CAT), which is a matrix addition of the procedures presented in the digraphs, is employed. The findings suggest that the change clause of the general conditions should emphasize early proposal pricing. CAT found that early notification and submission of proposals maintains management control and avoids impact claims. The research in developing this change order process places more emphasis on the contractor's proposal, shortens the notification and proposal duration, and establishes a change order

allowance in the bid process. The CAT lays the foundation for future contract change clauses in construction management.

Dickman and Kim (1992) reported on an ongoing research project to develop and an expert system (Super Change) to educate and advise inexperienced site engineers about the legal consequences of construction disputes. The expert system described in the paper was designed to analyze claims that arise under change clause as in the Federal Acquisition Regulation (FAR).

The researchers defined change clause as an attempt by the contractor to recover additional expenses that have been incurred or will be incurred in order to comply with the change. The knowledge base used in Super Change had been obtained from past research, literature case law and actual experts. The knowledge for the system was organized into interference trees. They identified 20 different legal issues that were potentially applicable to change claim analysis. Among those issues are scope of work, silence as approval, impossibility, implied warranty and site inspection.

A preliminary testing of the system was presented, which showed a 70% success rate for that version of the Super Change system, proved it to be weak in implied warranty analysis. The paper admitted that Super Change was not recommendable before more field trials and appropriate modifications.

Change clause is an essential part of any legal construction contract. It defines how the two parties will handle changes and change orders, and form the basis of any legal claims. There are many forms of change clause. Some are standard, such as the American

Institute of Architects (AIA) form. Hester et al (1991) presented a very nice summary of change clauses, their functions and forms.

Sometimes an owner or an engineer may attempt to avoid responsibility of changes by using a disclaimer clause or risk-shifting clause in the contract (CII publication 5-1(1986), Cox 1997). Such a clause may state that 'subsurface data provided is for information only' and the owner is not responsible for any variation. The owner or the engineer may also place a design responsibility on a contractor, whereas it is the responsibility of the engineer under common law or traditional industry practice. By using such clauses an owner or an engineer is transferring the risk to the contractor. These clauses, if used, become risk items in themselves which affect the contractor bidding strategy. "Some examples are the no damage for delay clause, a site condition disclaimer, a blanket indemnity clause …" (Cox, 1997) and the list is long which requires contractors to allow for these shifted risks in their bids and go into their project with open eyes.

## 2.3 **Cost Aspects**

This type of literature studies changes in construction from a cost point of view. The literature published can be classified as either qualitative or quantitative. Qualitative studies discuss the various attributes of cost and schedule impacts without quantifying them. Quantitative studies on the other hand attempt to quantify the various attributes of cost and schedule impacts. Most of the quantitative studies were done on the productivity factor in change. CII has great contributions to this type of studies. Quantitative assessments of change impacts can be done for different purposes:

- To predict change impacts before construction ( by owner or contractor )
- To calculate change cost during construction ( for accounting corrective actions)
- To calculate change cost after project close out or for claim purposes

Attempts to quantify change impacts usually confronted two major problems (Zeitoun and Oberlender, 1993):

- Difficulty in collection and accuracy of data
- Difficulty in assessing indirect impacts of changes

The cost impact of a change is greatly affected by the timing of the change (CII publications 5-1(1986) & 6-10 (1990)). A change issued before construction has limited effects as compared to a change issued after construction has already started and materials have been procured. Also successive changes cost more than a single change. Changes after construction or completion of design must provide high cost saving to be justified. Some owners request that a change must provide savings 10 times the direct cost required to implement them. "However if the idea that the cost of change can vary exponentially with time of introduction is accepted, that ratio should probably be 25:1 or higher in the

later stage of detail design" (CII publication 6-10,1990). It is clear that the relation between changes and time is an exponential function.

The impacts of a change are classified in the literature as follows: (CII publication 6-10,1990)

1. Direct cost impact
2. Direct schedule impact
3. Indirect or Consequential impact

Let us examine each of these impacts and its attributes making reference to published literature on the subject.

### 2.3.1 **Direct Cost Impact**

The direct impacts are those limited to the work package in which a change is introduced. The cost impact could be positive (savings) to the owner or negative (more expenditure). The contractor's view of a change being positive or negative will be the opposite. A change may also have a positive cost impact to both owner and contractor. Further, a change may have zero cost impact to both parties. There are two components to the cost of a change: labor cost and material cost. Material cost is easy to estimate and predict to a certain accuracy. However it is difficult to estimate labor cost due to:

- The effect of changes on the productivity rate itself.
- The uncertainty about the scope of a change (exact engineering, procurement, and construction activities that form a change work).

The discussion here about labor cost impact will use the situation where change is issued after construction as the setting. Labor cost of changes can be broken into three attributes (CII publication 6-10 , 1990):

a) Productivity Degradation

b) Delays

c) Demolition and Rework

Of the direct cost impact attributes, productivity is the most difficult to estimate, measure and control.

**i) The Human Factor: Productivity Degradation**

Interruption, delays and redirection of work, associated with change work have a negative impact on labor productivity which in turn translates into labor cost or dollar value. Many studies were conducted to evaluate this aspect of change (CII publication 6-10 (1990), Thomas et al 1994 &1995, Hester et al 1991). Two studies cited in CII publication 6-10 (1990) examined work by single craft crewmen and effects of changes on their productivity. "The setting of the first study was a major chemical facility and the craftsmen involved were union insulators". "Study 2 was undertaken on a revamp project at a refinery where changes were being generated at a rate that often exceeds 20 per week". Comparing the productivity index against the frequency of change, the studies concluded:

Productivity drops rapidly with increased frequency of interruptions.

- As the rate of disturbances to the normal flow of work increases, the extent of productivity degradation becomes compounded.
- More than 40% reduction in productivity was noticed with an extreme number of

disturbances.

Productivity degradation is not the same for all tasks and settings. The following factors are noted:

1. Concentration required to perform the task
2. Machine intensive tasks vs. labor intensive tasks
3. Frequency of interruptions and duration of time between them
4. Worker expectation of the change and his opinion about it

We can also expect productivity of workers to be greatly affected in cases where workers were required to work overtime for prolonged periods to compensate for schedule delays. In a study by Thomas and Napolitan (1995) productivity values from three industrial projects constructed between 1989 and 1992 were used in the analysis. The study concluded that on average there was 30% loss of efficiency due to changes (25-50% was the actual range). It is worth noting that Thomas and Napolitan concluded that changes do not lead to productivity degradation or efficiency loss in themselves. Instead, a construction change causes other disruptive influences to be activated. In fact, Thomas and Napolitan concluded that it is possible to perform changes without negatively impacting labor efficiency. However, it is difficult to qualify this statement. Changes are disruptive in nature and to think of eliminating some of these disruptions is impossible before the change is introduced.

Thomas and Napolitan show the same results in their Construction Industry Institute report (1994). The report indicated that earlier research done by the United Nations in 1965 identified two major factors affecting labor productivity, namely the nature of work being done (Organizational Continuity) and the management and the

environment of the work (Executional Continuity). The United Nation's report has led to the development of a model called the Factor Model that tries to explain factors affecting labor productivity. The discussion of the Factor Model and its representation is outside the scope of this review and the reader is referred to the cited references.

The CII report concluded again that changes normally lead to disruptions and these disruptions are responsible for labor productivity degradation: "The most significant types of disruptions are the lack of materials and information and having to perform the work out of sequence". Lack of material is reported as being the most serious disruption. The report emphasized that to manage changes one needs to manage these disruptions. However the disruptive effects "cannot be avoided in many instances".

**b. Cost of Delay**

To make a change and process takes time. This usually results in placing a hold on the work and waiting for new instructions to come. In addition, equipment, tools and materials may not be the same after the change is introduced. To procure or rent new material, tools and equipment will cause delay and cost of resources may be substantial. Furthermore, if delays are prolonged demobilization/remobilization may become quite costly. The cost of delay may apply to engineering and procurement activities if impacted by change (CII publication 6-10, 1990).

**c. Demolition and Rework**

Changes, which are introduced when the construction is underway or even complete involve several direct cost items (CII publication 6-10,1990) which can be summarized as follows:

1. Labor cost to demolish existing facility

2. Equipment cost to demolish existing facility
3. Materials wasted by removal of existing work
4. Associated cost of engineering/shipping and handling of waste materials

### 2.3.2 **Direct Schedule Impact**

It is easy to document a schedule impact of a change after change work is done, because all data is available regardless of its accuracy. However, it is difficult to predict impact of change on schedule before making a change because of the many uncertainties related to labor productivity, material availability or job interference. The cost of schedule slippage becomes very high if the contract includes a penalty clause.

Most projects are planned using a critical path method, CPM, (CII publication 6-10, 1990). This method of scheduling shows the activities included and their dependencies. CPM provides the basis against which impact of changes on schedule can be evaluated. Floats both total and free (see Appendix B) play an important role in schedule impact evaluation for they represent the flexibility available to handle the unforeseen conditions such as changes.

The magnitude of schedule slippage due to changes is reported by Zeitoun and Oberlender (1993) as 9% of the original schedule on average for 71 fixed price projects studied.

In a study by Ibbs, Lee & Li (1998) on the effects of schedule acceleration on project changes, researchers concluded that “a high level of fast tracking generally does not result in any more changes than non-fast tracking projects”. This study used data from

an earlier study (Ibbs & Allen) sponsored by the Construction Industry Institute in which 108 projects were analyzed for change data. The study found that fast track projects, however, tend to generate more changes toward the end of the project, resulting in increased labor intensity and a more hectic finishing and close out operation.

### 2.3.3 **Indirect or Consequential Impacts**

There are always indirect impacts to changes that are overlooked or underestimated (CII publication 6-10, 1990). Consequential effects can occur later in other work packages and thus on the total project. Therefore it is essential to acknowledge this possibility and establish the mechanism to evaluate its consequences. The contract change clause should fully consider both direct and indirect (consequential) effects.

The following are among the possible consequential effects (CII publication 6-10,1990).

1. Effects on the methods or procedures used in other work packages due to a change in a previous task or package.
2. Degradation of productivity in subsequent packages or activity: Productivity studies cited earlier confirmed that a degradation of productivity in the change package is followed by productivity degradation in subsequent packages. A degradation of productivity was also noted in concurrent activities due to a change.
3. Increase in overhead cost – Obviously if the change has an impact on schedule, material or administration level, the project overhead increases proportionally.
4. Impacts on subcontractors: Normally subcontractors have their own plan and schedule assuming that the main contractor will maintain the original conditions that allow start and end of work as scheduled. When a change takes a place, the

subcontractor may need to adjust his plans and schedule accordingly. The subcontractor in turn may seek price and or schedule adjustments.

5. Miscellaneous: The following are some potential cost items that may be overlooked:

- Time value of capital tied due to a change
- Shifting of work to a less favorable period.
- Additional bonding and insurance.
- Engineering work for correcting drawings and documents.
- Procurement activities effects

In summary, changes in construction generate effects that far exceed the working package or activity in which changes occur. This situation is called a "Ripple Effect". Thomas and Napolitan (1994) indicated that "While much has been said about the ripple effect, there have been no quantitative studies showing the magnitude of these effects". An attempt to measure ripple effects quantitatively was done by Zeitoun and Oberlender (1993). The attempt was not successful, because of the relative respondent interpretation of the term 'ripple effect'. The researchers then proposed a method called 'ripple tree'. Again results obtained applying the ripple tree method came out to be inconsistent with the actual situation. Zeitoun and Oberlender (1993) attributed the unexpected results to erroneous historical data and suggested the use of the method during construction.

Nevertheless, managers of construction projects must develop the means to evaluate and estimate the consequential impacts of a change. An effective tool in consequential impact evaluation is the use of Work Breakdown Structure (WBS). A contractor should consider using the Work Breakdown Structure (WBS) as an evaluation

tool especially on large projects. In this method, the whole project is broken into hierarchical fashion. Resources are allocated to each element in the WBS. "The WBS is a vital tool in change management. If a change involves work not previously included on the WBS, it can be logically added to the WBS and its relationship to the WBS element seen" (CII publication 6-6, 1988). Ripple effects can be traced by the use of WBS. The discussion of the details and applications of the WBS is beyond the scope of this paper and the reader is referred to the above CII publication. Other evaluation tools cited in literature include market factor (MF), forensic scheduling, and current control schedule. The details of these tools are covered in CII publication 6-6 and Hester et al (1991).

### 2.3.4 **Magnitude of Impacts**

The cost and schedule impacts of changes vary widely from one project to another. Although there have been cases where change cost accounted for as high as 100% of the budgeted funds , the industry norm of this percentage is about 10%.

Burati et al presented in their study (Burati et al, 1992) a quantitative analysis of changes and their associated cost. In this study, which was conducted again under the guidance of the CII, nine industrial projects of at least $500,000 in total installed cost were selected. The projects are of three types namely, grass-root (new), retrofit, and upgrade. The contracts are either fixed price or cost plus. The results showed that deviation (change) cost amounted to an average of 12.4% of the total cost of the project. As can be seen, this represents a significant amount of money. The study also shows the effect of the type of project on the cost of deviations or changes. Similar figures were cited by Zietoun and Oberlender (1993) for the cost growth because of changes. In this study 5.3% was the median accumulative cost growth and 9% the schedule growth. These results are for fixed price contract projects. Different results were given for cost re-reimbursable contract projects. Surprisingly, the construction management delivery system experienced the highest cost growth (12.1%) and the lowest schedule growth. The open bid solicitation system showed a very high schedule growth (18%) compared to 0% schedule growth for the approved list system. Government projects experienced lower cost growth compared to private projects (3.6% versus 8.1%).

Zeitoun and Oberlender (1993) correlated Money Left On The Table (MLOT) defined as the difference between the lowest bid and next lower bid, to cost and schedule

growth. Results showed projects with high MLOT have high cost and schedule growth. Cost and schedule growth is also high when the number of bidders is low.

### 2.3.5 **Costing of Changes**

In this section, we focus our attention on the actual procedures that contractors use to cost changes and whether they consider the possible impacts discussed in the last section or not.

Contractors have a strong price bargaining position when negotiating changes because of the fact that competition is replaced by a monopoly. Depending on the terms of contract, the owner could seek competitive bids from other contractors. We often hear that owners are 'squeezed' to pay the greatest possible amount for changes. But remembering that cost of changes grows exponentially with time and that productivity could drop by more than 30%, are contractors getting enough compensation? Many owners will not hesitate to declare that contractors make money on changes because their estimates of changes are too high. Thomas and Napolitan (1994) disagree "In reality, contractors lose money on changes because their estimates are too low". Hester et al (1991) made field studies on the conventional manual cost data collection methods and concluded that they " may not be appropriate for projects involving poorly defined work or extensive changes". Instead, the researchers proposed the use of an automated cost control system (site-based micro-computer) which according to Hester provides the following benefits:

- Reduced error in data input
- Immediate feedback on cost to date
- The opportunity to assess cost by task as well as cost code

Hester investigated four different projects using the proposed automated system to track cost of changes and to monitor their effects on labor productivity. The results and types of data analysis are shown in (Hester et al ,1991).

Costing of changes can become a real challenge on a fixed price or lump sum contract. On a cost plus, there is a direct transfer of cost to the owner and the problem does not exist. The following procedures are used in costing changes (CII publication 6-10,1990):

1. Price and schedule adjustments are negotiated prior to the start of implementation.
2. If unit prices are part of the contract, they will be used as the basis of change work pricing. Unit prices quoted in the contract should not be used to cost changes without consideration to change variation. A quantity limit of unit price validity may be used.
3. The contractor is directed to proceed with after the fact adjustment.

The first technique is in wide use in the construction industry. However, it requires a commitment from both parties to expedite and carry change procedures in an open and trustworthy environment. Many argue against the use of unit prices submitted with the bid for costing changes without variation (CII publication 6-10, 1990 and Hester et al 1991). Although the third practice is risky and opens the door for disputes and claims, it is used when handling fast track projects. In such a case, the normal procedures are too long to fit in the time frame available. Usually, a contractor prepares what is called the 'variance' to keep track of changes made. The variance is basically the difference between original and new scope in a detailed quantitative format.

Taking the question one step back, can an owner or a contractor predict the magnitude of changes expected on a certain project? It is well known that contractors use their expectations of changes to formulate their bidding strategy. An experienced contractor can evaluate the potential of changes in the bidding documents. By reviewing

drawings, data sheets and other documents, the contractor can highlight areas of possible changes. Certainly the contractor will try to make use of the loose scope to avoid any risk and to maximize profit in different ways:

1. The contractor may submit a low bid to beat the competition knowing that he can make up for that after the award of the contract by changes generated.
2. The contractor can utilize his knowledge about the work and the potential change and unbalance the bid in a unit price schedule.

Hester et al (1991) presents several points in trying to evaluate the potential for change in a certain project. Specifically they suggested the following factors:

- What is the basis of the estimate?
- How complete is the design? Is there subsurface information?
- Have the operation and maintenance sections added their input to the design?

Zeitoun and Oberlender (1993) have identified the following parameters that could reflect potential changes for fixed price projects:

- Money Left On the Table (MLOT)
- Number of bidders
- Execution format (delivery system)
- Manner of bid solicitation
- Owner type ( private or public)

They concluded that it is possible to formulate a model that predicts the magnitude of changes due to these factors but conceded that it will be a difficult task in the construction industry.

J. A. Kurpenas (1998) developed a Change Order Management Procedure (COMP) model to estimate the cost and schedule impacts of changes. The model uses influence diagrams to reach the value of a change before implementation. An influence diagram is a form of decision tree for the study of complex decision problems under uncertain conditions. As Kurpenas explained: "The interrelationship between variables is represented in a compact graphical framework which identifies the critical variables". The model includes internal and external cost factors to come up with the cost of the change. Kurpenas also indicated that his research showed the deficiencies of current change order pricing techniques and showed the strength of influence diagrams as a change management tool.

The model was tested using both hypothetical change scenarios and actual field data. Although both tests were conclusive, the many assumptions about productivity and duration make the model of little value in terms of practical application.

## 2.4 **Management Aspects**

The discussion so far has concentrated on the legal and cost aspects of a change. Equally important is the need to have a well developed program for the management of changes. This includes a change control program and change order administration during initiation, evaluation, approval and implementation. Very little is found in the literature on change order procedures and handling. Most of what is written deals with the control part. The Changes Impact Task Force of the Construction Industry Institute (CII) prepared a checklist of the most common parameters to consider when considering a change. These parameters were classified under different categories. According to Thomas and Napolitan (1994), the major categories are:

- Size and scope
- Nature of the scope
- Timing
- Managing Impact
- Who does the change
- Site conditions (environment)

In its special publication 43-1 (1994), the CII Project Change Management Research Team recognized five principles for effective change management:

- "Promoting a balanced change culture". According to the research team this means allowing 'beneficial' changes to proceed while discouraging or preventing changes that do not meet this criterion, or changes the team termed 'detrimental'. In defining 'beneficial' changes, the CII team stressed that long–range negative impacts are also studied. "Sometimes immediate beneficial change means potential long-term problems". Detrimental changes are defined as "those that reduce owner value or

have a negative impact on a project". To prevent detrimental changes from occurring the team recommended value engineering, understanding the basis of evaluation, financial justification for elective changes, and maintaining accountability.

- "Recognize Change". According to the CII team, there is a common disagreement between parties on what constitutes a change. Consequently, an environment that allows team members to openly communicate is important. The team suggested many ways to enhance change recognition including training team members, flowcharting change management process, devoting specific meetings for change identification, and the regular examination of the total number and value of changes.
- "Evaluate Change". This principle requires a change to be classified as required or elective. Required changes are required to meet original objectives of the project while elective changes are additional features that enhance the project. The team warns against quick judgement in favor of implementing elective changes.
- "Implement Change". This principle requires the flexibility of team members to implement changes at any point on the schedule. Established procedures must be set for authorization and documentation. "Authorization assures that all parties have been communicated with regarding the change" and that the change can be implemented. The research team stressed that the implementation process should contain a documentation system to follow up on the overall impact of the changes.
- "Continuously improve from the lessons learned". The research team emphasized the need to learn from the lessons of past projects executed by an organization. "From the outset, project strategies and philosophies should take advantage of lessons learned from past similar projects".

The team concluded that “significant savings in total installed costs of construction projects are achievable by improving management of changes”.

### 2.4.1 **Change Control**

As noted earlier, changes are usually introduced because of change in scope through addition or deletion by owner or through revision or improvement of design by engineer.

W. Bruce Pruitt ( 1992) wrote on the subject: “One of the proverbs proposed by Harold Kerzner is ‘If project content is allowed to change freely, the rate of change will exceed the rate of progress’.

Tiong (1990) conducted a study on various controls that should be provided for all phases of a major project: cost control, schedule control, quality control, design control, change order control and document control. He concluded that a change order control system should be established for the ultimate benefit of owners.

Dellon (1986) said: “As construction cost continue to rise, the use of project management techniques is needed to ensure credibility and productivity. Change orders are attributable to many different factors and affect both project cost and time schedule.”

Changes to original scope and design are responsible for 50% of changes reported (Burati et al 1992 and Hester et al 1991). Consequently if we can control the scope and define it well we can cut the amount of changes to a minimum. “Loss of scope control

during engineering ranks second in terms of impact on cost overruns…....This is often referred to as creeping scope" (CII publication 6-2,1990). The following actions will help in controlling changes (CII publication 6-12, 1990) :

1. The owner should define his needs and project objectives early in the project life. Design scoping paper or the conceptual development should be as clear as possible. Consistent changes even in the front-end engineering can cost many man-hours he can otherwise save. In defining project objectives, concerned departments in the owner's organization should be consulted for their input.
2. The owner must be committed to change control. The owner may consider forming a change review committee which includes the owner's Project Engineer, Business Manager and Process Engineer to carry out the owner's commitment to reduce change effects. Early in the project life, these individuals should be identified and procedures made clear to all parties.
3. A team effort by the owner, engineer and contractor to promote recognition, reporting, and resolution of a change is required throughout the life of the project.
4. Freezing the design is a strong control method. Many owners freeze the design and close the door for changes after completion of drawings.
5. All changes must be justified from a cost point of view. Both direct and indirect impacts must be studied before approval for implementation.
6. Expedient and efficient change procedures must be followed to avoid any delay in evaluation, approval, and execution. (See next section for details of change order procedures).
7. Owners should expend more effort (such as site studies) in the early development of the design to minimize changes during detail design and construction.

PMI Project Management Body of Knowledge guide (1996) defines the function of scope change as " concerned with:

(a) influencing the factors which create scope changes to insure that changes are beneficial

(b) determining that a scope change has occurred

(c) managing the actual changes when and if they occur.

PMI PMBOK guide recommends that "scope change control must be thoroughly integrated with the other control processes ( time control, cost control, quality control, and others)".

### 2.4.2 **Change Order Administration**

It might sound simple, but the procedures and documentation of a change are a very vital elements in any change management program. The process starts when the owner, the owner's representative, or the contractor initiates a change and continues until the change is ready to be implemented. This phase includes a number of important forms and guidelines that must be followed and adhered to in order to bring this change to a successful conclusion. The failure to follow these steps might even jeopardize the right of a contractor to collect fair compensation for a change (Cox 1997). Every major company as an owner has its own forms and procedures to manage a change. The fundamental elements of any procedure are (Saudi Armco Project Management Manual ,1995):

- Change recognition and scope definition.
- Change order initiation and documentation.
- Change order execution and closure.

In his discussion, Rowland (1981) presented a list of general rules to be followed to help in avoiding today's change order problems. Lidholt (1977) examined the current usability of advisory audits in the negotiation of navy construction contract change order in the United States. A survey was conducted to determine how audits are currently used to solicit suggestions on how current procedures might be improved. She came up with five recommendations to improve the current procedures:

1. Recognize different group backgrounds and experience level in the formulation of audit guidance;
2. Prepare a comprehensive informational reference;
3. Implement audits training and education;
4. Increase contractor awareness of informational responsibilities;

5. Maintain (establish) direct communication between contract administrators and auditors.

#### 2.4.2.1 **Change Scope Definition**

Perhaps the most important step in the development of a change order is the scope definition step. First, the original scope should be clear and well defined to distinguish between a change of scope and a change due to design development. "A poorly defined scope does not provide a clear baseline against which changes can be evaluated as being either changes within or outside of scope" (CII publication 6-2,1990).

The ability to define both original scope and change scope requires very strong technical skills. Many contractors find it "difficult to discuss changes with a client representative(s) who lacks the technical ability" (Saudi Armco Project Management Manual, 1995). Many contractors expressed dissatisfaction with client representatives asking the contractor to share risk for change work outside the original scope. As put by a contractor (J. Allen, 1995), "the biggest point of contention and disagreement usually revolves around the issue of (1) what actually constitutes a change". Hence the owner, owner representative and contractor have to be familiar with the facility, standards, and the contract when discussing a change scope.

2.4.2.2 **Change Order Documentation**

A change order as defined by Fisk (1988) is “the formal document that alters some conditions of the contract documents”. The word ‘formal’ implies legal binding and as such all changes should be in writing and verbal changes should be avoided. Although there is no mandatory form, owners usually have their own forms and procedures that must be followed to process a change.

According to W. Bruce Pruitt (1999), the approval of a change order is just the beginning, which must be followed by a course of action “to insure that the change is adequately documented”.

As the construction industry is characterized as ‘a hectic environment’, the procedure to process a change should be precise and ‘equally important’ fast. “One of the most aggravating conditions is the length of time that elapses between the time that a proposed contract modification is first announced and when the matter is finally rejected or approved as a change order” (Fisk 1988).

The complexity of procedures is a problem in large organizations. Too many control systems and technical department approvals become barriers to an efficient change order procedure. The inefficiency cost could be quite enormous. One owner emphasized: “Approximately 20% of project (team ) work effort is directed at developing, processing and negotiating Change Requests” (Saudi Aramco Project Management Manual, 1995). In addition, the level of trust between the parties has a direct impact on the simplicity or complexity of the change order procedures. The less the trust, the more cumbersome is the procedure. Typical change order procedures are shown in Appendices C & D

The following recommendations should help( Saudi Aramco Project Management Manual, 1995):

1. A trust should be maintained between the owner and contractor. Mistrust cost could be enormous. “One of the key findings of the study was that the level of trust established and maintained between the two contracting parties had a direct and significant bearing on the final cost of a project” . The level of trust is reflected by the level of openness, the level of flexibility, and fairness. In a situation of a low level of trust, contractors indicated that a contingency factor of 2.3% could be assigned. A high level of trust between the two parties could lead to what is called “partnering” in the development of change order. In practical terms, the contractor participates in scope definition, and pricing of change in a fair manner and open environment.
2. A reasonable level of technical expertise is a must in developing a change order. Since contractors usually have the required skills in each field that enable them to participate in this development (usually the discipline lead or the principal engineer), most emphasis should be placed on the owner’s side. The owner should provide people who possess the following skills besides in depth knowledge of the facility/process, contractors and the owner organization, and applicable standards and specifications.
    - Negotiation skills
    - Estimating skills
    - Engineering design and layout skills
    - Communication skills.

The lack of these skills translates into poor change management and could cost the owner a fortune. Emphasis on this aspect is especially applicable to owners in our country dealing with more advanced and technically stronger foreign contractors.

***PART TWO***

# CHAPTER THREE

# CAUSES, EFFECTS, AND CONTROLS

After our review of change literature, we can summarize and define our study targets and formulate our questions. Basically, we want to investigate three areas, namely, causes, effects, and controls and find out how these change related issues are viewed and treated by our Saudi consultants and contractors.

## 3.1 Causes

In this section we examine the potential causes of change orders in construction projects in general and large building projects in specific expected in this survey.

1. Change of Plans by Owner

Change of plans or scope of a project is by far the most significant cause of changes in construction as stated in the literature. Normally this source of changes results because of insufficient planning at the project definition stage or simply because of the lack of involvement of the owner at the design stage. This type of changes is normally costly especially if made later in the construction process.

An example of change of scope or change of plans is the increase in building area, an increase or decrease in the number of floors. Early involvement of the owner in the project objective definition and later in the design of the facility normally reduces such changes to a minimum.

2. Owner Financial Difficulties

The owner of the facility may run into difficult financial situations that force him to make changes in an attempt to reduce cost. The fact that many of the owners in this country especially in large building construction projects are wealthy individuals who might not have sound and reliable financial sources makes this risk a real one. Again proper planning and review of the project cash flow is enough to eliminate this problem.

3. Owner Change of Schedule

Time has an equivalent money value. This makes changes in the schedule as costly as change in scope or materials. As the contract was signed the contractor has leveled his resources over the time frame agreed upon with the owner. A change in the schedule means the contractor will either provide additional resources in a shorter time or idle some sources that he committed for certain activities. In both cases additional cost is incurred.

Although there are numerous causes of schedule change such as market conditions, user requirements, or lack of funding, the owner must be certain that the cost of change of schedule is well covered by the anticipated benefits.

4. Ill-defined Project Objectives

This might be a sub-category of change of plans but specifically indicates that the objectives of the project were not well defined.

5. Substitution of Materials or Procedures

If the contract calls for certain materials or work procedures, then a change order is required to substitute these materials or procedures. Especially in the Saudi environment, where material standardization is not common and where the market is full of all kinds of materials, making a pre-selection of material is quite difficult. This feature of the Saudi market forces people to move away from lump sum contracts that cover supply of material leaving the door open for the owner to select materials during installation.

The substitution of procedures includes changes in application methods of paints or insulation material for example. It is very obvious that different procedures are at a different cost to the contractor and hence adjustment to the original contract value is required in such instances.

6. Conflict between Contract Documents

Quite often, different documents are drawn by different engineers or design personnel during the design phase of the project. In spite of the close coordination between design personnel or disciplines, discrepancies are sometimes found. Normally contracts include guidelines as to which document governs in case of conflict. However the owner may find out that the governing document representation or requirements are not the best and may decide to change.

Owner must expend sizable effort to review contract documents for any possible contradictions before award of contract to avoid such changes. Phrases that can be interpreted differently have to be rewritten if confusion is to be avoided. The contractor will normally look for any phrase or note in the contract documents to justifying the cheaper option.

7. Change in Design

The changes in design happen more in projects where construction starts before design is finalized or in concurrent design and construction. The owner may opt for such a philosophy if the project is schedule driven and time is the controlling element. Owners normally object to any changes in design at this stage. However a new element of design may not have been considered before or a clear design advantage that is assumed by the change may favor going ahead with implementing this change. Change in design may also take place when the design is reviewed by the consultant, who has a different opinion than the designer, and he may wish to make changes. The owner or project manager should be careful however of approving preferential changes.

8. The Scope of Work for the Contractor is Ill-defined

Here the change is not forced because of change of a mind by the owner as we noted earlier, but rather because of lack of clarity in the documents about the scope of work. This might happen for example when work is contracted to different contractors but the boundaries are not made clear. It takes quite extensive efforts to draw the boundary lines between different packages or phases of the same projects especially in large complex projects where all systems are virtually interconnected. Clear demarcation on drawings

beside clarifying notes are a must to avoid such situations. In many instances, the owner contracts a third party to do work that he thought was included but cannot prove it was.

9. Errors and Omissions in Design

It is impossible to create a 100% error free design. Quite often, among the many documents of the project, one will find a note deleted, a detail mis-referenced or an incomplete specification sheet. The contractor's point of view is to escape the extra cost and will look for ways to minimize cost. This is quite legitimate and justified. In this case the owner will pay the extra cost (change order) or accept an inferior product or design. A quality assurance program in the designer office should minimize this source of changes.

10. Lack of Coordination

It is quite important in a multi-player environment like a construction project to keep strong and continuous coordination. The owner should convey his new ideas and concerns which form the basis for changes to the consultants in a timely manner. The owner should avoid giving direct orders to the contractor without the involvement of the party who is acting on his behalf. The consultant has to update the contractor of any concern he might have with the scheduled work. If we keep in mind that changes have an exponential relationship with time, we do not need to stress this point any further. Ways to improve coordination include coordination meetings, progress reports, and conference calls among others.

11. Value Engineering

Cost saving ideas are always welcome. This is a source of changes that cannot be ignored. Value engineering may be practiced formally as an official value engineering study that has all the required elements of this practice or it may be practiced in a simple and unorganized way. In either case the cost saving must be high enough to justify a change because it is not worth going through the problems of changes if the benefit to cost ratio is not attractive.

11. Technology Changes

Major construction projects and especially those which have technology items might face this reason for change especially if the time between design and construction is long. The presence of new technology in the market such as a new HVAC system, a new desalination unit or a new erection method might encourage the owner or the consultant to initiate this type of change.

12. Differing Site Conditions

This cause of changes happens most of the time on soil conditions in building construction. The contractor may face rock instead of soft soil as the tender document may have indicated. This will require extra effort for excavation and extra compensation to the contractor. This type of changes occurs mostly on renovation or revamp projects where new constructions interface with existing structures and require things to be re-evaluated.

13. Contractor Desire to Improve his Financial Conditions

Although no contractor wants to admit it, changes are looked at as a source of additional work. The contractor may talk directly to the owner and convince him to do

certain changes only to give himself the additional benefit of change work. The contractor may take any excuse to claim that certain parts of the work are not in his scope and therefore request compensation for doing it.

14. Contractor Financial Difficulties

Due to the fact that we in Saudi Arabia have many new contractors in large building construction projects, many of them face financial difficulties in executing large projects. These difficulties affect their ability to execute and deliver. Therefore, delays in the completion schedule (schedule change) may occur due to the financial problems.

15. Unavailability of Skills (Shortage of Skilled Labor)

Certain jobs may require certain expertise that is not available in the local market and for that reason the owner or consultant may agree to modify the method or procedure of construction. This type of change is more likely to happen in construction involving some degree of technological complexity and not in normal building construction.

16. Unavailability of Equipment (Lack of Equipment)

Like the previous source of change the lack of a piece of equipment may force a change to the plan. For example, lifting of some heavy structure may require crane capacity that is not available in the country forcing the contractor to think of other lifting methods. The danger in this comes from the fact that some designs are done outside the country by companies not familiar with the resources available locally. Active participation of the owner during design will minimize this source of changes.

17. Defective Workmanship

Defective workmanship of completed work may bring about demolition and re-work or may bring about changes in some instances. Acceptance of defective workmanship due to schedule may force a change in the facility to correct for it.

18. Safety Considerations

If some safety aspects were overlooked during the design phase, the owner or consultant may initiate a change to install additional safety features in the facility. This can not be different from any other design oversight, except for the fact that safety is usually un-compromised. The addition of specific safety controls such as a relief valve in an industrial facility or an escape door in a building is typical of such changes.

19. Weather Conditions

This cause is an example of the force majeure conditions discussed in literature. In this case, if the contractor is forced to alter his work schedule due to weather conditions such as high temperature or high winds, he might be entitled for compensation according to contract terms. Also if part of work done is damaged by wind for example, the contractor will be compensated according to contract terms.

20. New Government Regulations

Local authorities may have specific codes and regulations that must be adhered to. Normally the designer insures that his design is in compliance with these codes. However, new regulations may be issued between design and construction and may force some changes to the original plan. Codes such as environmental or labor codes are revised periodically and the contractor or facility owners are requested to comply.

## 3.2 **Effects**

There are numerous effects brought about by changes and change order in construction. In this section we examine some of these effects which are commonly encountered.

1. Decrease in Productivity

As we have seen in our review of change literature, the productivity of workers is negatively impacted by change orders especially repetitive changes. Labor cost accordingly increases and so the total project cost. In countries where labor is cheap, this impact is not felt. However this degradation of productivity may cost extra days or weeks of expensive labor.

2. Delay in Completion Schedule

Changes often result in time extension. In other instances, the owner may want to compensate the contractor for accelerating the work in order to keep up with the original schedule. In either case, additional time means additional money. Delays in completion can be quite costly. Imagine a facility such as a refinery or a large commercial center that costs millions when it is delayed for weeks or even days. Whoever is signing the change order ought to know the cost of delay before granting a time extension.

3. Dispute between Owner and Contractor

Changes and change orders are among the most common reason leading to claims and disputes. All other work is agreed upon in the contract. However changes must go through evaluation, estimation and negotiation leading to stress and strains in the relation between

parties. If these disputes are not settled peacefully through direct negotiations and arbitration they end up in court and legal procedures may suspend the whole project.

4. Decrease in Quality

Sometimes changes lead to a lower level of workmanship. As changes alter the original plan in certain items or areas, they might create a mismatch with other items or areas affecting the overall quality of the work. As discussed above, the low morale of the crew after many changes are made is also expected to affect the quality of their performance.

5. Increase in Project Cost

This is very evident result of change orders. Literature reviewed presented figures of common project cost increases due to change orders.

6. Additional Money for Contractor

No matter how much was said about the negative effects of change orders, there is often additional money gained by the contractor for executing additional scope. The accuracy of this statement depends on the awareness of contractors and owners of direct and indirect impacts of changes and on the willingness to accept this fact in change order pricing.

7. Delay of Material and Tools

Change orders bring about problems with materials and tools required to carry out a certain activity. Consider for example an order to change the type of doors of a building at a time after the order for doors was issued to the vendor. The new type of doors may not be available from the vendor and may require extra time to order or fabricate. This creates

delay for materials which in turn holds up work for finishing subsequent work. The delay of tools happens for example when a certain erection procedure has changed requiring a larger crane that is not readily available. The cost of such a delay can be quite costly.

8. Work on Hold

Change in a certain work package can put the work on other activities on hold. This happens when activities are interdependent. This action may freeze a certain craft crew or shift the schedule of its schedule. Speedy and quick change order procedures are very vital in order to minimize this effect.

9. Increase in Overhead Expenses

Normally change orders require processing procedures, paper work and reviews before they even proceed. They may requires holds on funds that otherwise will be used for other activities. These minor expenses are normally not charged to the change order account as they are difficult to define and separate from the different accounts. The charge normally goes on the contractor's overhead account.

10. Delay in Payment

If payments due to the contractor are made against a certain milestone then there is a possibility of delay in payment as a result of a change that delays the achievement of that milestone.

11. Demolition and Re-work

Quite often, changes that occur after construction of the project cause some parts of the work done to be demolished and done again. This is the worst phase to think of changes and the cost of changes is the highest on the project time curve.

## 3.3 **Controls**

In this section we will review the common control procedures used to minimize the effects of change orders. These include measures taken prior to the start of construction and before generation of change orders and measures taken to minimize impact of change orders after they have been generated.

1. Clarity of Change Order Procedures

Every project engineer must ask these questions before the kickoff meeting:

a) Are the procedures to handle changes clear to all parties?

b) Are the forms and instructions to complete them available?

c) Are the people responsible for approving, negotiating, and reviewing changes identified?

The clarity of these procedures at the beginning of the job will save a lot of time and effort.

2. Quick Approval

The time between recognizing the need to make a change and actually doing the change can be days or months. The longer the period between recognition and implementation, the more costly the change is. Because of the dynamics of construction projects, work impacted by changes increases as the project progresses to a more detailed phase. This control is quite important in large organizations or large projects and a multi-player environment.

3. Ability to Negotiate Changes

There are certain skills required to be able to negotiate change orders. Knowledge of contract terms, project details, technical background in the field, and negotiation skills are required to come to a successful agreement on change orders. Lack of any of these skills may complicate the negotiation and lead to disputes, delays or making the wrong decision.

4. Approval in Writing

Changes should not be made without approval in writing. It is difficult to prove the right for compensation if there is no authorization in writing from the owner. In the hectic environment of construction many verbal agreement can be forgotten leaving the contractor disarmed in the battle to get compensation for a change.

5. Change Order Scope

Like the original scope of a project, the scope for a change must be clearly defined. Affected drawings must be reviewed to insure the extent of construction or demolition and to see the effect of this change on other parts of the facility. This gets critical when working in a renovation project where there is a constant interface with existing structure.

6. Pricing of Indirect Effects

We have seen in our literature review that changes have direct as well as indirect effects on projects. Often indirect effects are not accounted for. In simple projects this might not be a problem. However indirect effects can be substantial in more complex projects. These effects include effects on labor productivity, additional bonding and

insurance, extra overhead expenses, shift of schedule to a less favorable period, etc. Pricing of change orders must consider these factors to come up with fair compensation.

7. Justification of Changes

Any change request must be carefully examined to insure there is enough justification. Knowing the problems associated with construction changes, the authority who approve change must insure a high benefit to cost ratio to proceed with the change. An extra effort must be exerted to determine the extent of the effect of a change on scope, cost, material, finance etc. before approval.

8. Review of Contract Documents

Owners and contractors must review contract terms and documents prior to bidding or award. In many instances, specific teams are formed to carry out this review. Improper use of change potential in the document can cost a lot. Special attention must be given to gray areas where different interpretation can arise. Clarifications shall be made as early as possible to the particular vague part of documents. In many cases, it was seen that unanswered question is carried over from the conceptual development of the project all the way to construction phase.

9. Freezing Design

Many owners consider this measure after feeling that the design has developed to a satisfactory level. This is quite effective in a large multi-departmental owner organization. In such a case each department may continue to request modification to the scope. By

using this scope control procedure, the owner is committing himself to a comprehensive review at early stages of the project.

10. Team Effort

Many researchers have concluded that team effort minimizes impact of changes. Encouraging teamwork is considered an effective control in change management. This approach requires that all parties (owner, contractor ,and consultant) work together to identify and implement project changes and openly share information on pricing and implementing of changes.

11. Use of WBS

As discussed in the literature review, an effective means of tracking the cost of change orders is the use of Work Breakdown Structure (WBS). This technique allows the project management to see the effects of a change happening in a certain work package on other work packages represented in the WBS tree.

# CHAPTER FOUR

# SURVEY QUESTIONNAIRE

## 4.1 Questionnaire Design

The questionnaire design took into consideration the objectives of the study as stated in section 1.3 with the aim to answer the research questions. Great effort and brainstorming went into designing the questionnaire. Meetings with members of the industry were conducted to identify the right questions required and to present them in a clear and an unambiguous format. Special care also went into phrasing the questions in a language that is easily understood by respondents. In anticipation that many respondents may not be fluent English readers or speakers, an Arabic version of the questionnaire was developed. The same effort was put into the Arabic version to present a clear and easy to understand format.

### 4.1.1 Contents of the Questionnaire

The questionnaire as shown in Appendix I is divided into six sections. The first section includes instructions to respondents defining the key terms in the study and providing respondents with instructions on completing the questionnaire.

The second section contains general information about the respondents such as contact address, company size, type etc.

The third section addresses the general industry characteristics such as size, experience, amount of change etc. Questions in the last two sections are posed in a multiple choice question format.

The fourth section addresses causes leading to change orders. A list of major causes of changes as read from the literature is presented and the respondent is asked to state the frequency of occurrence of these causes in his projects. Most frequent causes corresponds to ‘very often’ whereas the least frequent correspond to ‘never’ which denies existence of the condition as a cause. The causes were further grouped as owner originated, designer/consultant originated, contractor originated or others for ease of analysis. Respondents were given a chance to add other causes and rate them. A review of these causes is presented in section 3.1 above.

The fifth section addresses the possible effects of change orders. This list was developed from the literature review. A review of these effects is presented in section 3.2. Responses in this section are given on a 5-point scale starting with VERY OFTEN and ending with NEVER.

The last section in the questionnaire addresses the normally adopted controls of changes in the construction industry and the administrative procedures set to minimize their impact. A review of these controls is presented in section 3.3. Likewise, responses in this section are given on a 5-point scale.

### 4.1.2 The Statistical Sample

Four restrictions were imposed on the selection process of respondents:

1. Restricted to large projects (20 million SR or more)
2. Restricted to large contractors (Grade 2 or better as classified by the Chamber of Commerce)
3. Restricted to building projects (excluding industrial, highway, and other types of construction)
4. Restricted to Eastern Province of Saudi Arabia

With these restrictions in mind, the researcher targeted both populations i.e. all the list of contractors and consultants as presented in the Chamber of Commerce classification. This listing included forty two (42) contractors and forty one (41) consultants in the Eastern Province. This list is summarized in Appendices F & G.

The size of the sample required from each population was determined on the basis of statistical principles for this type of exploratory research. For such research, sample size was determined as follows (Farooq, 1997):

$$\mathbf{n_0 = (p*q)/ V^2} \quad \text{…….} \quad \mathbf{(1)}$$

$$\mathbf{n = n_0 / [\ 1+ (\ n_0 / N)]} \quad \text{……..} \quad \mathbf{(2)}$$

Where:

$\mathbf{n_0}$ : First estimate of sample size

**p** : The proportion of the characteristic being measured in the target population

**q** : Complement of ‘p’ or 1-p

**V** : The maximum standard error allowed

**N** : The population size

**n** : The sample size

To maximize n, p is set at 0.5. The target populations N are 42 and 41 for contractors and consultants respectively. To account for more error in qualitative answers of this questionnaire, maximum standard error V, is set at 10% or 0.1. Substituting in Equations 1 and 2 above, minimum required sample is calculated to be 15.67 and 15.53 for contractors and consultants respectively. This means that minimum sample size for each populations is 16.

### 4.1.3 **Gathering of Data**

Questionnaires were mailed to contractors and consultants and completed forms were requested to be mailed or faxed back to the researcher. The response to this request was poor and another approach of collecting data was used. This approach involved follow-up telephone calls and subsequent visits to consultants and contractors offices and work sites. The majority of the data was collected by this method. Forms were given to project managers or general managers to complete. Completed forms were either faxed to the researcher or collected later. In many instances, however, forms were completed at the meeting. This method has the added benefit of making clarifications to respondents about questions in the form. It also gave a chance to the researcher to explore further the change management practices and concerns. Over a period of three months after mailing the questionnaire and making contact with the contractors and consultants, the researcher collected 37 responses from which twenty (20) were contractors and seventeen (17) were consultants. This means a rate of response of 47% for contractors and 41% for consultants.

The raw data was edited for missing data, double entry answers and other ambiguities. Many respondents were called for corrections and clarifications. The questionnaires were separated between the two groups, consultants and contractors, and further coded for ease of entering the data.

To maintain the original 1:1 ratio between the original populations the researcher decided to use only 17 contractors' responses and all 17 consultants' responses. Back calculating the standard error in this survey as in equation 1 above, actual standard error is slightly less than the assumed 10%.

### 4.1.4 **Scoring**

The main sections of the questionnaire on causes, effects and controls use basically an ordinal scale. This ordinal scale does not offer in its qualitative 5 point scales a direct quantitative comparison between its intervals. This scale will be transformed into an interval scale by assigning a weight to each interval. So if we think of intervals from 'never' to 'very often' as an interval scale from zero to 100, we can achieve this transformation which will enable us to carry the required parametric statistics. As long as we keep alert of the "possibility of gross inequality of intervals" we can proceed with treating our 5 point scale as an interval scale and use parametric statistics. We can use the arithmetic mean as the measure of central tendency, standard deviation as the measure of dispersion and the F-test , t-test and other paramatric tests as the statistical procedures. (Cooper & Emory, 1995).

The questions in sections II and III of the questionnaire are either in ordinal scale or ratio scale. Ordinal scale questions will be transformed into interval scale as above. Ratio and interval scale questions will be used directly in the analysis.

No scoring will be used for questions in sections II and III of the questionnaire, since these sections contain general information and characteristics of the market.

Sections IV, V, and VI on causes, effects, and controls respectively will be scored as follows to come up with an Index to indicate its importance, or utilization as in the case of controls of each:

- ‘VERY OFTEN’ equals to one hundred percent (100%)
- ‘OFTEN’ equals to seventy five percent (75%)
- ‘SOMETIMES’ equals to fifty percent (50%)
- ‘SELDOM’ equals to twenty five percent (25%)
- ‘NEVER’ equals to zero percent (0%)

Importance Index, Prevalence Index, and Utilization Index of each cause, effect or control respectively will be calculated as follows:

$$II_{c1} = 100x_1 + 75\,x_2 + 50x_3 + 25x_4 + 0x_5 \;/\; (\,x_1 + x_2 + x_3 + x_4 + x_5\,)$$

Where:

II : Importance Index ( C1 denotes cause 1 in this case)

$X_1$ : Number of respondents answering (VERY OFTEN)

$X_2$ : Number of respondents answering (OFTEN)

$X_3$ : Number of respondents answering (SOMETIMES)

$X_4$ : Number of respondents answering (SELDOM)

$X_5$ : Number of respondents answering (NEVER)

Prevalence and Utilization Indices will be calculated in the same way. Causes, effects, and controls will be ranked on the basis of their indexes with the first rank assigned to the highest index.

CHAPTER FIVE

# RESULTS AND FINDINGS

In the analysis of obtained data, the same order used in the questionnaire will be followed. The first section will discuss the results on general information and the prevailing industry characteristics. These include size of companies working in this industry, their level of experience, and the extent of cost and schedule slippage. These features are thought to have bearing on the change orders magnitude and consequences. Understanding these features of the construction industry will help to better understand the settings of this study.

In the second section, data on causes of change orders will be analyzed. Minimum and maximum values, standard deviation, and Importance Indexes (II) will be reported for contractors and consultants and will be categorized per importance indexes and source of change order. The causes will be ranked based on their importance indexes.

In the third section, data on the effects of change orders will be analyzed. The effects will be categorized and ranked according to their Prevalence Indexes (PI).

In the fourth section, data on controls of change orders will be analyzed. We will look at the distribution of data and examine the basic statistics of controls. Utilization Indexes of the common controls will be calculated and compared among contractors and consultants.

The fifth section will test the hypothesis that ‘contractors and consultants do not agree on the causes of change orders’. Identical hypothesis for the level of agreement between contractors and consultants on the effects of change orders and the controls used in the industry.

Before we proceed with the analysis, it is worth noting that no major causes, controls, or effects, other than those listed in the questionnaire, were indicated by respondents. Almost all respondents interviewed agreed that listed causes, effects, and controls as in the questionnaire cover the subject well. Minor comments and suggested causes, effects, and controls were indicated by some respondents and documented in section 5.6.

## 5.1 General Information and Industry Characteristics

The general information section contains information on the size and level of experience of the contractors and consultants in the field of large building construction in Saudi Arabia. It has also information on the level of owner involvement, extent of cost and schedule overruns due to changes, and type of contract formats employed. Survey results on general characteristics in this section are presented in graphical representation.

The distributions of size and level of experience for contractors and consultants are shown on Figure 5.1.1 through Figure 5.1.4. Size of companies are categorized according to the number of employees as follow:

1. Very Large (more than 1000 employees)
2. Large (between 500 and 1000 employees)
3. Medium (between 200 and 500 employees)
4. Small (less than 200 employees)

As expected contractors are larger in size (number of employees) than consultants. As evident from Figure 5.1.2, most consultants companies (70%) have less than 200 employees whereas only 35% of the contractors have less than 200 employees.

The level of experience among participating contractors and consultants are classified as follows:

1. Very Long (more than 15 years)
2. Long (between 10 and 15 years)
3. Short (between 5 and 10 years)
4. Very Short (less than 5 years)

Over 50% of the contractors and about 60% of the consultants reported over 15 years of experience. None of the contractors and consultants participating in the survey has experience of less than 5 years.

**Figure 5.1.1: Size of Contractors**

y = 17 * 1 * normal (x, 2.588235, 1.277635)

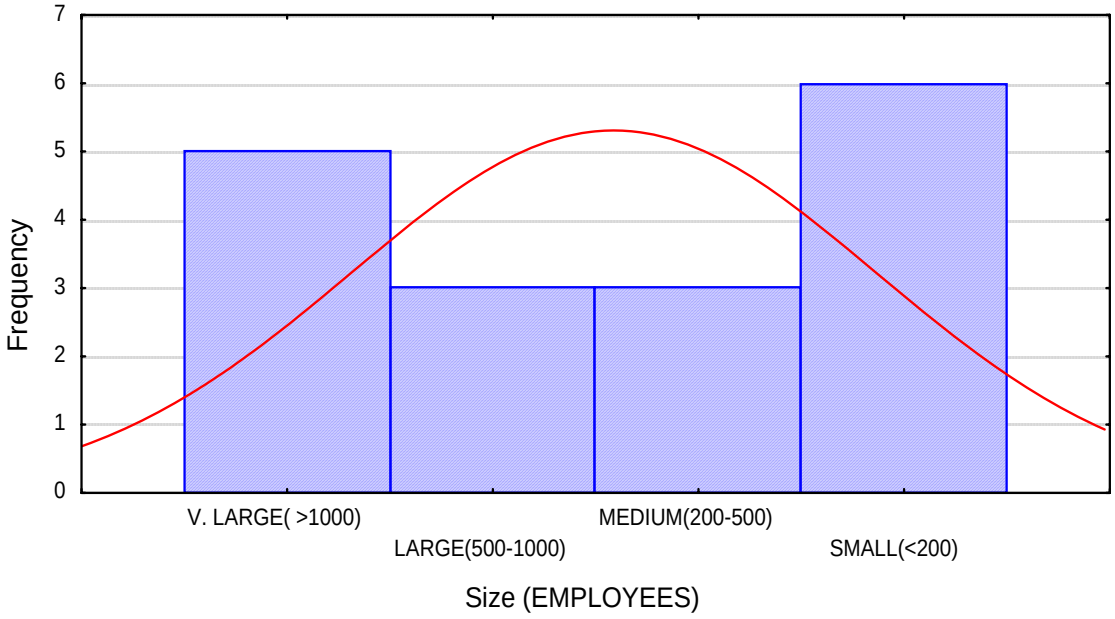



**Figure 5.1.2: Size of Consultants**

y = 17 * 1 * normal (x, 3.70588, 0.587868)

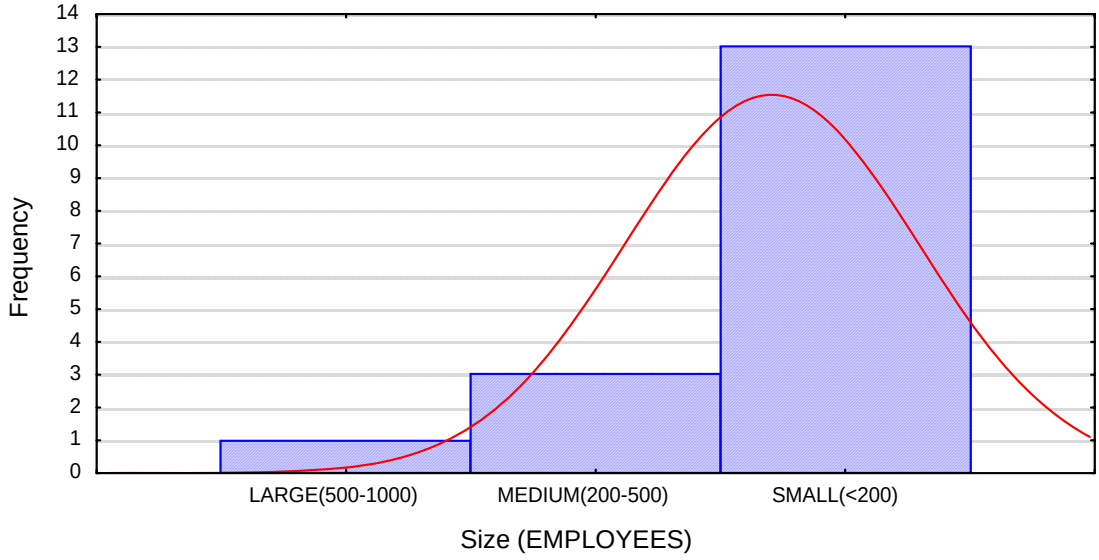


**Figure 5.1.3 : Experience of Contrcators**

y = 17 * 1 * normal (x, 1.764705, 0.903425)

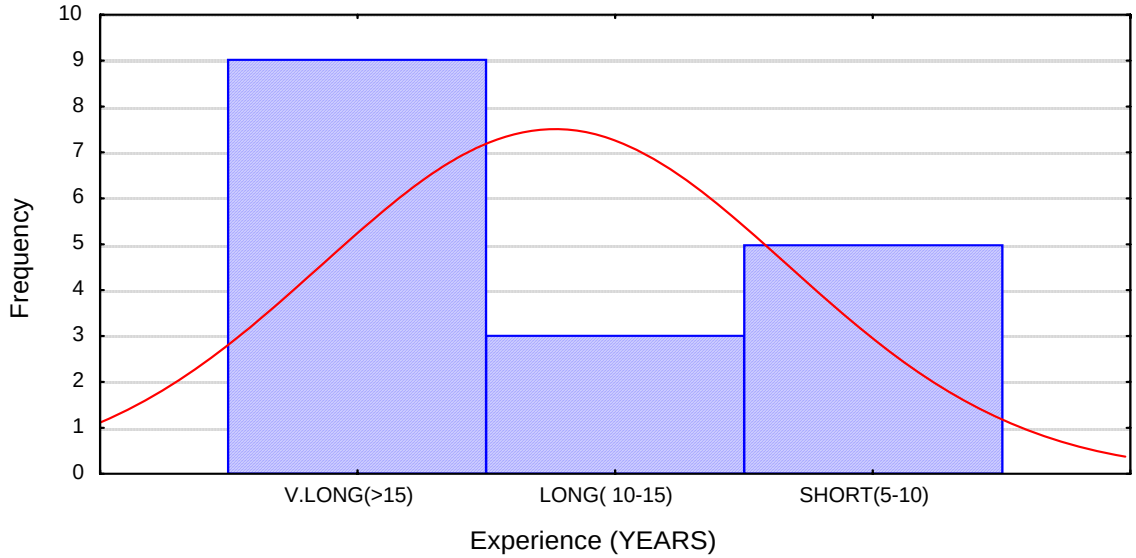



**Figure 5.1.4 : Experience of Consultants**

y = 17 * 1 * normal (x, 1.588235, 0.795206)

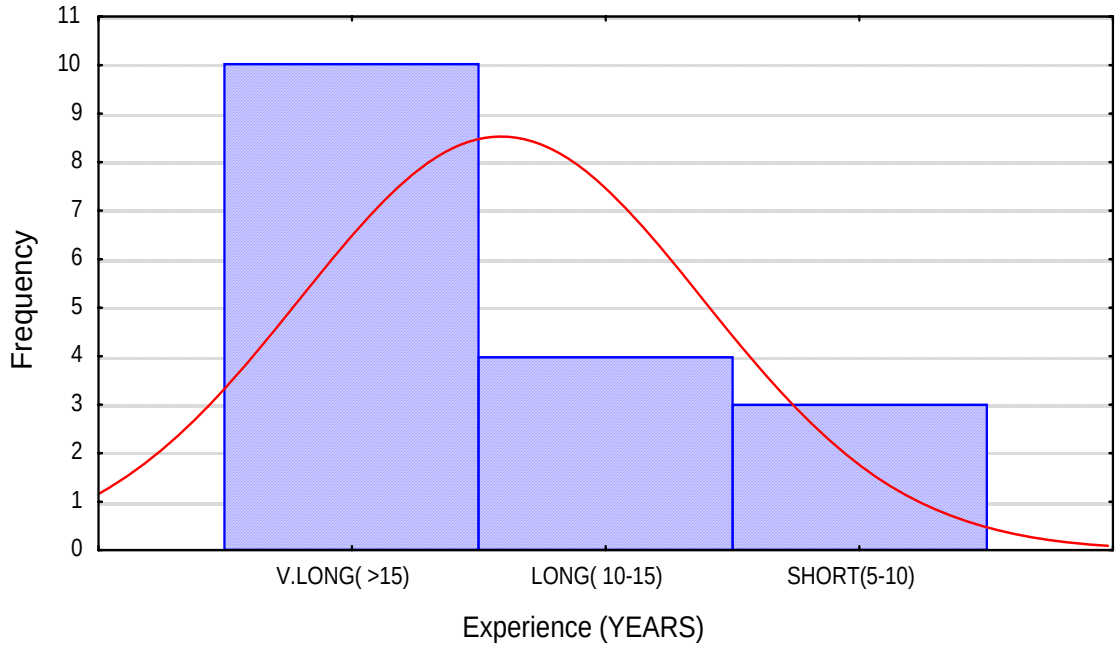


Figure 5.1.5 shows the distribution of contractors and consultants over the type of construction contract format. Survey questionnaire included five choices:

1. Lump Sum Turn Key (LSTK)
2. Cost Plus (c+)
3. Lump Sum for Labor ( LS-LBR)
4. Design and build (D&B)
5. Other Formats

65% of respondents said that construction contracts of their projects are lump sum turnkey type (LSTK). 18% indicated that construction contracts of their projects are lump sum for labor work only (LS-LBR). None of the respondents reported design and build (D&B) type contract.

**Figure 5.1.5 : Types of Contract**

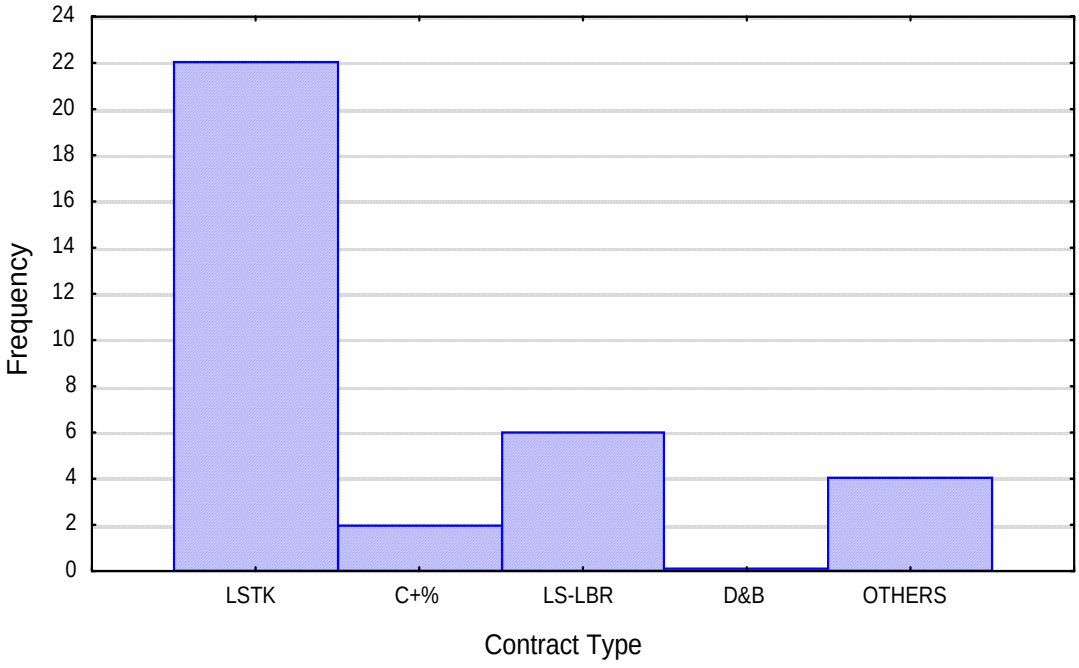


Figure 5.1.6 shows the distribution of change orders over the different construction crafts. As can be seen from the histogram, 21 out of 34 contractors and consultants (over 60%) indicated that civil/structural is the most change order generating craft in large-building construction. 23% of respondents said electrical is the most change order generating craft. These results are quite expected considering the nature of building projects.

**Figure 5.1.6 : Change Orders over Construction Crafts**

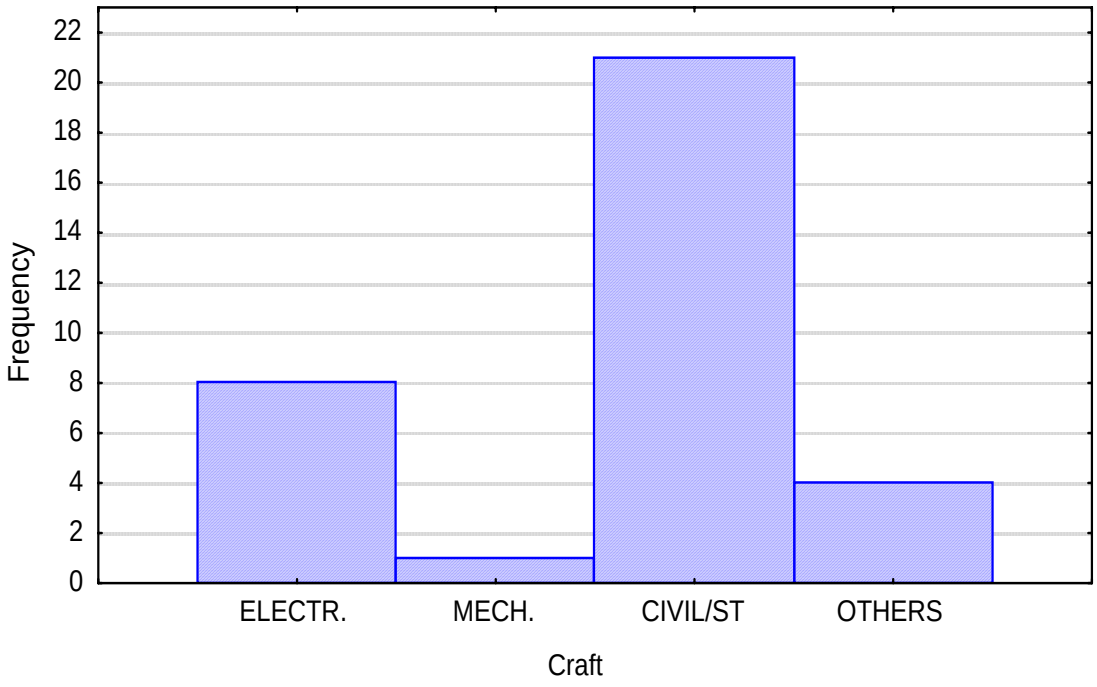


Figure 5.1.7 shows the histogram of the relation between the principal parties in the construction process, the owner, the contractor, and the consultant. 21 out of 34 or 61.8% have either excellent or very good relation with the other parties. Only 3 cases indicated a fair or poor relation among principal parties.

**Figure 5.1.7 : Relation of Principal Parties**

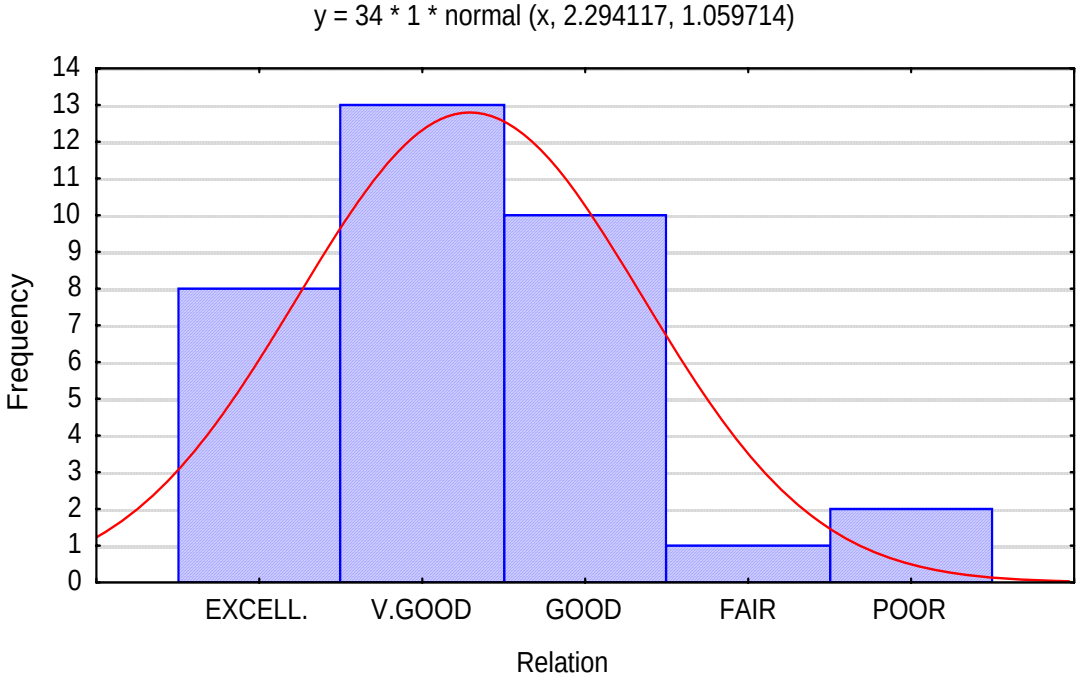


Figure 5.1.8 shows the histogram of involvement of owner in construction projects. The level of owner involvement is expressed in terms the stages he get involved in the process of design and construction of the project. 41.2% said that the owner gets involved in both design and construction stages. 21.6% said that the owner gets involved in the design stage only. 35.3% indicated that the owner gets involved in the construction stage only.

**Figure 5.1.8 : Involvement of Owner**

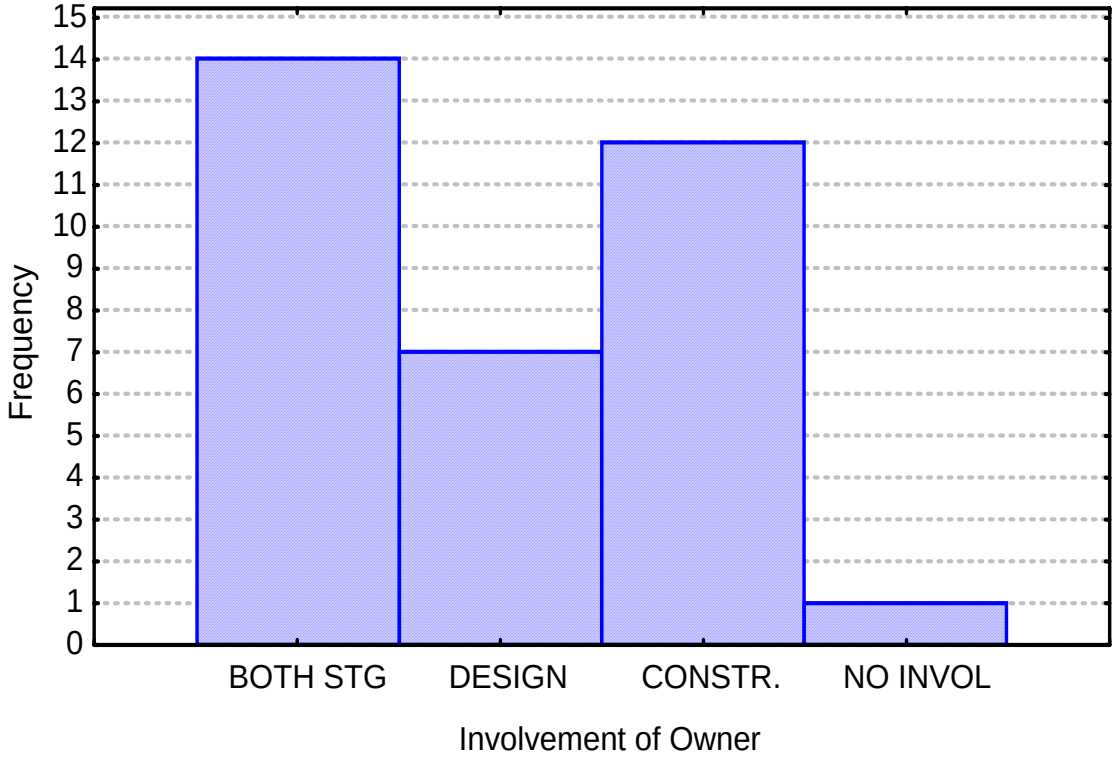


Figure 5.1.9 below shows the histogram of the percent increase in project cost due change orders. Cost overruns as a percentage of original contract value is classified as follows:

1. 0-5%
2. 6-10%
3. 11-15%
4. 16-20%
5. More than 20%

Over 50% of both contractors and consultants said the percent increase due to change orders is 6 to 10% of the total project cost. 26% reported a cost overrun between 11-15%

**Figure 5.1.9 : Increase in Cost Due to Change Orders**

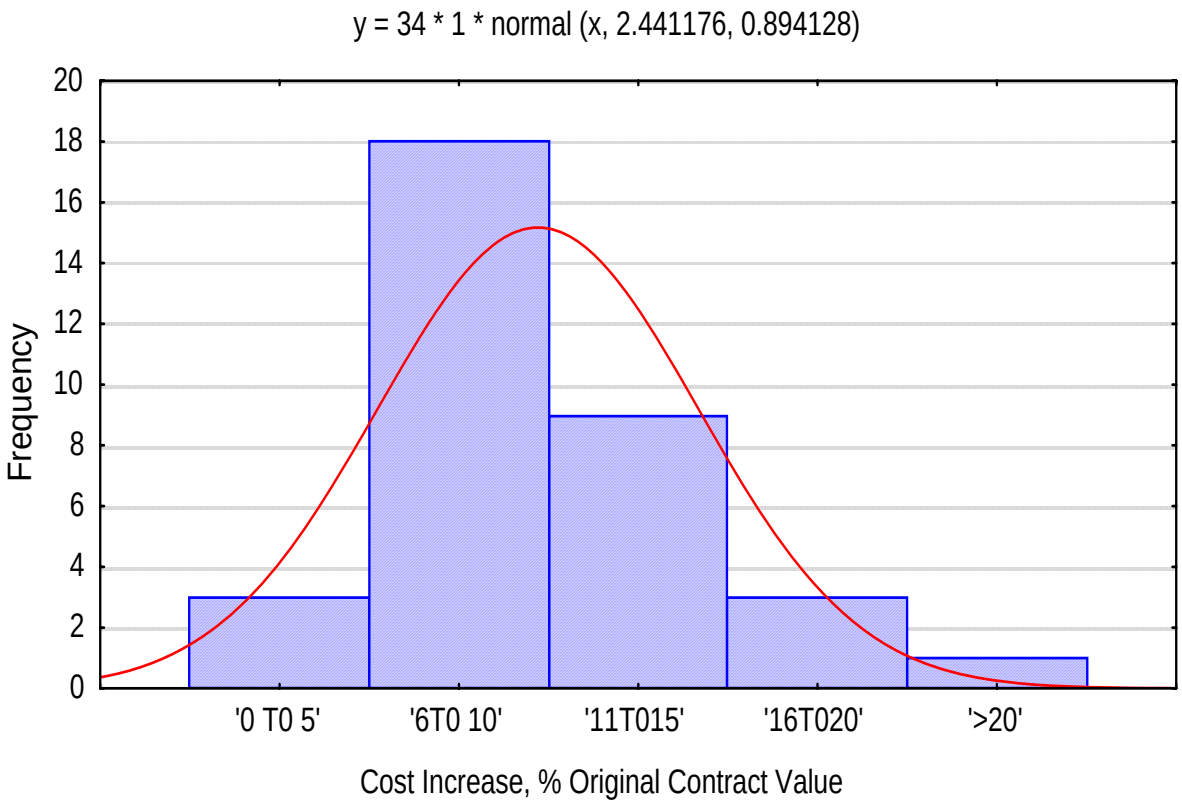


Figure 5.1.10 shows the percent increase in schedule due to change orders. Schedule overruns as a percentage of the original schedule are classified as follows:

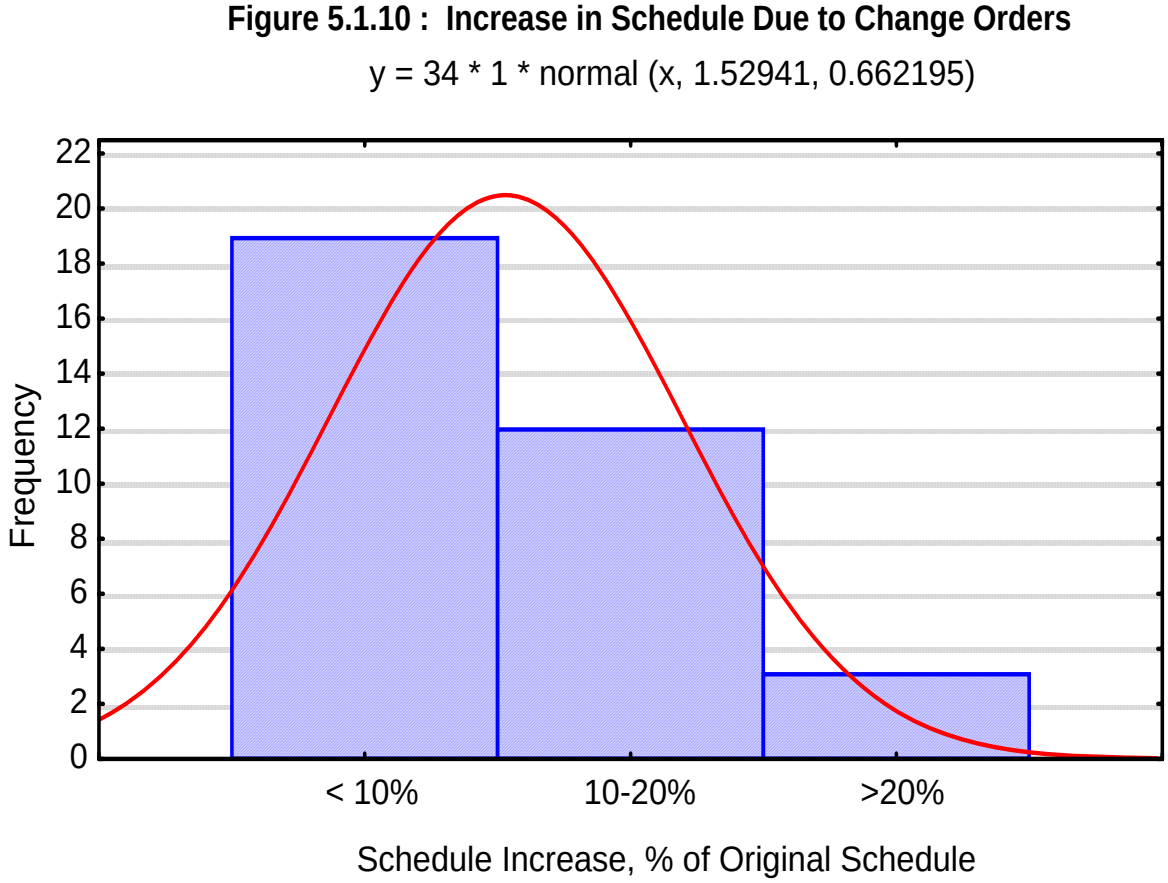
1. Less than 10%

1 Between 10% and 20%

3. More than 20%

Over 55% of the contractors and consultants said the percent increase is less than 10% of the original schedule. 35% said the schedule overrun is between 10 and 20% of the original schedule. Less than one percent said the increase is more than 20%.

**Figure 5.1.10 : Increase in Schedule Due to Change Orders**



## 5.2 Causes of Change Orders

The responses on the causes of change orders will be looked at from three different perspectives. First we will examine the data provided by contractors and that will be the basis for case selection. For these cases we will report minimum and maximum values and the standard deviation to see the dispersion of data. The Importance Index will be calculated as outlined in chapter four above. As discussed earlier we will also look at the categories of causes, owner generated, contractor generated, design or consultants generated, and other causes. Causes will be ranked and categorized based on the importance index reported.

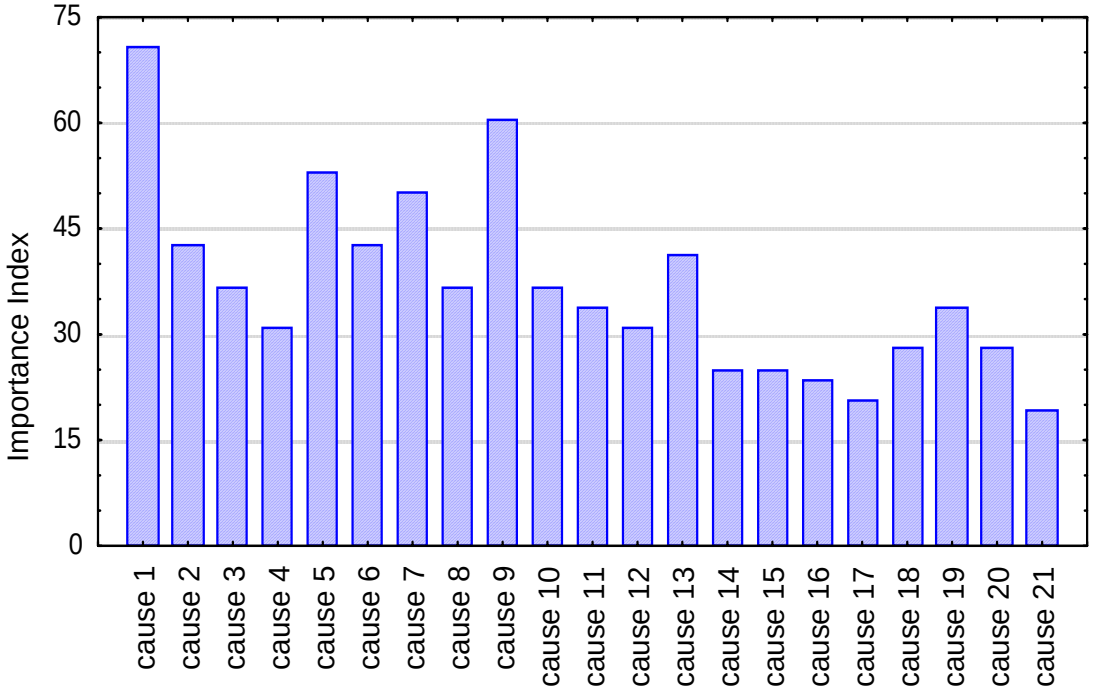
The same analysis will be carried out on data from consultants. Finally, overall data will be analyzed calculating importance indexes for the overall data and comparing data from contractors to that of consultants.

**a) Contractors:** Table 5.2.1 below lists the results of responses of contractors on the causes of change orders.

**Table 5.2.1: Importance Indexes of Causes – Contractor's View**

| Source or Cause of Change Order | Minimum | Maximum | Standard Deviation | Importance Index (II) |
|---|---|---|---|---|
| 1. Change of plans by owner | **0** | **100** | **26.86** | **70.59** |
| 2. Owner's financial problems | **0** | **75** | **26.18** | **42.65** |
| 3. Owner's change of schedule | **0** | **100** | **28.11** | **36.75** |
| 4. The objective of the project is not well defined | **0** | **75** | **22.58** | **30.88** |
| 5. Substitution of materials or procedures | **0** | **75** | **24.81** | **52.94** |
| 6. Conflict between contract documents | **25** | **100** | **24.63** | **42.65** |
| 7. Change in design by consultant | **0** | **75** | **12.5** | **50** |
| 8. The scope of work for the contractor is not well defined | **0** | **75** | **25.18** | **36.74** |
| 9. Errors and omissions in design | **0** | **100** | **26.60** | **60.29** |
| 10. The lack of coordination between contractor and consultant | **0** | **100** | **26.69** | **36.75** |
| 11. Value engineering | **0** | **75** | **23.29** | **33.82** |
| 12. Technology changes | **0** | **50** | **16.60** | **30.88** |
| 13. Differing site conditions | **0** | **100** | **26.43** | **41.17** |
| 14. Contractor's desire to improve his financial situation | **0** | **75** | **26.52** | **25** |
| 15. The contractor's financial difficulties | **0** | **75** | **26.52** | **25** |
| 16. The required labor skills are not available | **0** | **50** | **20.67** | **23.53** |
| 17. The required equipment and tools are not available | **0** | **50** | **20.22** | **20.59** |
| 18. Workmanship or material not meeting the specifications | **0** | **75** | **24.81** | **27.94** |
| 19. Safety considerations | **0** | **100** | **26.43** | **33.82** |
| 20. Weather conditions | **0** | **75** | **24.81** | **27.94** |
| 21. New government regulations | **0** | **50** | **20.78** | **19.12** |

**Figure 5.2.1 : Importance Indexes for Causes - Contractors' View**




The results in table 5.2.1 are depicted graphically on Figure 5.2.1. It is apparent that contractors rank cause no.1 " change of plans and scope by owner" as the prime cause of change orders in the large building construction. Causes in Figure 5.2.1 and other figures are numbered as in Table 5.2.1 above and as defined in section 3.1.

Now, if we list the five most common causes of change orders from the contractor's point of view, we have the following list starting with the most important:

1. Change of plans by owner.
2. Errors and omissions in design.
3. Change in design by consultant.
4. Substitution of materials or procedures.

5. Owner's financial problems and conflict between contract documents (both having the same index)

It might be noted that all these causes are originated either by the owner or by the designer/consultant. This is expected since each party is trying to blame the other for causing changes in construction. If we want to compare the strength or the importance of each category, we may do so by finding the mean value of the causes that compose this category. The results of this calculation are tabulated below:

**Table 5.2.2: Importance Indexes Categorized – Contractors**

| Category | Importance index |
|---|---|
| Owner originated ( 1-5) | **46.76** |
| Designer originated (6-12) | **41.59** |
| Contractor originated(13-18) | **27.21** |
| Miscellaneous (19-21) | **26.96** |

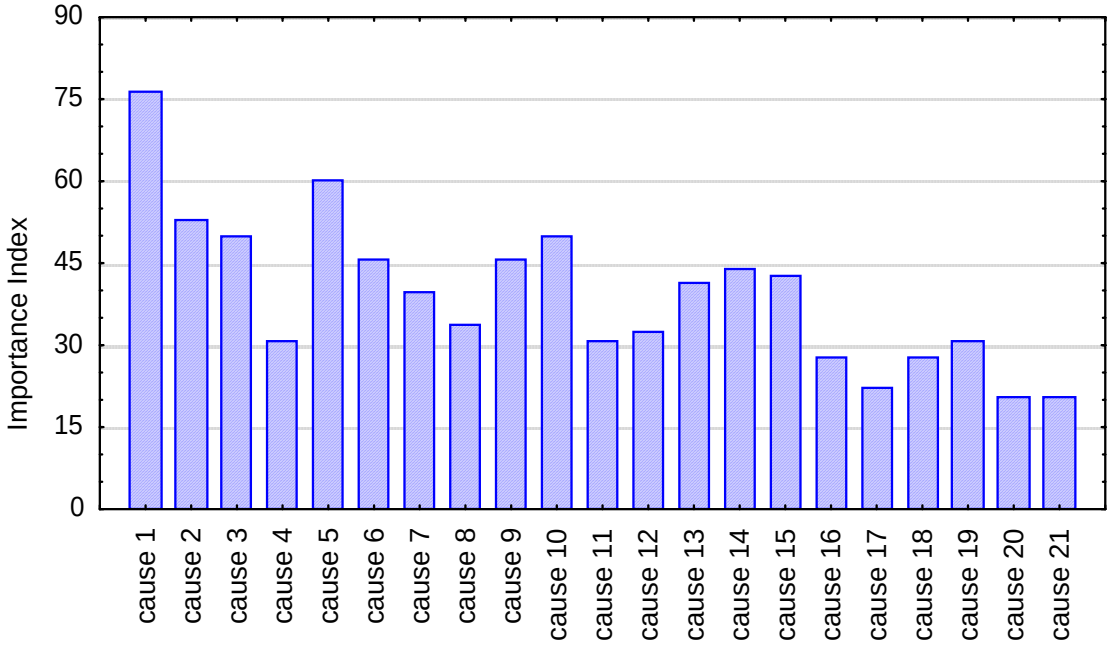
It is worth noting that the data from the 17 contractors is widely dispersed and reflects differing opinions about the importance of each cause. This wide dispersion is clearly reflected by the high standard deviation (variance) values calculated in table 5.2.1 above. From table 5.2.1 above we can observe also that the significance index given to many causes are less than 50% indicating a frequency of less than 'sometimes' or actually happens only rarely or never at all. This might be due to the difficulty in assigning a number to a qualitative response. Trends here are more important than the numerical value.

b) **Consultants**: Table 5.2.3 below lists the results of the survey from 17 consultant firms in the field of large building construction projects. Figure 5.2.2 below is a histogram of the importance indexes of these causes.

**Table 5.2.3: Importance Indexes of Causes – Consultants' View**

| Source or Cause of Change Order | Minimum | Maximum | Standard Deviation | Importance Index (II) |
|---|---|---|---|---|
| 1. Change of plans by owner | **25** | **100** | **25.72** | **76.47** |
| 2. Owner's financial problems | **25** | **100** | **17.41** | **52.94** |
| 3. Owner's change of schedule | **25** | **100** | **23.38** | **50** |
| 4. The objective of the project is not well defined | **0** | **75** | **24.25** | **30.88** |
| 5. Substitution of materials or procedures | **25** | **75** | **15.46** | **60.29** |
| 6. Conflict between contract documents | **0** | **100** | **23.77** | **45.59** |
| 7. Change in design by consultant | **0** | **75** | **19.88** | **39.70** |
| 8. The scope of work for the contractor is not well defined | **0** | **75** | **23.29** | **33.82** |
| 9. Errors and omissions in design | **0** | **75** | **18.19** | **45.59** |
| 10. The lack of coordination between contractor and consultant | **0** | **100** | **23.38** | **50** |
| 11. Value engineering | **0** | **75** | **18.81** | **30.88** |
| 12. Technology changes | **0** | **50** | **17.15** | **32.35** |
| 13. Differing site conditions | **0** | **75** | **21.54** | **41.18** |
| 14. Contractor's desire to improve his financial situation | **0** | **100** | **31.29** | **44.11** |
| 15. The contractor's financial difficulties | **0** | **75** | **22.99** | **42.65** |
| 16. The required labor skills are not available | **0** | **75** | **26.34** | **27.94** |
| 17. The required equipment and tools are not available | **0** | **50** | **19.53** | **22.05** |
| 18. Workmanship or material not meeting the specifications | **0** | **50** | **21.44** | **27.94** |
| 19. Safety consideration | **0** | **75** | **22.58** | **30.88** |
| 20. Weather conditions | **0** | **50** | **18.19** | **20.59** |
| 21. New government regulations | **0** | **50** | **18.19** | **20.59** |

**Figure 5.2.2 : Importance Index of Causes- Consultants' View**




If we carry out the same exercise we did for contractor data, we can list the five most important causes from the point view of consultants as follows:

1. Change of plans by owner.
2. Substitution of materials or procedures.
3. Owner's financial problems.
4. Owner change of schedule.
5. Lack of coordination between contractor and consultant.

Owner's change of plans and scope remains most predominant. Consultants scored change of schedule by owner and lack of coordination among the first five top causes of change orders. Four out of five of these causes are attributed to the owner, hence the owner still receives most of the blame. The importance index of each category is tabulated below:

**Table 5.2.4: Importance Indexes Categorized - Consultants**

| Category | Importance Index |
|---|---|
| Owner originated ( 1-5) | **54.12** |
| Designer originated (6-12) | **39.70** |
| Contractor originated(13-18) | **34.31** |
| Miscellaneous (19-21) | **24.02** |

Comparing the data in this table to that of Table 5.2.2 for contractors, it can be seen that consultants placed more blame on owners and on contractors but less on themselves.

c) **Overall**: Table 5.2.5 lists the results of the survey for both contractors and consultants.

**Table 5.2.5: Importance Indexes of Causes - Overall**

| Source or Cause of Change Order | Minimum | Maximum | Standard Deviation | Importance Index (II) |
|---|---|---|---|---|
| 1. Change of plans by owner | **0** | **100** | **26.07** | **73.53** |
| 2. Owner's financial problems | **0** | **100** | **22.50** | **47.79** |
| 3. Owner's change of schedule | **0** | **100** | **26.33** | **43.38** |
| 4. The objective of the project is not well defined | **0** | **75** | **23.08** | **30.88** |
| 5. Substitution of materials or procedures | **0** | **75** | **20.70** | **56.62** |
| 6. Conflict between contract documents | **0** | **100** | **23.88** | **44.11** |
| 7. Change in design by consultant | **0** | **75** | **17.16** | **44.85** |
| 8. The scope of work for the contractor is not well defined | **0** | **75** | **23.93** | **35.29** |
| 9. Errors and omissions in design | **0** | **100** | **23.65** | **52.94** |
| 10. The lack of coordination between contractor and consultant | **0** | **100** | **25.60** | **43.38** |
| 11. Value engineering | **0** | **75** | **20.90** | **32.35** |
| 12. Technology changes | **0** | **50** | **16.64** | **31.62** |
| 13. Differing site conditions | **0** | **100** | **23.74** | **41.18** |
| 14. Contractor's desire to improve his financial situation | **0** | **100** | **30.16** | **34.56** |
| 15. The contractor's financial difficulties | **0** | **75** | **26.03** | **33.82** |
| 16. The required labor skills are not available | **0** | **75** | **23.42** | **25.73** |
| 17. The required equipment and tools are not available | **0** | **50** | **19.59** | **21.32** |
| 18. Workmanship or material not meeting the specifications | **0** | **75** | **22.83** | **27.94** |
| 19. Safety considerations | **0** | **100** | **24.25** | **32.35** |
| 20. Weather conditions | **0** | **75** | **21.75** | **24.26** |
| 21. New government regulations | **0** | **50** | **19.25** | **19.85** |

The ranking of the different causes or sources of change orders based on importance indexes is presented in Table 5.2.6 below for contractors, consultants as well as the overall ranking.

**Table 5.2.6: Ranking of Causes of Change Orders**

| Source or Cause of Change Order | Ranking By Consultants | Ranking By Contractors | Overall Ranking |
|---|---|---|---|
| 1. Change of plans by owner | **1** | **1** | **1** |
| 2. Owner's financial problems | **3** | **5** | **4** |
| 3. Owner's change of schedule | **4** | **7** | **7** |
| 4. The objective of the project is not well defined | **11** | **10** | **14** |
| 5. Substitution of materials or procedures | **2** | **3** | **2** |
| 6. Conflict between contract documents | **5** | **5** | **6** |
| 7. Change in design by consultant | **9** | **4** | **5** |
| 8. The scope of work for the contractor is not well defined | **10** | **8** | **9** |
| 9. Errors and omissions in design | **5** | **2** | **3** |
| 10. The lack of coordination between contractor and consultant | **4** | **7** | **7** |
| 11. Value engineering | **12** | **9** | **12** |
| 12. Technology changes | **11** | **10** | **13** |
| 13. Differing site conditions | **8** | **6** | **8** |
| 14. Contractor's desire to improve his financial situation | **6** | **12** | **10** |
| 15. The contractor's financial difficulties | **7** | **12** | **11** |
| 16. The required labor skills are not available | **13** | **13** | **16** |
| 17. The required equipment and tools are not available | **14** | **14** | **18** |
| 18. Workmanship or material not meeting the specifications | **13** | **11** | **15** |
| 19. Safety consideration | **12** | **9** | **12** |
| 20. Weather conditions | **15** | **11** | **17** |
| 21. New government regulations | **15** | **15** | **19** |

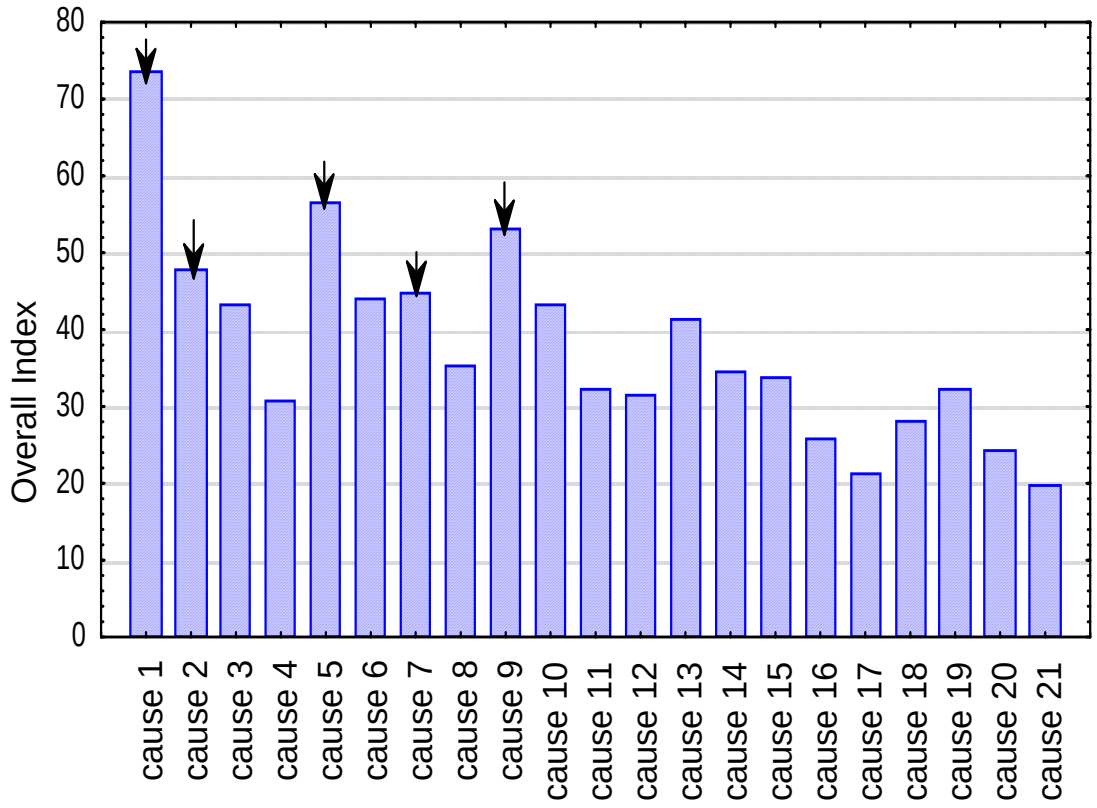
The overall ranking of the top five causes of changes among all contractors and consultants is as follows:

1. Change of plans by owner.
2. Substitution of materials and procedures.

3. Errors and omissions in design.
4. Owner's financial problems.
5. Change in design by consultant.

Figure 5.2.3 below is a histogram of the overall importance index of causes of change orders as summarized in table 5.2.5.

**Figure 5.2.3 : Importance Indexes of Causes - Overall**



If we construct a table of the distribution of the overall Importance Indexes categorized as either owner-originated, consultant-originated, or contractor-originated, we get the following:

**Table 5.2.7: Categorized Importance Indexes of Causes - Overall**

| Category | Importance Index |
|---|---|
| Owner originated (1-5) | **50.44** |
| Designer originated (6-12) | **40.65** |
| Contractor originated (13-18) | **30.76** |
| Miscellaneous (19-21) | **25.49** |

Hence, both contractors and consultants believe that the owner is the major source of changes in large building projects. The importance indexes are further categorized in Table 5.2.8 and Figure 5.2.4 below. Data was divided into four categories. Those are:

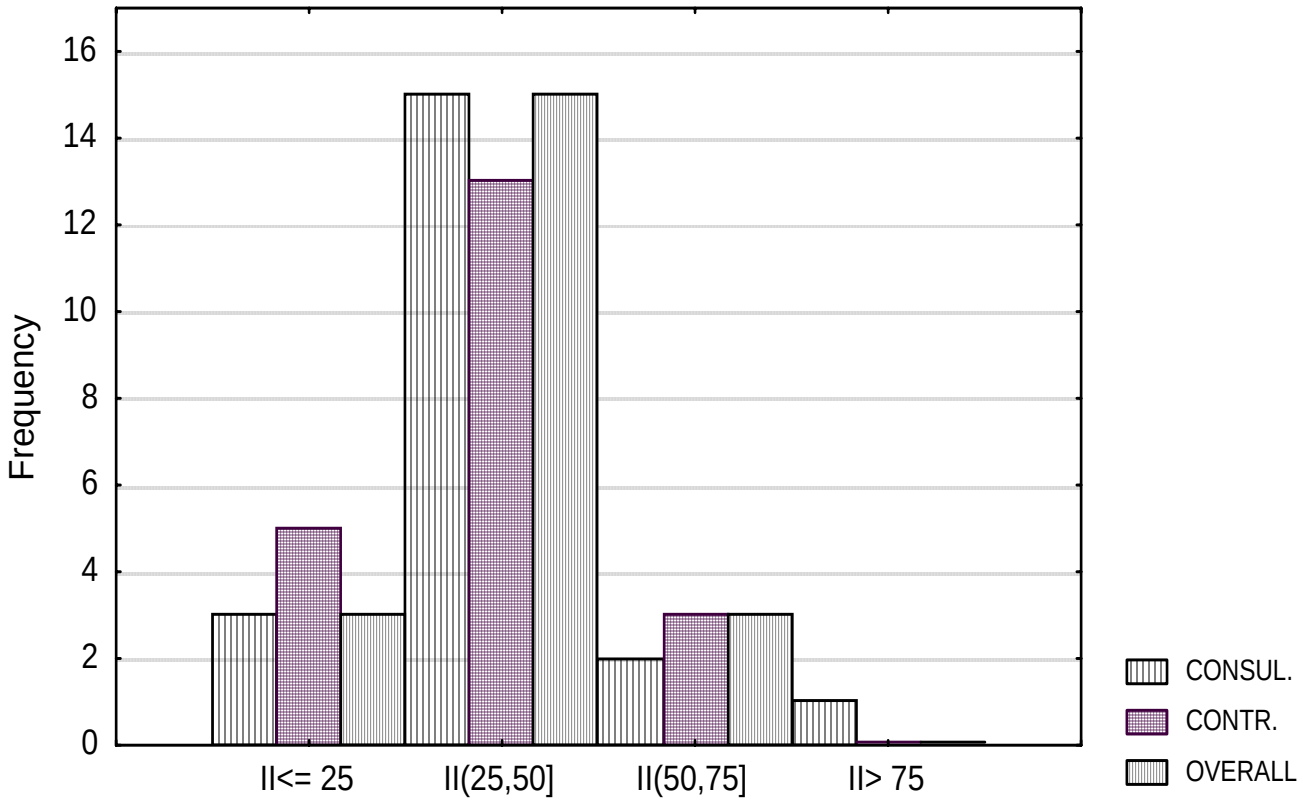
1. Importance Index larger than 75
2. Importance Index between 50 and 75
3. Importance Index between 25 and 50
4. Importance Index less than 25

As evident from Table 5.2.8 and Figure 5.2.4, no causes scored higher than 75 and that the majority of causes have importance indexes between 25 and 50. The first three important causes scored in the first category. The majority of the causes fall in the category 25-49.

**Table 5.2.8: Categories of Overall Importance Indexes**

| Source or Cause of Change Order | Minimum | Maximum | Standard Deviation | Importance Index (II) |
|---|---|---|---|---|
| 1. Change of plans by owner | **0** | **100** | **26.07** | **50-75** |
| 2. Substitution of materials or procedures | **0** | **75** | **20.70** | |
| 3. Errors and omissions in design | **0** | **100** | **23.65** | |
| 4. Owner's financial problems | **0** | **100** | **22.50** | **25-49** |
| 5. Change in design by consultant | **0** | **75** | **17.16** | |
| 6. Conflict between contract documents | **0** | **100** | **23.88** | |
| 7. Owner's change of schedule | **0** | **100** | **26.33** | |
| 8. The lack of coordination between contractor and consultant | **0** | **100** | **25.60** | |
| 9. Differing site conditions | **0** | **100** | **23.74** | |
| 10. The scope of work for the contractor is not well defined | **0** | **75** | **23.93** | |
| 11. Contractor's desire to improve his financial situation | **0** | **100** | **30.16** | |
| 12. The contractor's financial difficulties | **0** | **75** | **26.03** | |
| 13. Value engineering | **0** | **75** | **20.90** | |
| 14. Safety considerations | **0** | **100** | **24.25** | |
| 15. Technology changes | **0** | **50** | **16.64** | |
| 16. The objective of the project is not well defined | **0** | **75** | **23.08** | |
| 17. Workmanship or material not meeting the specifications | **0** | **75** | **22.83** | |
| 18. The required labor skills are not available | **0** | **75** | **23.42** | |
| 19. Weather conditions | **0** | **75** | **21.75** | **Less than 25** |
| 20. The required equipment and tools are not available | **0** | **50** | **19.59** | |
| 21. New government regulations | **0** | **50** | **19.25** | |

Figure 5.2.4: Categorized Importance Indexes



## 5.3 Effects of Change Orders

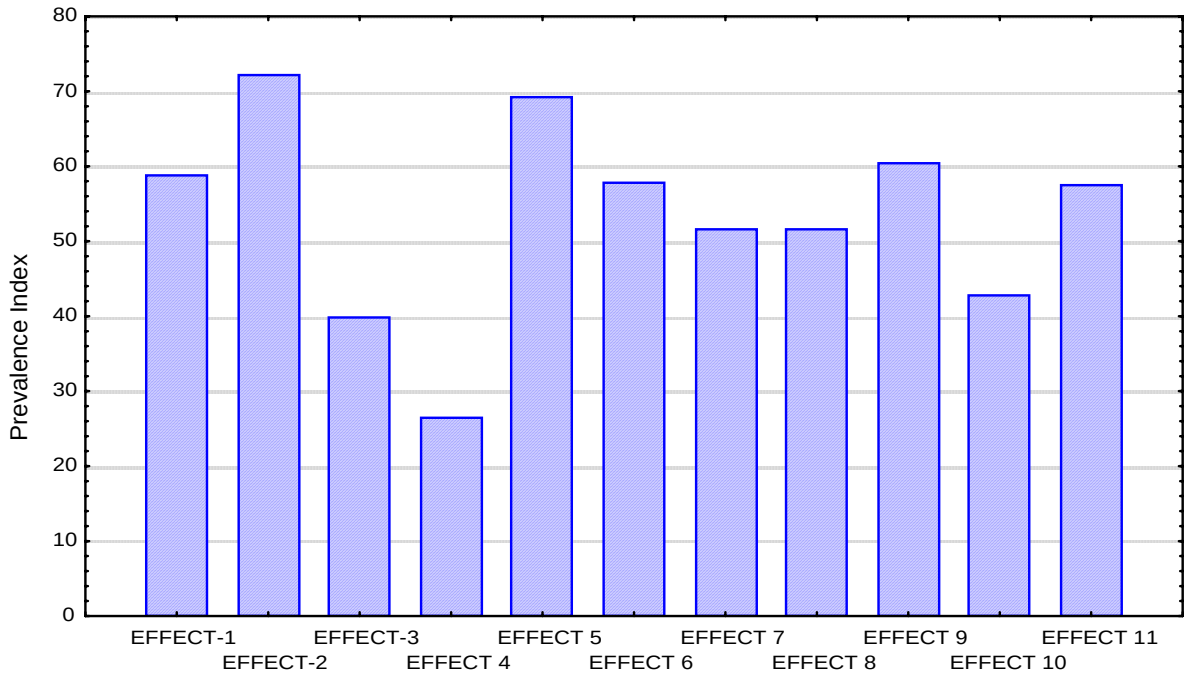
In this section we will examine the overall response on the effects of change orders in large building projects in Saudi Arabia.

a) **Contractors**: Table 5.3.1 below summarizes the results of responses of 17 contractors who participated in the survey on the effects of change orders on their large building projects. The data is still widely dispersed reflecting the wide variation of opinion. However the mean values or the indexes are generally higher than those given to causes in the previous section. The data in Table 5.3.1 is represented graphically in Figure 5.3.1 below.

**Table 5.3.1: Prevalence Indexes of Effects – Contractor's View**

| Effect of Change Order | Minimum | Maximum | Standard Deviation | Prevalence Index ( PI ) |
|---|---|---|---|---|
| 1. Decrease in productivity | **0** | **100** | **33.00** | **58.82** |
| 2. Delay in completion schedule | **25** | **100** | **23.19** | **72.06** |
| 3. Dispute between owner and contractor | **0** | **100** | **26.60** | **39.71** |
| 4. Decrease in quality of work | **0** | **75** | **20.67** | **26.47** |
| 5. Increase in project cost | **25** | **100** | **20.78** | **69.12** |
| 6. Additional revenue for contractor | **25** | **100** | **21.83** | **57.81** |
| 7. Delay of material and tools | **25** | **75** | **10.72** | **51.47** |
| 8. Work on hold in other areas | **0** | **100** | **24.16** | **51.47** |
| 9. Increase in contractor's overhead | **0** | **100** | **23.48** | **60.29** |
| 10. Demolition and re-work | **25** | **100** | **24.63** | **57.35** |
| 11. Delays in payment to contractor | **0** | **75** | **27.62** | **42.65** |

**Figure 5.3.1: Prevalence Indexes of Effects - Contractors**




From the contractors' point of view, the top five effects (prevalence) of change orders in their large building projects listed in descending order are:

1. Delay in completion schedule.
2. Increase in project cost.
3. Increase in contractor's overheads.
4. Decrease in productivity of workers.
5. Additional revenue for contractors.

b) **Consultants:** Table 5.5 below shows the results of the responses of 17 consultants on the effects of change orders on their large building construction projects.

**Table 5.3.2: Prevalence Indexes of Effects - Consultants**

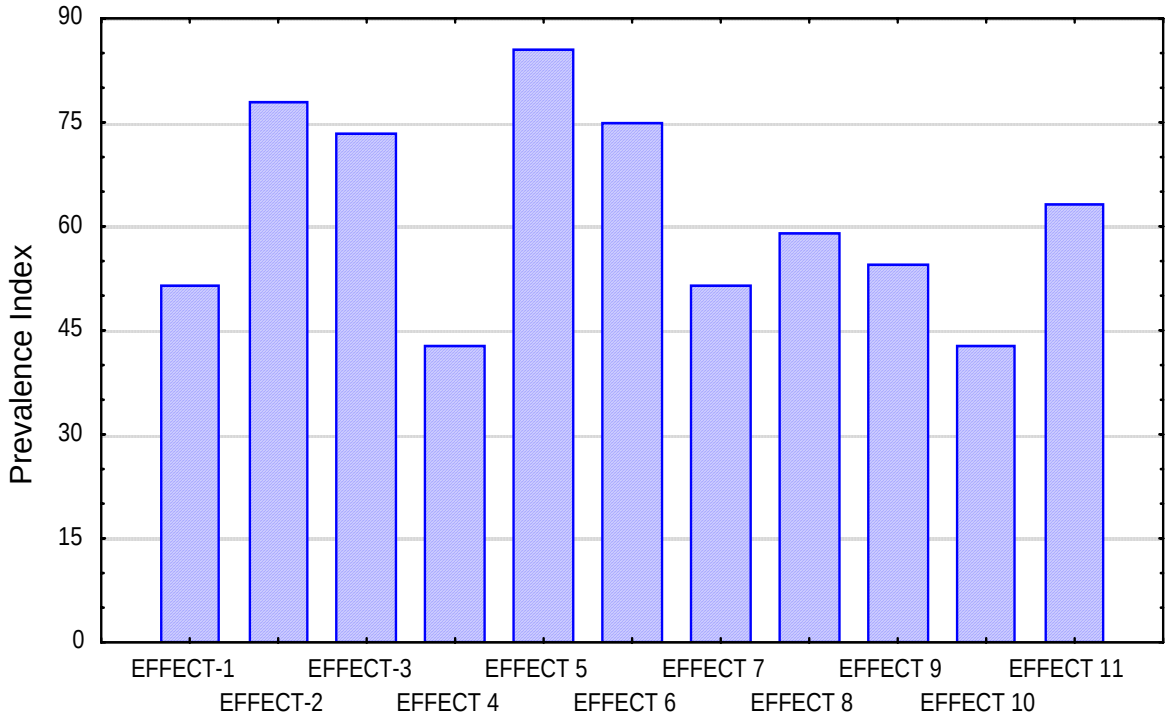
| Effect of Change Order | Minimum | Maximum | Standard Deviation | Prevalence Index ( PI ) |
|---|---|---|---|---|
| 1. Decrease in productivity | **0** | **100** | **31.21** | **51.47** |
| 2. Delay in completion schedule | **25** | **100** | **21.44** | **77.94** |
| 3. Dispute between owner and contractor | **50** | **100** | **20.67** | **73.53** |
| 4. Decrease in quality of work | **0** | **75** | **26.17** | **42.65** |
| 5. Increase in project cost | **50** | **100** | **17.81** | **85.29** |
| 6. Additional revenue for contractor | **25** | **100** | **23.39** | **75** |
| 7. Delay of material and tools | **0** | **75** | **20.67** | **51.47** |
| 8. Work on hold in other areas | **25** | **75** | **15.16** | **58.82** |
| 9. Increase in contractor's overheads | **25** | **75** | **18.19** | **54.41** |
| 10. Delays in payment to contractor | **0** | **100** | **27.62** | **42.65** |
| 11. Demolition and re-work | **25** | **100** | **19.99** | **63.23** |

From the consultants' point of view, the top five effects (prevalence) of change orders on their large building projects listed in descending order are:

1. Increase in project cost.
2. Delay in completion schedule.
3. Additional revenue for contractors.
4. Dispute between contractors and owners.
5. Demolition and re-work.

We might also note here that importance indexes reported by consultants are generally higher than those reported by contractors. This means that consultants consider these effects more prevalent than the contractors. Figure 5.3.2 below gives a clearer picture of the distribution of prevalence indexes of effects of changes in large building projects as seen by consultants:

**Figure 5.3.2: Prevalence Indexes of Effects - Consultants**



c) **Overall**: Table 5.3.3 shows the overall results of the survey of responses on effects of change orders in large building construction considering both contractors and consultants.

**Table 5.3.3: Prevalence Indexes of Effects - Overall**

| Effect of Change Order | Minimum | Maximum | Standard Deviation | Prevalence Index ( PI ) |
|---|---|---|---|---|
| 1. Decrease in productivity | **0** | **100** | **31.85** | **55.15** |
| 2. Delay in completion schedule | **25** | **100** | **22.19** | **75** |
| 3. Dispute between owner and contractor | **0** | **100** | **29.07** | **56.62** |
| 4. Decrease in quality of work | **0** | **75** | **24.63** | **34.56** |
| 5. Increase in project cost | **25** | **100** | **20.75** | **77.21** |
| 6. Additional revenue for contractor | **25** | **100** | **23.93** | **66.67** |
| 7. Delay of material and tools | **0** | **75** | **16.21** | **51.47** |
| 8. Work on hold in other areas | **0** | **100** | **20.21** | **55.15** |
| 9. Increase in contractor's overheads | **0** | **100** | **20.90** | **57.35** |
| 10. Delays in payment to contractor | **0** | **100** | **27.20** | **42.65** |
| 11. Demolition and re-work | **25** | **100** | **22.29** | **60.29** |

Listing the five most prevalent effects from the above table, we find the following:

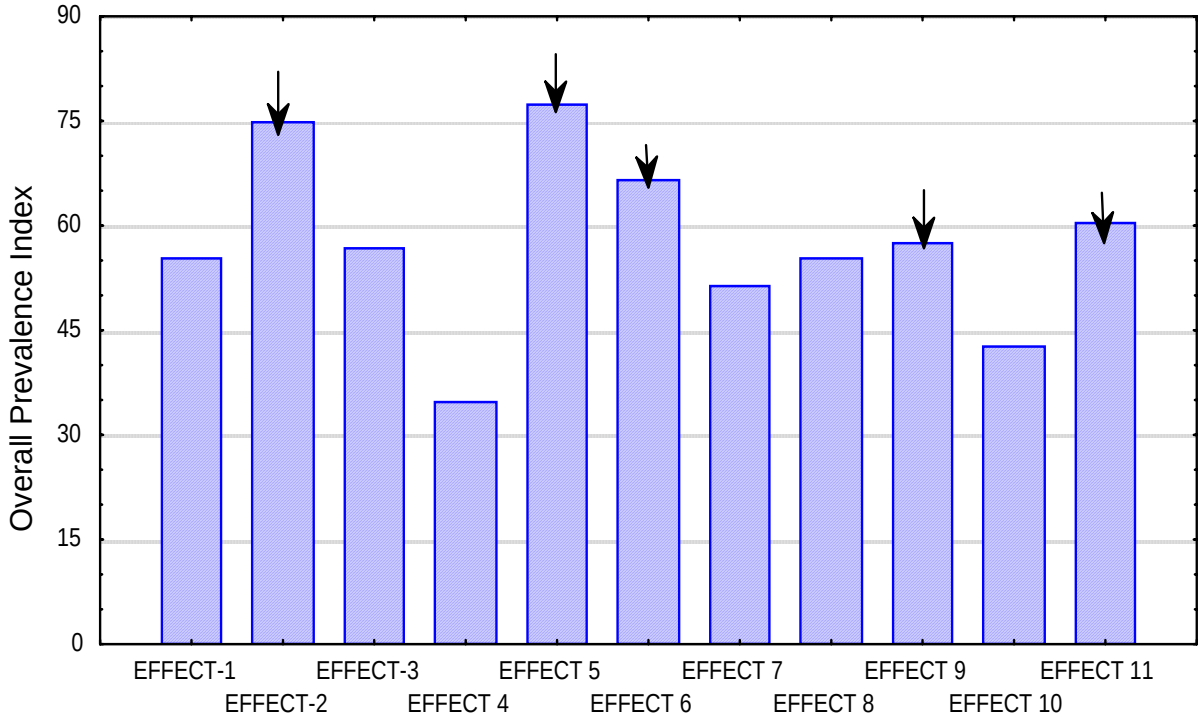
1. Increase in project cost.
2. Delay in completion schedule.
3. Additional revenue for contractors.
4. Demolition and re-work.
5. Increase in contractor's overheads.

The overall prevalence index of effects of change orders in the large building construction projects is shown in Figure 5.3.3 below. The five most prevalent effects are highlighted.

**Table 5.3.4: Categorized Overall Prevalence Indexes**

| Effect of Change Order | Minimum | Maximum | Standard Deviation | Prevalence Index ( PI ) |
|---|---|---|---|---|
| 1. Increase in project cost | 25 | 100 | 20.75 | > 75 |
| 2. Delay in completion schedule | 25 | 100 | 22.19 | 50-75 |
| 3. Additional revenue for contractor | 25 | 100 | 23.93 | |
| 4. Demolition and re-work | 25 | 100 | 22.29 | |
| 5. Increase in contractor's overheads | 0 | 100 | 20.90 | |
| 6. Dispute between owner and contractor | 0 | 100 | 29.07 | |
| 7. Decrease in productivity | 0 | 100 | 31.85 | |
| 8. Work on hold in other areas | 0 | 100 | 20.21 | |
| 9. Delay of material and tools | 0 | 75 | 16.21 | |
| 10. Delays in payment to contractor | 0 | 100 | 27.20 | <50 |
| 11. Decrease in quality of work | 0 | 75 | 24.63 | |

**Figure 5.3.3 : Prevalence Index of Effects - Overall**

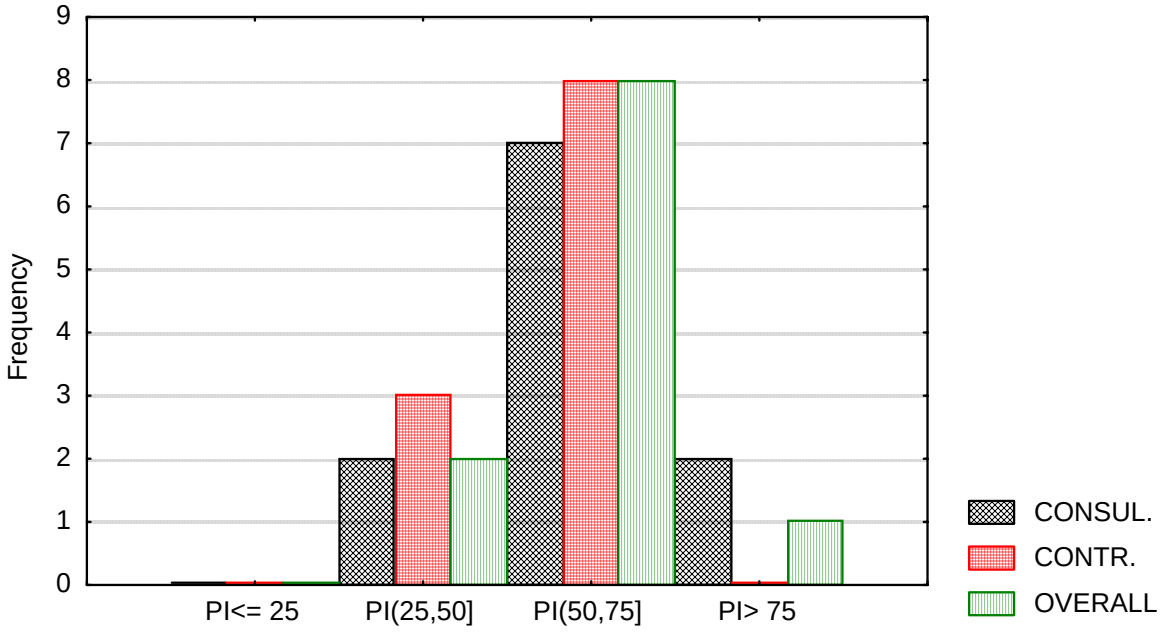


The ranking of the effects of change orders on the construction process based on the prevalence index of these effects is shown in Table 5.3.4 below.

**Table 5.3.5: Ranking of Effects of Change Orders**

| Effect of Change Order | Ranking By Consultants | Ranking By Contractors | Overall Ranking |
|---|---|---|---|
| 1. Decrease in productivity | **8** | **4** | **7** |
| 2. Delay in completion schedule | **2** | **1** | **2** |
| 3. Dispute between owner and contractor | **4** | **9** | **6** |
| 4. Decrease in quality of work | **9** | **10** | **10** |
| 5. Increase in project cost | **1** | **2** | **1** |
| 6. Additional revenue for contractor | **3** | **5** | **3** |
| 7. Delay of material and tools | **8** | **7** | **8** |
| 8. Work on hold in other areas | **6** | **7** | **7** |
| 9. Increase in contractor's overhead | **7** | **3** | **5** |
| 10. Delays in payment to contractor | **9** | **8** | **9** |
| 11. Demolition and re-work | **5** | **6** | **4** |

**Figure 5.3.4: Categorized Prevalence Index**




## 5.4 Controls of Change Orders

In this section we will examine the responses from contractors, consultants, and the overall responses on the controls of change orders in large building construction projects in Saudi Arabia.

a) **Contractors**: Table 5.4.1 shows the summary of the results of the survey's responses from the 17 contractors who participated in the survey.

**Table 5.4.1 Utilization Index of Controls - Contractors**

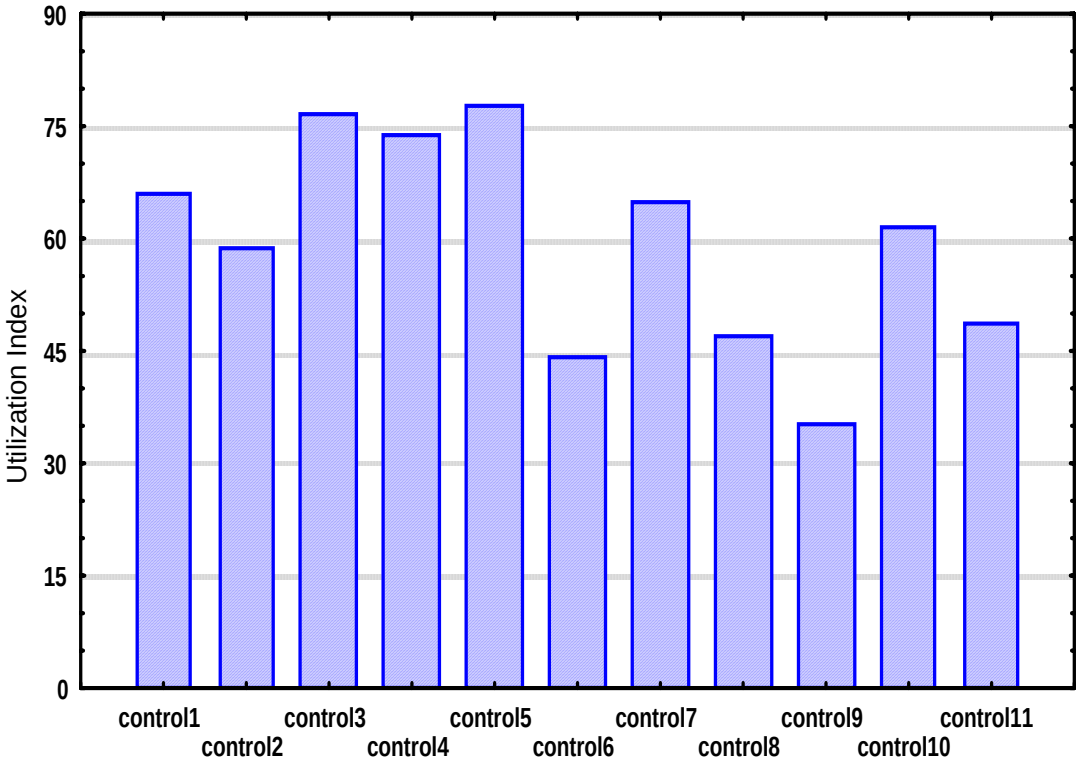
| Controls of Change Order | Minimum | Maximum | Standard Deviation | Utilization Index ( UI ) |
|---|---|---|---|---|
| 1. Early setting of change order handling procedures | **0** | **100** | **35.29** | **66.18** |
| 2. Timely approval of change order | **25** | **100** | **26.43** | **58.82** |
| 3. Negotiation by knowledgeable people | **50** | **100** | **16.47** | **76.47** |
| 4. Appropriate approval in writing | **25** | **100** | **25.72** | **73.53** |
| 5. Clarity of scope of change | **50** | **100** | **17.41** | **77.94** |
| 6. Giving consideration to indirect effects in change order pricing | **0** | **100** | **32.51** | **44.12** |
| 7. Checking and review of design changes for feasibility | **0** | **100** | **33.14** | **64.71** |
| 8. Review of gray areas in contract documents | **0** | **100** | **35.22** | **47.06** |
| 9. Freeze of design | **0** | **75** | **25.09** | **35.29** |
| 10. Team effort between parties | **0** | **100** | **33.21** | **61.76** |
| 11. Work-break down structure | **0** | **100** | **33.62** | **48.53** |

The five most utilized controls by contractors to safeguard against occurrence of change orders or to minimize their impacts if they occur are:

1. Clarity of scope of work of the change order.
2. Negotiation of change orders by knowledgeable people.
3. Appropriate approval in writing.
4. Early setting of change order procedures.
5. Review of design changes for feasibility before approval.

Figure 5.4.1 shows the distribution of utilization index of controls for contractors only.

**Figure 5.4.1 : Utilization Indexes of Controls - Contractors**



b) **Consultants**: Table 5.4.2 below summarizes the responses of the 17 consultants who participated in the survey on the utilization of change order control procedures.

**Table 5.4.2: Utilization Indexes of Controls - Consultants**

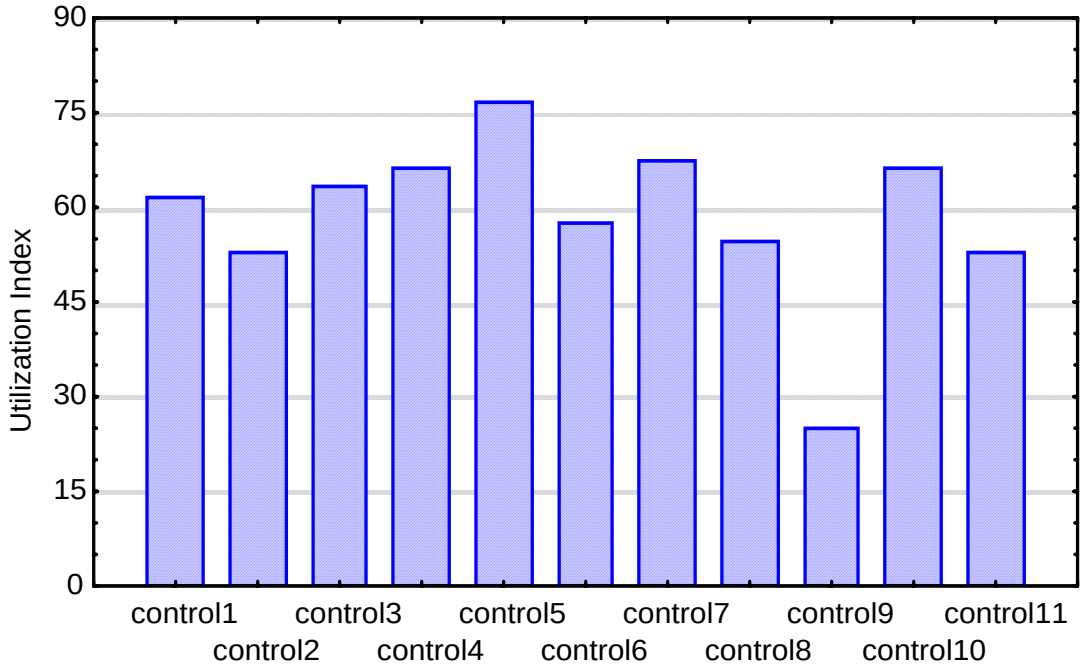
| Controls of Change Order | Minimum | Maximum | Standard Deviation | Utilization Index ( UI ) |
|---|---|---|---|---|
| 1. Early setting of change order handling procedures | **0** | **100** | **29.47** | **61.76** |
| 2. Timely approval of change order | **0** | **100** | **27.79** | **52.94** |
| 3. Negotiation by knowledgeable people | **0** | **100** | **26.69** | **63.23** |
| 4. Appropriate approval in writing | **0** | **100** | **27.86** | **66.18** |
| 5. Clarity of scope of change | **50** | **100** | **13.89** | **76.47** |
| 6. Giving consideration to indirect effects in change order pricing | **25** | **100** | **22.99** | **57.35** |
| 7. Checking and review of design changes for feasibility | **25** | **100** | **22.99** | **67.65** |
| 8. Review of gray areas in contract documents | **25** | **100** | **23.77** | **54.41** |
| 9. Freeze of design | **0** | **50** | **19.76** | **25** |
| 10. Team effort between parties | **25** | **100** | **26.43** | **66.18** |
| 11. Work-break down structure | **0** | **100** | **27.79** | **52.94** |

The five most utilized controls by consultants of large building construction projects are:

1. Clarity of the scope of work of the change order.
2. Review of design changes for feasibility before approval.
3. Appropriate approval in writing.
4. Team effort among construction parties.
5. Negotiation by knowledgeable people.

Data in Table 5.8 above is shown graphically in Figure 5.4.2 below.

**Figure 5.4.2 : Utilization Indexes of Controls - Consultants**




b) **Overall**: Table 5.4.3 summarizes the results from contractors and consultants

**Table 5.4.3: Utilization Indexes of Controls - Overall**

| Controls of Change Order | Minimum | Maximum | Standard Deviation | Utilization Index ( UI ) |
|---|---|---|---|---|
| 1. Early setting of change order handling procedures | **0** | **100** | **32.09** | **63.97** |
| 2. Timely approval of change order | **0** | **100** | **26.87** | **55.88** |
| 3. Negotiation by knowledgeable people | **0** | **100** | **22.85** | **69.85** |
| 4. Appropriate approval in writing | **0** | **100** | **26.67** | **69.85** |
| 5. Clarity of scope of change | **50** | **100** | **15.53** | **77.21** |
| 6. Giving consideration to indirect effects in change order pricing | **0** | **100** | **28.53** | **50.73** |
| 7. Checking and review of design changes for feasibility | **0** | **100** | **28.12** | **66.18** |
| 8. Review of gray areas in contract documents | **0** | **100** | **29.83** | **50.73** |
| 9. Freeze of design | **0** | **75** | **22.85** | **30.15** |
| 10. Team effort between parties | **0** | **100** | **29.64** | **63.97** |
| 11. Work breakdown structure | **0** | **100** | **30.45** | **50.73** |

The ranking of utilized controls of change orders is shown in Table 5.4.4 below:

**Table 5.4.4: Ranking of Controls of Change Orders**

| Controls of Change Order | Ranking By Consultants | Ranking By Contractors | Overall Ranking |
|---|---|---|---|
| 1. Early setting of change order handling procedures | **5** | **4** | **4** |
| 2. Timely approval of change order | **8** | **7** | **5** |
| 3. Negotiation by knowledgeable people | **4** | **2** | **2** |
| 4. Appropriate approval in writing | **3** | **3** | **2** |
| 5. Clarity of scope of change | **1** | **1** | **1** |
| 6. Giving consideration to indirect effects in change order pricing | **6** | **10** | **6** |
| 7. Checking and review of design changes for feasibility | **2** | **5** | **3** |
| 8. Review of gray areas in contract documents | **7** | **9** | **6** |
| 9. Freeze of design | **9** | **11** | **7** |
| 10. Team effort between parties | **3** | **6** | **4** |
| 11. Work break down structure | **8** | **8** | **6** |

The overall response shows the following descending order of the five most utilized by contractors and consultants:

1. Clarity of the scope of work of the change order.
2. Appropriate approval in writing.
3. Negotiation by knowledgeable people.
4. Review of design changes for feasibility before approval.
5. Team effort among construction parties.
6. Early setting of procedures.

The least used control among contractors and consultants is freezing of design. This means that the design continues to be modified until the last activity in construction. The data for overall utilization index is depicted on Figure 5.4.3.

**Table 5.4.5: Overall Utilization Indexes Categorized**

| Controls of Change Order | Minimum | Maximum | Standard Deviation | Utilization Index ( UI ) |
|---|---|---|---|---|
| 1. Clarity of scope of change | 50 | 100 | 15.53 | Over 75 |
| 2. Negotiation by knowledgeable people | 0 | 100 | 22.85 | 50-75 |
| 3. Appropriate approval in writing | 0 | 100 | 26.67 | |
| 4. Checking and review of design changes for feasibility | 0 | 100 | 28.12 | |
| 5. Early setting of change order handling procedures | 0 | 100 | 32.09 | |
| 6. Team effort between parties | 0 | 100 | 29.64 | |
| 7. Timely approval of change order | 0 | 100 | 26.87 | |
| 8. Giving consideration to indirect effects in change order pricing | 0 | 100 | 28.53 | |
| 9. Review of gray areas in contract documents | 0 | 100 | 29.83 | |
| 10. Work breakdown structure | 0 | 100 | 30.45 | |
| 11. Freeze of design | 0 | 75 | 22.85 | 25-50 |

**Figure 5.4.3 : Utilization Index of Controls - Overall**

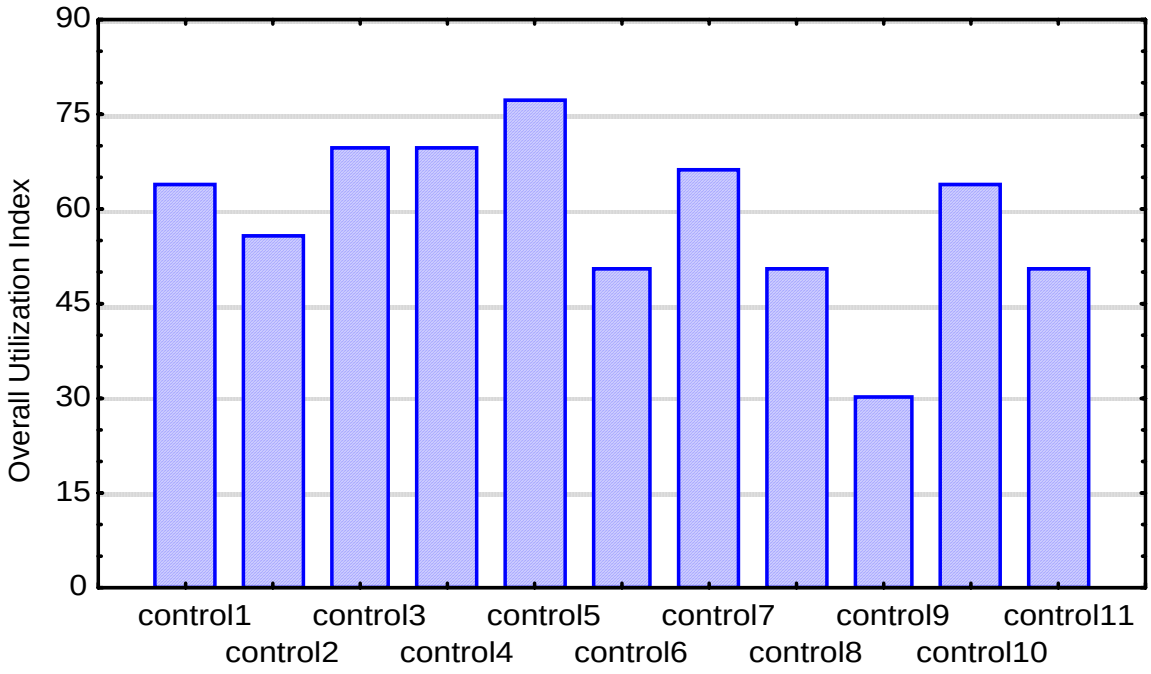


**Figure 5.4.4: Categorized Utilization Indexes**

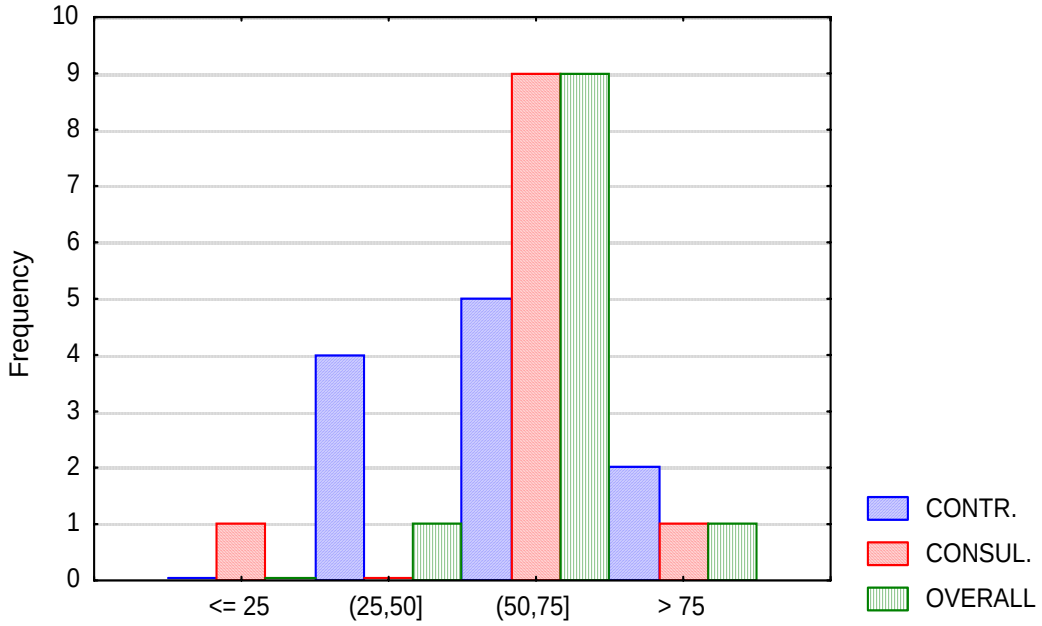


Table 5.4.7 summarizes the most important causes, effects, and controls for both contractors and consultants.

**Table 5.4.6: Most Important Causes, Effects, and Controls**

| Contractors | | |
|---|---|---|
| **Causes** | **Effects** | **Controls** |
| 1. Change of plans by owner | 1. Delay in completion schedule | 1. Clarity of CO scope of work |
| 2. Errors and omissions in design | 2. Increase in project cost | 2. Knowledgeable people for CO negotiation |
| 3. Changes by consultant | 3. Increase in contractor overheads | 3. Approval in writing |
| 4. Substitution of materials and procedures | 4. Decrease in labor productivity | 4. Early setting of CO procedures |
| 5. Conflict within contract document | 5. Additional revenue for contractors | 5. Review of CO for feasibility |
| **Consultants** | | |
| 1. Change of plans by owner | 1. Increase in project cost | 1. Clarity of CO scope of work |
| 2. Substitution of materials and procedures | 2. Increase in project schedule | 2. Review of CO for feasibility |
| 3. Owner financial problems | 3. Additional revenue for contractors | 3. Approval in writing |
| 4. Owner's change of schedule | 4. Dispute between owner and contractor | 4. Team effort |
| 5. Lack of coordination | 5. Demolition and rework | 5. Knowledgeable people for CO negotiation |

## 5.5 Test of Agreement

In this section, we want to test for the degree of agreement or disagreement between the consultants and contractors on the causes, effects, and controls of change orders. To do this we will use the t-test for independent samples as outlined in Appendix A. The analysis here was done on the mean values for causes, effects, and controls. Numbers of causes, effects, and controls indicated on Figures 5.5.1 to 5.5.3 refer to their order as they appear in the questionnaire forms and also in previous tabulation.

The null hypothesis and the alternative hypothesis can be formulated as follows:

**$H_0$ : Contractors and consultants agree on the causes of change orders.**

**$H_A$ : Contractors and consultants disagree on the causes of change orders.**

The t value calculated is –0.65 (parameters: $n_1$=21, $n_2$ =21, $s_1$ =13.21, $s_2$ =13.97). The critical value of t is 2.02 (df = 40, $\propto$ = 0.05). The statistical decision therefore is not to reject the null hypothesis. Contractors and consultants do agree on the causes of change orders. Figure 5.5.1 is a scatter plot of the mean values of for contractors and consultants and shows the close agreement on the assigned importance index.

Likewise for the effects of change orders, the null hypothesis and the alternative hypothesis can be formulated as follows:

**$H_0$ : Contractors and consultants agree on the effects of change orders.**

**$H_A$ : Contractors and consultants disagree on the effects of change orders.**

The t value calculated is –1.366 (parameters: $n_1$=11, $n_2$ =11, $s_1$ =13.20, $s_2$ =14.61). The critical value of t is 2.09 (df = 20, $\propto$ = 0.05). The statistical decision therefore is not to reject the null hypothesis. Contractors and consultants do agree on the effects of change

orders. Figure 5.5.2 is a scatter plot of the mean values of effects for contractors and consultants and shows the close agreement on the assigned importance index.

Finally for the utilization of control procedures of change orders, the null hypothesis and the alternative hypothesis can be formulated as follows:

**$H_0$ : Contractors and consultants agree on the controls of change orders.**

**$H_A$ : Contractors and consultants disagree on the controls of change orders.**

The t value calculated is 0.160 (parameters: $n_1$=11, $n_2$ =11, $s_1$ =14.14, $s_2$ =13.26). The critical value of t is 2.09 (df = 20, $\propto$ = 0.05). The statistical decision therefore is not to reject the null hypothesis. Contractors and consultants do agree on the controls of change orders. Figure 5.5.3 is a scatter plot of the mean values of controls for contractors and consultants. Close agreement is very evident.

**Figure 5.5.1 : Contractors' & Consultants Agreement on Causes**

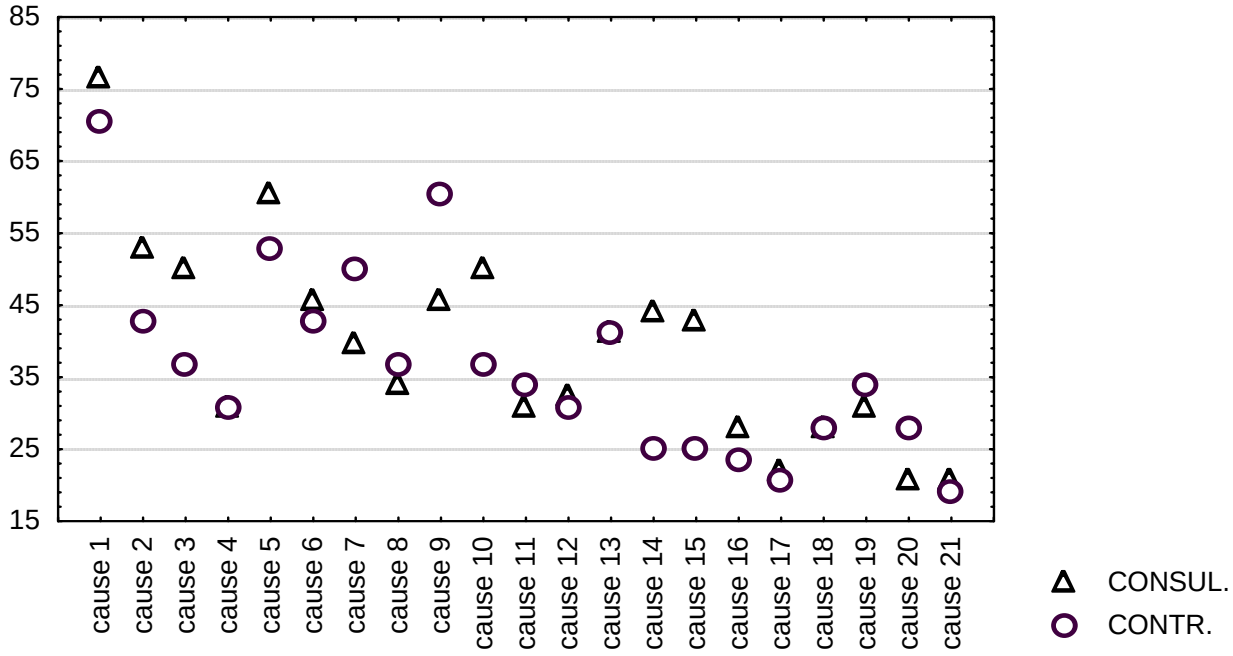



**Figure 5.5.2 : Contractors and Consultants Agreement on Effects**

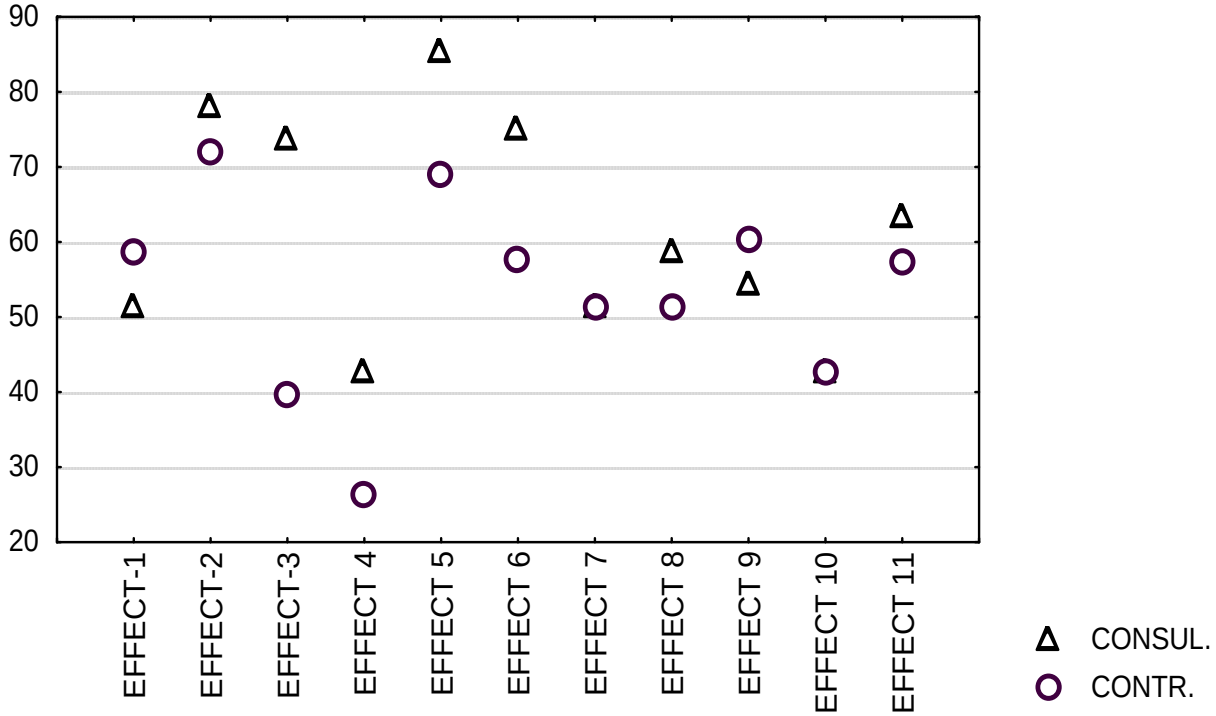
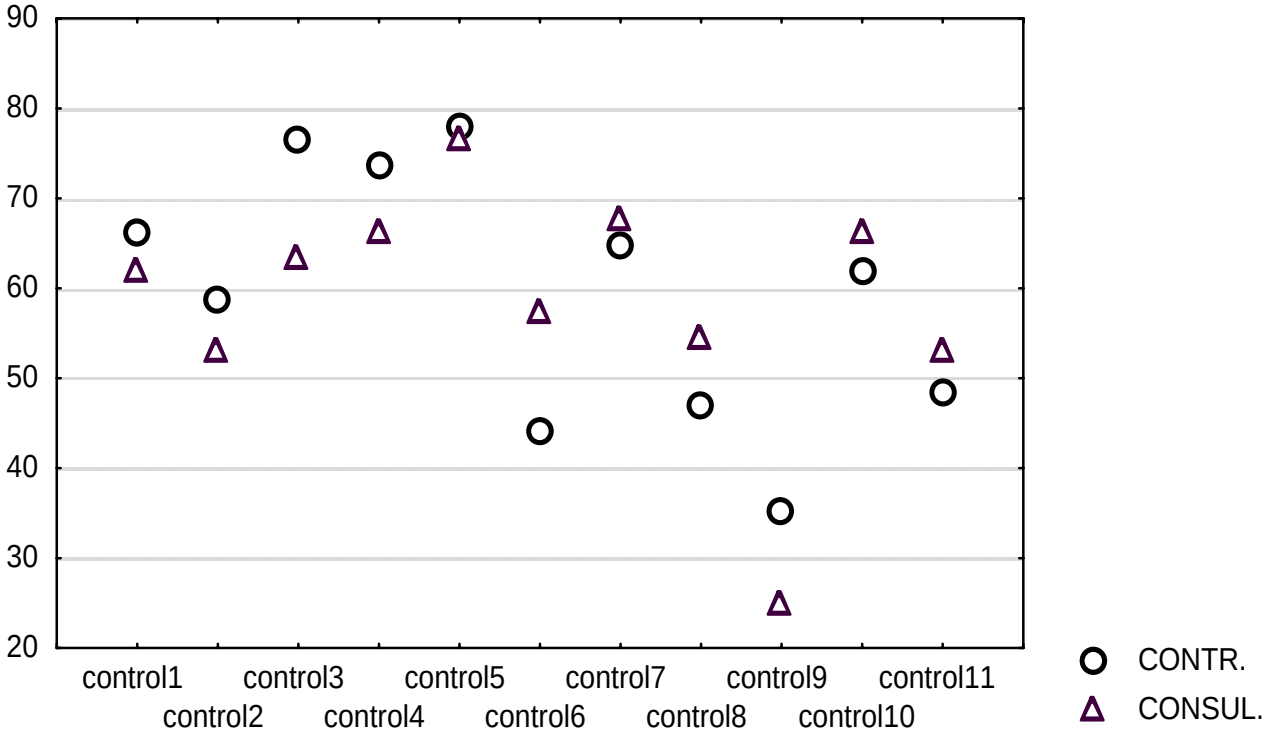


**Figure 5.5.3: Agreement of Contractors and Consultants on Controls**



## 5.6 Comments from Respondents

The following comments are made by consultants and contractors on the questionnaire forms and are documented here for reference. The comments will give a further understanding of the nature and problems of the construction in large building projects in Saudi Arabia. The comments are documented here as written on the forms with slight correction if necessary.

### Consultants

1. Accuracy of documents, drawings, specifications and bill of quantities (BOQ) is required to minimize changes.
2. Coordination helps improve change order problems
3. Improvement of project management in governmental projects is required to solve the problems of change orders
4. Use of project management consultant (PMC) will help
5. The absence of standard contract format increase the problems with change orders
6. Sometimes problems arise between the owner and consultant because owners do not appreciate that change orders are required sometimes to account for new site conditions or improvement during construction.
7. All finishing materials and equipment need to be selected prior to construction and specified clearly in the tender documents and the same to get approved by owner during the design stage.
8. Specify a minimum of three (3) manufacturers in each item, to enable the contractor to price competitively.
9. Try to select materials mostly available In-Kingdom agencies.

10. Try to influence the owner not to change too much during construction. Stick to the original scope of work.

11. Normally, procedures for implementation of change orders are well defined in the contract conditions. If the system is followed in letter and spirit of the contract by all parties concerned, the contractor, the supervising engineer and the owner, most of the disputes could be avoided. Always, for other reasons, the change orders are kept pending till final stage of the contract when the parties concerned sit for negotiation and settlement and find that most of the items are not properly documented, nor proper approval of the concerned authorities are obtained in time. This leads to disputes. The best solution is the timely documentation, discussion, and settlement as and when any variations/change order is required and implemented in line with contract conditions.

**Contractors**

1. Changes happen because the owner does not have full understanding of the project and I think that it is the obligation of the consultant or the design engineer to explain clearly the design and its benefits tot he owner to minimize changes.
2. Contractor shall not interfere between the owner and the consultant so that ideas of change orders takes it time to develop and then the owner issue it to contractor through his consultant.
3. Consultant squeeze in behalf of owner when it comes to pricing of change orders.
4. Change orders come from two sources:
    a. By owner during construction
    b. Ambiguity in the contract which leads to dispute.

5. Change orders occur due to improper studies of the site conditions and design packages. Sometimes there is no discussion between owner and the designer or the owner does not have the proper understanding.
6. To minimize change orders the following should be followed:
    a. Drawings, specifications and scope should be clear for negotiation of change orders later.
    b. Cost of change order shall be negotiated and a written direction from consultant is required before commencement of any work.
    c. Material specification should be clear.
    d. Project guidelines of quality, productivity, safety and milestones should be followed strictly.
7. Change orders should not be meant to increase project cost.
8. A certain amount for change orders should be included in the budget and can be broken into two components:
    a. Unknown factors or deficiencies in design
    b. Construction factors
9. Client should consider the bad and negative effect of change orders and try to avoid as much as possible, by doing a good design job before calling for bidders to price.
10. It is a fact that change orders disturb the contractor. Their pricing is a very difficult task and not always appreciated by the client due to major effects on the price that are not considered fairly by clients.
11. Due to the nature of change orders, pricing should be considered with all factors including stage of work as per time schedule and type of left-over job at time of pricing change orders.

12. Try to avoid any delay in the contract period to get the best deal in change orders otherwise pricing of work items will show overhead effects that might go to 25% of direct cost.

*CHAPTER SIX*

# SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

## 6.1 Summary

The study is treated in six chapters. Chapter one is an introduction to the study highlighting the significance of the study of change orders, the objective set for it, its scope and limitations and a brief description of the specific conditions of the construction in Saudi Arabia.

Chapter two is a review of change orders in literature and it encompass a review of many articles, research studies, master and Ph.D. dissertations, as well as books written on the subject of change orders. The review is organized under four sections: basics of change orders, legal aspects of change orders, cost aspects of change orders, and management aspects of change orders.

Chapter three defines the parameter to be measured and studied in the field survey part of this study. It includes definitions for 21 possible causes of change orders and 11 possible effects of the change orders process and 11 possible controls which can be utilized for managing change orders.

Chapter four discusses the process of developing the survey questionnaire and the approach for defining the sample size, the procedures used for gathering field data and the scoring used to come up with the different indexes and ranks.

Chapter five presents the results and findings of the study in five sections: general industry information, causes of change orders, effects of change orders, controls of change orders and testing of hypothesis on the agreement between consultants and contractors on causes, effects and controls of changes. Results on all these parameters from 34 consultants and contractors are presented. Importance Index (II) of causes, Prevalence Index (PI) of effects, and Utilization Index (UI) of controls are tabulated. Each cause, effect, and control is ranked for consultants and contractor. One section at the end of this chapter was dedicated for the comments made by respondents on the questionnaire forms.

## 6.2 Conclusions

The causes of change orders, and their effects on project cost and schedule are complex and influenced by numerous interrelated factors. The risk and uncertainties associated with project changes make predictions and planning for changes a difficult task. The objective of this research study was to carry out a literature review and field survey to identify major causes of changes, their effects on projects, and control procedures adopted in large building projects in Saudi Arabia.

Based on the field survey conducted and the results presented in chapter five, the following can be concluded:

1. The general industry information collected indicates the following facts: contractors involved in large building construction are large in size and most of them reported over 15 years of experience. The common contract format in large building construction is the lump sum turnkey (LSTK). Most changes in large building projects are architectural in nature. The working relation between principal parties in the construction process is generally very good. Results indicated an active participation of owners during design and construction of large buildings. The cost overrun due to change orders is shown to be between 6 and 10% of the original contract value in large building construction. This value agrees with values indicated by some studies as discussed in literature. Similarly, the schedule overrun is shown to be less than 10% of the original project duration. This extension of the schedule is close to values reported in other studies. Hence, the effects of change orders on cost and schedule are comparable to other sectors or locations.
2. The owner is the main source of changes in large building projects. Change of plans by owner is the main cause of changes. There are three possible explanations to this. First,

the owner was not involved in the design development. This is unlikely considering the positive or active participation of owner indicated in the first conclusion. Second, the owner did not understand or visualize the design. The designer may not have made the design clear or the owner just lack the ability to read the drawings. Third, it is merely a change of mind while not appreciating the negative impacts of changes.

The results showed that changes can be made by owner due to financial problems facing the owner.

3. Substituting materials and or procedures is the second source of change orders generated by the owner. This might be due to new materials becoming available in the h market or due to change in mind on part of the owner directly or through his representative.
4. Consultant is the second major contributor to changes by generating conflicting design documents or through change in design after award. Another source is errors and omissions in design.
5. Noticeably the following causes rated low which might be particular to the environment in Saudi Arabia:
    - Differing site conditions
    - Value engineering
    - Technology changes
6. Increase in project cost and duration are the two main effects being noted for change orders. Degradation of labor productivity and disputes scored lower and are less prevalent. The degradation of productivity is considered a major concern here. This might be explained by the low labor wages. Quality of work is not effected by changes. Additional revenue for contractors is considered an outcome of changes.

7. Clarity of the scope of change ranked the first among controls adopted. Freeze of design, use of WBS, and review of contract for gray areas, ranked last and are least utilized by contractors and consultants.
8. Finally, the research showed that contractors and consultants agree to a large extent on the causes of change orders, effects of these changes and the controls adopted. This is contrary to the common perception that consultants and contractors would not agree. The normally adversarial relation did not affect their evaluation of the problem. This indicates a mature and well-developed contractual relationship in this field of construction. This may not be present in small-scale construction projects.

## 6.3 Recommendations

Based on the findings of this research discussed in chapter five with main conclusion listed above and the referring to findings of previous studies discussed in the literature review, the following recommendation are made:

1. As concluded earlier, the research indicates that owner is the major source of change orders in large building construction. Although the research showed that the owner gets involved during the design phase of the project, this is not enough for minimizing problems associated with changes and cost overruns. As gathered from many field interviews, the owner normally lack the ability to read design documents prepared by the engineer. Many interviews suggested that owners, in many instances, get surprised that what is being constructed is not what they have anticipated or envisioned. Owners of large building projects are usually businessmen who have a good level of education and with extra effort and visual aids they should be able to visualize the design. As the research showed that most changes are architectural, a three-dimension model is very helpful in this regard and should be used to help owners see their project before construction starts. This extra effort in understanding the design would minimize the changes made by the owner.
2. It is recommended that owners make adequate financial planning during planning stage to avoid changing plans later or during construction.

3. It is worth noting that owners of large building projects are not repetitive owners of such projects, and their opinion will be based mostly on one project. Another justified recommendation for those owners is to get a project management consultant firm (PMC) to supervise both the design and construction activities to insure that the

owners' needs and expectations are met by the design. The practice of appointing PMC is rarely adopted currently.

4. Substitution of materials or procedures came as the second source of change orders and is normally originated by the owner. It is recommended that the engineer specify the material for the building in a detailed manner (by make and model for example) to eliminate the possibility of changes later. Although this might be difficult in a market like ours, where nothing is standardized, sufficient (adequate) specification of material will minimize this source of change orders. Performance specification is another way of insuring materials used meet the requirements regardless of make or type.

5. The research showed that change orders are thought of as additional revenue for the contractor. It is recommended that contractors educate their personnel on the negative effects of change orders. As concluded in the review of literature earlier, changes should prove a very high benefit to cost ratio to be considered feasible. Contractors should consider direct and indirect impact of changes for their evaluation to be complete.

6. The research showed that freezing of design is the least used control against change orders. Owners should consider using this control more often to avoid the problem of creeping scope where the control over scope is lost. This condition definitely accelerates rate of changes generated in the project.

7. The utilization index for control no. 8 'review of contract documents for gray areas' is very low. As explained in the literature review this could be a source of many changes

and claims during construction. Contractors should expend more effort prior to contract award to review contract document for both legal and contractual conditions as well as technical details to spot unclear areas where conflict over its interpretation may arise. These matters should be closed and resolved prior to the start of construction.

8. Contractors should consider using a Work Breakdown Structure or other tracking system more often than is used now. Many contractors indicate they are not using any type of structuring system for their construction activities and this may lead to an inability to trace the effects of change orders on the rest of the project.

## 6.4 Recommendations for Further Studies

The following are areas of related interest that can be explored in light of information provided in this study.

1. The study included two major participants in the construction process, namely the contractor and consultant. The third major party is the owner. As discussed in the conclusions, the owner received most of the blame for generating changes. Few explanations were given as possible reasons. However, field survey is required to provide answers to the following questions:
    - ♦ Why does owner make changes during construction?
    - ♦ What could be done in the design stage to improve the owner understanding of the design drawings?
    - ♦ Would owners prefer to see a model of their project before construction?
    - ♦ Is there enough material specification to minimize the need for material substitution?

2. Since this study address the subject for large building project, it would be interesting to study the subject of change orders in the industrial construction and compare the results.

## Appendix A

## Basic Statistics: Definitions and Formulas

The following information is provided to give a brief glossary of terms and equations essential to the understanding of statistical procedures used in the context of this thesis. Information is summarized from the statistical package manual (STATISTICA 4.3) used in the analysis in this paper and from " Business Research Methods" by D. R. Cooper and C.W. Emory (1995).

a. Elementary Concepts

In a survey like ours, we attempt to measure certain characteristics of a population. We call these characteristics **variables.** These could be dependent or independent. **Dependent** variables are those, which we measure and **independent** are those, which we manipulate. Variables differ in how well they can be measured. Specifically variables are classified as **nominal, ordinal, interval, or ratio**. Rank and attitude scales are presumed to be interval.

**Probability Sampling** refers to the sampling technique in which every element in the surveyed population has the opportunity to be selected. In **Non-probability Sampling**, on the other hand, the probability of selecting population elements is not known.

Statistics could be Descriptive or Inferential. **Descriptive Statistics** refers to the statistical techniques and procedures used to describe, organize and present the data. **Inferential Statistics** are the concepts and techniques used in reaching conclusions or making inferences about the body of data.

**Parametric Statistics** are those tests and techniques used to analyze data collected by the probability sampling procedures. **Non-parametric statistics** are the tests and techniques used to analyze no-probability sampling data. Nominal and ordinal data are tested using non-parametric techniques. However, many statisticians think that ordinal data could be transformed into interval data allowing the use of the more powerful parametric statistics. This is the approach taken in this study.

Data from the survey together with their frequency of occurrence form a **distribution** of values. The characteristics of location, spread and shape describe distributions. The most familiar distribution is the bell-shaped normal distribution. The **standard normal distribution** has a mean of zero and a standard deviation of 1.

b. Calculation of Basic Statistics

The most frequently used measure of central tendency is the mean. The mean is the arithmetic average of data points. Sample mean can be calculated as follows:

$$\mathbf{X = \Sigma x_I / n} \quad \text{..... (1)}$$

Where $x_I$ represents the individual data points and n is the number of observations.

The other measures of central tendency used are the median and the mode. **Median** is the midpoint of the distribution. **Mode** is the most frequently occurring value.

The most frequently used measure of the spread or dispersion of data is the **standard deviation**. Standard deviation is calculated as follows:

$$\mathbf{S = SQRT\{\Sigma ( x_I - x)^2 / (n-1) \}} \quad \text{..... (2)}$$

Where SQRT stands for the positive square root, $x_I$ is the individual observations, and x is the mean value.

The other measure of dispersion of data is the variance. **The variance** is the average of the square deviations from the mean. It is the square of the value of standard deviation.

c. Hypothesis testing

Testing comes under the inferential statistics. For the purpose of this study, t-test will be the statistic test of choice. The **t-test** for small size samples of two independent variables (Contractors' point of view and consultants' point of view) is :

$$\mathbf{t = [X_1 - X_2 - (\mu_1 - \mu_2)_0] / \{SQRT(S_p^2 (1/n_1 + 1/n_2)\} \ldots\ldots\ldots\ldots\ldots\ldots (3)}$$

Where:

$X_1$ and $X_2$ : Sample mean values for sample 1 and 2 respectively

$\mu_1$ and $\mu_2$ : Population mean values for population 1 and 2 respectively

$S_p$ : is the pooled variance for the two samples and is equal to

$$\mathbf{S_p^2 = \{S_1^2(n_1-1) + S_2^2(n_2-1)\} / [n_1 + n_2 - 2] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)}$$

$n_1$ and $n_2$ are sizes of sample 1 and 2 respectively.

$S_1$ and $S_2$ are standard deviation of sample 1 and 2 respectively.

## APPENDIX B

### Definition of Terms

**Change:** Any modification to the original contractual agreement.

**Change Order**: Formal modification order to alter original contract requirements.

**Cost Reimbursable Contract**: A contract providing financial arrangement to allow price adjustment relative to project cost. Also called cost plus contract.

**Constructability:** The optimum use of experience in design, procurement and planning to achieve the objectives of the project in the least possible cost.

**Control Account:** A selected account to manage resources, productivity and historical database.

**Cost Growth:** The percentage increase in original contract value.

**Cost Overruns:** The difference in cost between actual and original contract award amount.

**Creeping Scope:** Loss of control of a project scope. Creeping scope provides good grounds for construction and design changes.

**CPM : (Critical Path Method ):** A scheduling method that arranges all activities of a project in a network showing all interdependencies.

**Fixed price Contract:** A contract that establishes a fixed lump sum for the execution or completion of a defined scope. Also called “hard money“ contract. It can be lump sum or unit price format.

**Free Float:** Free time available to the scheduler assuming that all proceeding and following activities will start on early start dates.

**LSPB Contract:** A construction contract that includes all parts of LSTK contract except engineering and design.

**LSTK Contract:** A construction contract, which includes engineering, procurement, construction, construction management and commissioning.

**Money Left On the Table (MLOT)**: The difference between the low bid and the next higher bid in a fixed price contract.

**Productivity Index(PI):** The ratio of planned productivity over actual productivity.

**Ripple Effect:** The propagation of change impacts to other activities in other work packages.

**Quality Deviation:** A departure from established requirements. It could be imperfection, defect or non-conformance.

**Schedule Growth:** The percentage increase in original contract schedule.

**Schedule Overruns:** The difference in project duration between actual and original contract award schedule.

**Total Float:** Total free time available to the scheduler assuming that all proceeding activities have been started on early start and that all succeeding activities will start on late start dates.

**Value Engineering:** An engineering review to economize the cost of the project.

**Variance:** The quantitative difference between original scope and new scope after changes. It is prepared for later settlement of price /shekel adjustment if required.

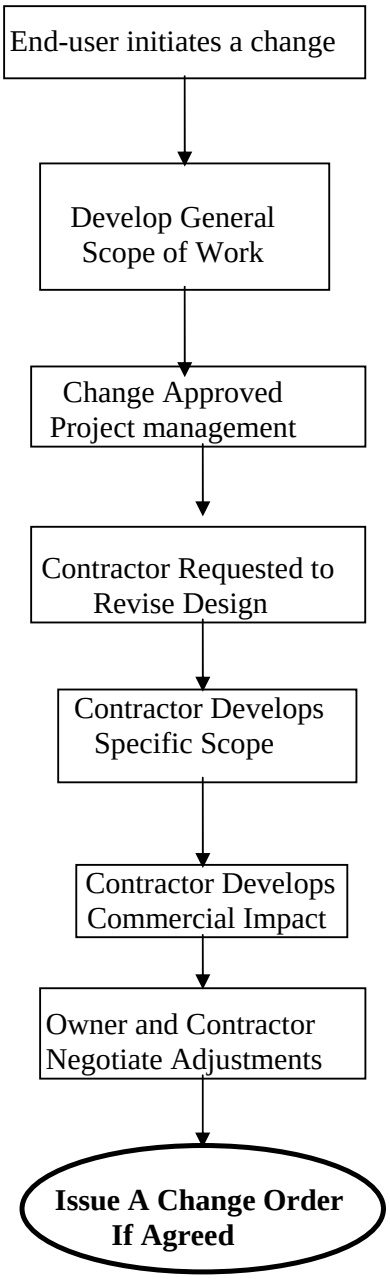
**Unit Price Contract**: A form of contract, which involves fixed unit prices against a variable quantity. Owner takes the risk in quantity variation.

**Work Breakdown Structure (WBS):** An ordered representation of the construction project organized in an increasing detail array.

**Work Package:** A group of products and activities that requires to be managed as a unit within the project structure.

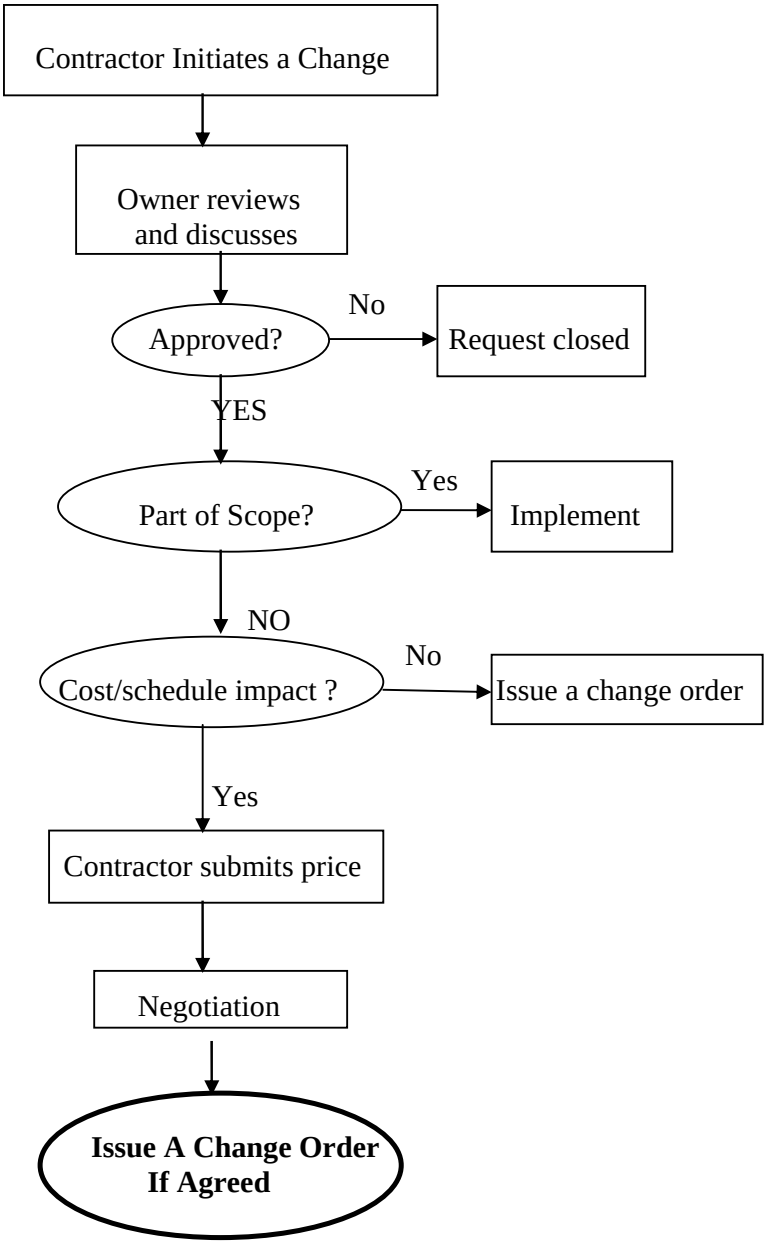
**APPENDIX C**

Typical Change Order Procedure Initiated By Owner



**APPENDIX D**

Typical Change Order Procedure
Initiated by Contractor



## APPENDIX E

## LIST OF CONTRACTORS

The following is the list of contractors in the Eastern Province as classified by the Chamber of Commerce for Grade 2 or better:

| Name of contractor | Address of contractor |
|---|---|
| 1) A. A. AL-QAHTANI & SONS | P.O.BOX 20 , DAMMAM 31411 |
| 2) SAUDI ARABIAN PONGLEM FOR CONSTRUCTION | P.O.BOX 2578, DAMMAM 31461 |
| 3) AL-NAHDA FOR ENGINEERING AND CONTRACTING | P.O. BOX 121, DAMMAM 31411 |
| 4) ALFOZAN COMPANY | P.O. BOX 38, AL-KHOBAR 31952 |
| 5) A. A. AL-DOSSARY FOR TRADING | P.O. BOX 973, AL-KHOBAR 31952 |
| 6) N. ALSEBAIE COMPANY | P.O. BOX 12, AL-KHOBAR 31952 |
| 7) AL-MADAR COMPANY FOR CONTRACTING | P.O. BOX 120, DHAHRAN AIRPORT 31932 |
| 8) A& S AL-MOJIL COMPANY | P.O.BOX 53, DAMMAM 31411 |
| 9) SAUDI TAISI LIMITED | P.O. BOX 90 , AL-KHOBAR 31952 |
| 10) AL-MIRA CENTER FOR TRADING | P.O.BOX 2120 , DAMMAM 31451 |
| 11) IKHWAN COMPANY | P.O.BOX 7999, DAMMAM 31472 |
| 12) AL-QAHTANI AND CO. | P.O.BOX 2224, DAMMAM 31451 |
| 13) SAUIDI CONDRICO LIMITED | P.O.BOX 693, DAMMAM 31421 |
| 14) EASTERN ESTABLISHMENT | P.O.BOX 204, AL-KHOBAR , 31952 |
| 15) SAUDI ARABIAN MAROBINI | P.O.BOX 3203 , AL-KHOBAR , 31952 |
| 16) REZAYAT COMPANY | P.O.BOX 90, AL-KHOBAR , 31952 |
| 17) AL-ERAIFI COMPANY | P.O.BOX 345, DAMMAM 31411 |
| 18) AL-SARAN & AL-HAJRI CONTRACTING | P.O. BOX 214, DHAHRAN AIRPORT 31932 |
| 19) SAUDI DANISH COMPANY FOR CONTRACTING | P.O.BOX 718, DAMMAM 31421 |
| 20) AL-MAHA FOR CONTRACTING | P.O.BOX 2118, DAMMAM 31451 |
| 21) AL-OTAISHAN AND SONS COMPANY | P.O.BOX 2178, DAMMAM 31451 |
| 22) AL-HAIDER COMPANY FOR CONTRACTING | P.O.BOX 18 , RAHIMA 31941 |

| Name of contractor | Address of contractor |
|---|---|
| 23) LINA COMPANY FOR CONTRACTING | P.O.BOX 4379, DAMMAM 31491 |
| 24) AL-JOUL FOR CONTRACTING | P.O.BOX 86 , AL-KHOBAR , 31952 |
| 25) AL-AJINA FOR CONTRACTING | P.O.BOX 344 , AL-KHOBAR , 31952 |
| 26) SAUDI GROUP FOR CONSTRUCTION MATERIAL | P.O. BOX 857, DHAHRAN AIRPORT 31932 |
| 27) MASTORA FOR CONTRACTING AND TRADE | P.O. BOX 24 , RAS TANURA 31941 |
| 28) AL-HALA FOR CONTRACTING | P.O. BOX 341, DHAHRAN AIRPORT 31932 |
| 29) AL-ZAYER COMPANY | P.O. BOX 679 , QATIF 31911 |
| 30) ASIAD INTERNATIONAL FOR CONTRACTING | P.O.BOX 50 , RAHIMA 31941 |
| 31) COMMUNICATION SYSTEMS COMPANY LTD. | P.O.BOX 30248 , AL-KHOBAR , 31952 |
| 32) F. D. AL-DOSSARY FOR CONTRACTING | P.O.BOX 4011, DAMMAM 31491 |
| 33) AL-MOHANA CONTRACTING | P.O.BOX 1945, DAMMAM 31411 |
| 34) SHAFI BINJABER &BROS FOR CONTRACTING | P.O. BOX 285, DHAHRAN AIRPORT 31932 |
| 35) SAMRY COMPANY LTD | P.O.BOX 257, DAMMAM 31411 |
| 36) SAUDI NATIONAL ESTABLISHMENT | P.O.BOX 54 , HAFR ALBATIN 31991 |
| 37) M. AL-SAEED COMPANY | P.O.BOX 120 , AL-KHOBAR , 31952 |
| 38) AL-YAMAMA FOR CONTRACTING AND TRADE | P.O.BOX 2110, DAMMAM 31451 |
| 39) AL-MASHAREG FOR CONTRACTING | P.O.BOX 2540, DAMMAM 31461 |
| 40) AL-JORAN FOR CONTRACTING | P.O. BOX 20760 , AL-THOGBA 31952 |
| 41) AL-TADAMON NATIONAL COMPANY | P.O.BOX 2072, DAMMAM 31491 |
| 42) AL-YOSSR CONTRACTING | P.O. BOX 293 , AL-JUBAIL 31951 |

NOTE: NAMES ARE TRANSLATED FROM THE ARABIC ORIGINAL.

PRONUNCIATION MAY BE DIFFERENT.

## APPENDIX F

### List of Consultants

The following is the list of consultants in the Eastern Province as in the Chamber of Commerce listing:

| Name of consultant | Address of consultant |
|---|---|
| 1) SAUDI WIMBI | P.O.BOX 90 , AL-KHOBAR 31952 |
| 2) ARABIAN COMPANY FOR SCIENTIFIC RESEARCH | P.O.BOX 1272 , AL-KHOBAR 31952 |
| 3) DALLA EFCO | P.O.BOX 383 , DHAHRAN AIRPORT 31932 |
| 4) CONTEL FEDERAL SYSTEM | P.O.BOX 888 , AL-KHOBAR 31952 |
| 5) SCADO | P.O.BOX 1713 , AL-KHOBAR 31952 |
| 6) NOOR CONSULT TELEMATIX | P.O.BOX 1498 , AL-KHOBAR 31952 |
| 7) PETROCON | P.O.BOX 212 , DHAHRAN AIRPORT 31932 |
| 8) MITCAF WIDI INTERNATIONAL | P.O.BOX 1713 , AL-KHOBAR 31952 |
| 9) JUANO OVERSEAS COMPANY | P.O.BOX 720 , AL-KHOBAR 31952 |
| 10) SAUTER FOR ENGINEERING CONSULTANTS | P.O.BOX 3422 , DAMMAM 31471 |
| 11) DESIGN AND CONSULTATION OFFICE | P.O.BOX 3168 , AL-KHOBAR 31952 |
| 12) ABAL KHAIL OFFICE | P.O.BOX 417 , DHAHRAN AIRPORT 31932 |
| 13) ALNASSAR CONSULTANTS | P.O.BOX 1802 , AL-KHOBAR 31952 |
| 14) SAUDI TECH CONSULTANTS | P.O.BOX 1323, DAMMAM 31431 |
| 15) ENGINEERING CONSULTANT OFFICE | P.O.BOX 1736 , AL-KHOBAR 31952 |
| 16) AL-OTAISHAN ENGINEERING CONSULTANT | P.O.BOX 1445, AL-KHOBAR 31952 |
| 17) DAR AL-RIYADH | P.O.BOX 20753 , AL-KHOBAR 31952 |
| 18) GULF GROUP ENGINEERING CONSULTANTS | P.O.BOX 2930, DAMMAM 31431 |
| 19) AL-NASSAG AL-ARABI CONSULTANTS | P.O.BOX 3513, AL-KHOBAR 31952 |
| 20) AL-ZAHID CONSULTANTS | P.O.BOX 692 , DHAHRAN AIRPORT 31932 |
| 21) AL-MOJIL CONSULTANTS | P.O.BOX 6226 , DAMMAM 31442 |
| 22) AL-AMODI OFFICE | P.O.BOX 1445, AL-KHOBAR 31952 |

| Name of consultant | Address of consultant |
|---|---|
| 23) AL-BURAIKI ENGINEERING | P.O.BOX 234 , QATIF 31911 |
| 24) AL-OBAIDLY OFFICE | P.O.BOX 5816 , DAMMAM 31432 |
| 25) SAUDI DESIGNERS | P.O.BOX 7953 , DAMMAM 31472 |
| 26) AL-MOMEN ENGINEERING OFFICE | P.O.BOX 2309, AL-KHOBAR 31952 |
| 27) AL-BILALI CONSULTANTS | P.O.BOX 4662 , DAMMAM 31412 |
| 28) SAUD CONSULTING SERVICES OFFICES | P.O.BOX 1293, DAMMAM 31431 |
| 29) AL-OTHMAN FOR CONSULTANTS | P.O.BOX 30052, AL-KHOBAR 31952 |
| 30) AL-HUSSAIN CONSULTANTS | P.O.BOX 8943 , DAMMAM 31492 |
| 31) ZAMIL AND TURBAG ENGINEERING | P.O.BOX 981 , AL-KHOBAR 31952 |
| 32) ALJAZEERA CONSULTANTS | P.O.BOX 31467 , AL-KHOBAR 31952 |
| 33) AL-NEMRAN CONSULTANTS | P.O.BOX 340 , AL-KHOBAR 31952 |
| 34) AL-HARBI AND RADI CONSULTANTS | P.O.BOX 684 , AL-KHOBAR 31952 |
| 35) AL-HOJAILAN ENGINEERING OFFICE | P.O.BOX 3863 , AL-KHOBAR 31952 |
| 36) AL-ZEKRY FOR ENGINEERING | P.O.BOX 2203, DAMMAM 31451 |
| 37) AL-MULLA CONSULTANTS | P.O.BOX 3278, DAMMAM 31471 |
| 38) A. BALTOUR ENGINERING OFFICE | P.O.BOX 30087, AL-KHOBAR 31952 |
| 39) AL-FOZAN ENGINEERING OFFICE | P.O.BOX 3908 , AL-KHOBAR 31952 |
| 40) ALTAMMIMI ENGINEERING OFFICE | P.O.BOX 11006, DAMMAM 31453 |
| 41) G. BOHLAIGA ENGINEERING OFFICE | P.O.BOX 7389, DAMMAM 31462 |

## Appendix G

## References:


1) Construction Industry Institute (CII) Publication 6-10: *The Impact of Changes on Construction Cost and Schedule*. The University of Texas at Austin, April 1990.

2) CII Publication 5-1: *Impact of Various Construction Contract Types and Clauses on Project Performance.* The University of Texas at Austin, July 1986.

3) Edward R. Fisk: *Construction Project Administration*, third edition. John Wiley & Sons Inc., New York, 1988.

4) H. Randolph Thomas and Carmen L. Napolitan: *Quantitative Effects of Construction Changes on Labor Productivity*, Journal of construction engineering and management, Vol.121, No.3, September 1995.

5) CII Publication 6-6: *Work Packaging for Project Control*, The University of Texas at Austin, November 1988.

6) James L. Burati Jr., Jodi j. Farrington, and William B. Ledbetter: *Causes of Quality Deviations in Design and Construction*; Journal of construction engineering and management, Vol. 118, No.1, March 1992.

7) CII Publication 2-3: *Productivity Measurement, An Introduction*, October 1990.

8) CII Publication 6-2: *Scope Definition and Control*. The University of Texas at Austin, October 1990.

9) Saudi Aramco Project Management Manual: *Partnering Scope Changes ( LSTK contractors ) : Change Request Development Process*. Dhahran, Saudi Arabia, August 1995

10) Jimmy H. Allen: *Management of Fixed Cost Contract*; Proceeding of the ASCE-SAS second seminar, Al-Khobar, Saudi Arabia, October 1995.

11) Kuprenas J. Algimantas: *Use of Influence Diagrams to Asses the Cost and Schedule Impact of Construction Changes*, PhD Dissertation, University of California, Berkeley, 1998.

12) Krone, Stephen Jeffrey: *Decreasing The impact of Changes ( Ripple Effect , Scope Changes , Change orders* ) , Dissertation Abstract , The George Washington University , 1991.

13) Robert K. Cox: *Managing Change Orders and Claims*, Journal of Management in Engineering, January/February 1997.

14) H. Randolph Thomas and Carmen L. Napolitan: *The Effects of Changes on Labor Productivity : Why and How Much* , CII Source Document No 99, The Pennsylvania State University, August 1994 .

15) Dennis Lock: *Project Management*, fifth edition, The Macmillan Press Limited, London, 1992.

16) Alaa Zeitoun and Garold Oberlender: *Early Warning Signs of Project Changes*, Oklahoma State University/CII Source Document No.91, April 1993.

17) Weston Hester, John A. Kuprenas, T. C. Chang: *Construction Changes and Change Orders: Their Magnitude and Impact*, The University of California- Berkeley/ CII Source Document No.66, April 1991.

18) Rowland Henry: *The Causes and Effects of Change Orders on the Construction Process*. M. S.Thesis submitted to the Faculty of the Georgia Institute of Technology. November 1981.

19) Edward D. Leidholt: *An Analysis of Navy Construction Contract Change Order Audits.* M.S. Thesis submitted to the Faculty of Naval Postgraduate School, Monterey, California. December 977.

20) Kevin P. Grant: *An Analysis of Factors Affecting the use of Change Orders and Supplement Agreements*. M.S. Thesis submitted to the Faculty of air Force Institute of Technology, Ohio, November 1983

21) James R Resmond: *Analysis of Low Bidding and Change Orders Rates for Navy Facilities Construction Contracts*. M.S. Thesis submitted to the Faculty of Naval Postgraduate School, California, June 1984.

22) Robert L.K Tigon: *Effective controls for Large Scale Construction Projects*. Project Management Journal, Vol.21, March 1990.

23) Alferd L. Dellon: *The Role of the Cost Engineer and the Change Order Process*. American Association of Cost Engineers Transactions, Vol.232, 1986.

24) Stephen J. Krone: *Modeling Construction Change Order Management*. Project Management Journal, Vol.23, September 1992.

25) Kelvin Yu: *Project Control: cost/schedule/progress management*. Cost Engineering (ACO) Vol. 38 April 1996.

26) J.E Dickman and M.P Kim: *SUPER CHANGE: Expert System for Analysis of Change Claims*. Journal of construction engineering and management, Vol. 118, No. 2, September 1995 .

27) W. Bruce Pruitt: *The Value of the System Engineering Function in Configuration Control of a Major Technology Project*; Project Management Journal, Vol. 30, No. 3, September 1999.

28) Project Management Institute; *A Guide to the Project Management Body of Knowledge*, PMI Headquarter Publishing Division, N. Carolina,1996.

29) CII Special Publication no. 43-1; *Project Change Management,* November 1994.

30) D.R. Cooper and C.W. Emory: Business Research Methods, 5th edition, Irwin Inc. Chicago, 1995.

31) Charles Ayers; Specifications for Architecture Engineering and Construction, 2nd edition, John Wiley and Sons Inc. New York, 1987.

32) Robert D. Gilbreath; *Managing Construction Contracts*, 2nd edition, John Wiley and Sons Inc. New York, 1992.

33) John Webb; *Reward and Risk in Partnership-Based Contract Methods*, Global Construction, June 1995.

34) Gulam Farooq; *Quality Management Practices Among A/E Organizations*, MS Thesis, King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, 1997.