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Impact of Variation Orders on Performance of Repetitive Residential Projects in Egypt

BY

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Abstract

The construction industry is one of the most active sectors of the Egyptian economy. This industry links with other sectors such as manufacturing of steel. One of the most projects that are continuing to grow rapidly in Egypt is the repetitive residential units due to the expansion of population in Egypt. The composition of the Egyptian population is a major contributor to the booming of the repetitive residential units sector in Egypt. This is because of more than half of the Egyptian population are under the age of 25. Construction projects contain complex operations that cannot be predicted. Also it is rare to find a construction project without changes. This leads to the issue of variation order. Variation orders cause time delay, cost overrun, quality defects, and other negative impacts. Moreover, variation orders lead to uncertain flow processes and increase of non value-adding activities which reduce the output value.

This research aims to study the impact of variation orders on performance of repetitive residential units in Egypt by identifying the causes, impact on project performance and the associated non value-adding activities from the point of view of owners, consultants and contractors. A compiled list was prepared regarding variation orders causes, non value-adding activities and impact of variation orders. This was done through an extensive literature review. This compiled list was concluded and adapted to the Egyptian construction industry through seven semi-structured interviews. The interviewees commented according to their experiences to the Egyptian context. Three further interviews with experts were conducted to ensure and confirm the results of the list that has been reached. Subsequently, a questionnaire survey was submitted to the participants and 76 responses were received including 23 owners, 24 consultants and 29 contractors. The data received was analyzed and the

importance index was used for ranking. The analyzed data presents the result of each party independently.

The degree of agreement was measured between different parties and it was noticeable that some conflicting points of view between the owner and the contractor, while good correlation was found between the owner and the consultant.

The overall results indicated that the most three important causes of variation orders for the repetitive residential units in Egypt are change of plans or scope by owner, change of schedule sequence by owner and change in specifications by owner. Moreover, the most significant impacts of variation orders were time overrun, disputes between parties to the contract and professional reputation of one or more parties adversely affected. The study also found that the top five non value-adding activities with variation orders are waiting due to resources problem, rework due to varied works, waiting due to ignorance of specifications, frequent design changes and idling due to the shortage of skilled labor.

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Chapter One

Introduction

1.1 Background

The construction industry is a major contributor to the growth of the nation economy because of its connection with other industries such as metals, cement, etc. Recent events in the Middle East region coupled with reformation of economies are expected to yield an unprecedented growth in construction activities. The Egyptian construction industry has been undergoing a massive growth as Construction is one of the most active sectors of the Egyptian economy. The Egyptian economy growth is highly depending on the country's real estate sector development. In fact, the construction sector is expected to attract investment of around $7.5 billion in 2015 from domestic and foreign investments, making it one of the country's biggest revenue sources. The Egyptian real estate investments have risen since 2001/2002 when it recorded EGP7.9 billion ($1 billion), eventually reaching approximately EGP31.8 billion in 2012/2013. Moreover, in 2013 it accounted for 8.3% of national GDP. The real estate sector is expected to grow from $7.2 billion in 2012 to $12 billion by 2020 (Real estate sector to grow, 2015).

The Egyptian population composition is about 90 million people. In addition, more than half of the Egyptians are under the age of 25. This is one of the major contributors to the booming of the real estate sector. Moreover, the marriages development has increased as the married couples recorded a total of 33-37% of total population. Also the Egyptians live in only 5-7% of the Egyptian total land area. Thereof, the government considers enlarging the inhabited area by residents to be an effective solution to the problem. Accordingly, this increases the demand for more residential projects to take place. Certainly, such expansion in young population which is predicted to double in the next 25 years adds more pressure for the

expanding urbanization. Previously, 27 new urban cities have been built around Egypt, with plans to increase this number to a further 59 cities by the end of 2017 (Real estate sector to grow, 2015). This booming in the real estate sector means more repetitive residential units in Egypt.

The repetitive residential projects consist of a number of similar or identical units. A unit could simply be a typical floor in a high-rise building or a model house in a housing project. Repetitive projects have repetitive activities with identical durations in all units. An example, the housing project, where the same set of activities performed in constructing a typical house is repeated in all housing units within the project. (Moselhi & El-Rayes, 1993).

Construction projects contain complex operations that cannot be precisely determined in advance. One of the major problems facing the construction projects are issuing of variation orders during the construction phase (Mohammad et al., 2010).Variation orders have long been an inherent part of the construction industry. It is hard to spot a construction project being constructed without a change which normally arises as a result of some causes attributed to the different parties involved in the project execution (Alaryan & Elbeltagi, 2014). Therefore, variation order clause is common to be found in construction contracts, to explain how to deal with variation order throughout the project. Construction contract is an agreement that is subjected to variability. The Contractual clauses concerning changes and variations allow the Employer to freely initiate variation order within the scope of work without change the original contract (Enshassi et al., 2010). Variation orders involve alteration, addition, omission, and substitution in terms of design, specifications, schedule, and quantity of work. The causes of variation orders maybe due to the construction parties performance, availability of resources, environmental conditions and involvement of other parties. The time delays, cost overrun and quality defects of construction can be attributed to variation orders at various stages of the project (Enshassi et al., 2010).

The variation according to Enshassi et al. (2010) is defined as "change in construction projects refers to an alteration to design, building works, project programs or project aspects caused by modifications of preexisting conditions, assumptions, or requirements. Also, "a variation order is written order issued to the contractor during execution of the contract by the owner, which authorize a change in the work or an adjustment in the contract sum or even the contract time" (Osman et al., 2009).

The project duration and cost can be uninterrupted if variation orders are managed successfully however, this is not always practically achievable (Ndihokubwayo, 2008**).** A study of delays and cost increases in the construction of private residential projects in Kuwait showed that the more number of variation orders issued during the construction phase the more time and cost overruns as shown in Figure 1.1. The projects that experienced variation orders suffered from more than 58% time delay and cost increases when compared to those with no variation orders. In addition, it was noticed that a variation order generally increases the total cost of the residential projects in Kuwait (Koushki et al., 2005).

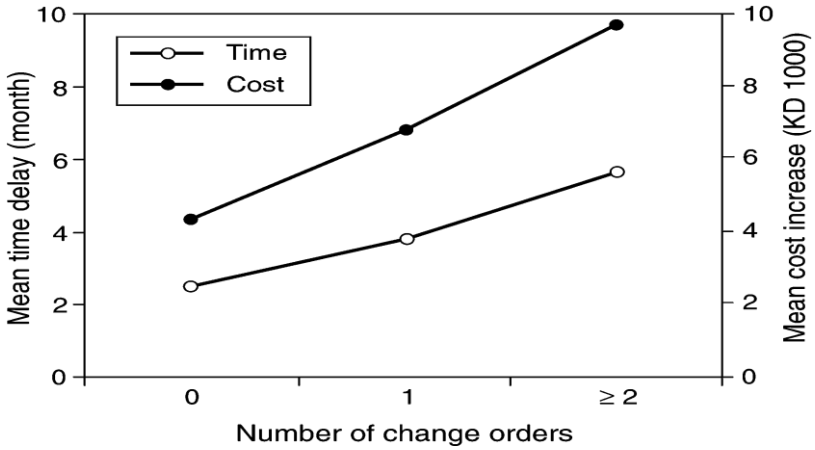

Figure 1.1 No. of variation orders and project time/cost (Koushki et al., 2005)

Every time a variation order is issued, whether leading to additions, omissions, alterations or substitutions, unnecessary costs are likely to be incurred. According to Ndihokubwayo (2008) three types of operations, namely *non value-adding, necessary but non value-adding* and *value-adding* operations. The *non value-adding* activity or waste is an activity that absorbs

resources without adding value to the customer, namely both internal and external customers such as mistakes that require alteration. The *necessary but non value-adding* are necessary tasks that do not directly add to the customer value, but enable delivering the value to the customer. These tasks enable the business to stay such as accounting and legal activities. The *value-adding activity* is to change the form, fit, or function of a product in order to satisfy the customer (Ndihokubwayo, 2008). Unfortunately, the construction industry lacks adequate knowledge to identify and quantify non value-adding activities associated with variation orders.

In a developing country like Egypt where the residential buildings are being upgraded or replaced with newly built ones, the incidence of variation orders on construction projects seems inevitable. Ndihokubwayo (2008) mentioned that a degree of change should always be expected as it is hard for clients to imagine the end product they want. Although it is hard that variation orders can be avoided completely, they can be minimized or prevented if their origin and causes were clearly known (Awad, 2001). The greater the knowledge and awareness of non-value adding activities associated with variation orders, the greater the prediction of their avoidance and consequent reduction of overall construction delivery costs.

1.2 Problem Statement

The research problem may be stated as follows:

Variation orders in the repetitive residential unit construction projects can be unreasonably increase the time and cost of construction especially that the variation might be repeated in many units. The identification of variation order causes might lead to their reduction, possible elimination and subsequent improvement in overall project performance.

1.3 Research Objectives

The main objective of the research is determining the impact of variation orders on the performance of repetitive residential unit projects through:

- Identifying causes of variation orders. This will guide to understand the sources of variation orders and the most important causes of variation orders.
- Identifying the non value-adding activities associated with variation orders. These activities influence the project performance and are not considered from the project parties. Hence, their identification will make the project parties to have more knowledge of their impact on the project.
- Identifying the impact of variation orders on overall project performance. This shall make the project parties aware of the nature of the variation order and to ascertain the most significant impacts of variation orders.

1.4 Research Methodology

To achieve the research objectives the following methodology is adopted:

- A literature review is conducted to acquire a thorough understanding of variation order and its causes, through books and leading construction management and engineering journals. The causes of variation orders, impact of variation orders and variation order non value-adding activities are identified to prepare a compiled list.
- Interviews with experts in the Egyptian construction industry are conducted to modify, add or remove from the list based on their experience. In addition, the experts will adjust and assess the suitability of the selected compiled list to the Egyptian construction industry and the research scope.
- Further interviews are done to verify the appropriateness of the selected list to the Egyptian industry.
- Causes, non value-adding activities and impact of variation orders were set in a questionnaire. Participants in the questionnaire were asked to rank the causes, non value-adding activities and impact of variation orders. The questionnaire was

presented to engineers working in owner companies, consultant project management companies and contracting companies in Egypt.

- Gathered data has been analyzed using statistical analysis method.

1.5 Scope of Research and Limitations.

This research aims to investigate the impact of variation orders on performance of repetitive residential projects in order to take proactive measures to reduce them. This type of projects is considered to be highly demanded in Egypt. Accordingly, the presence of repetitive units can significantly affect the project when there is variation order.

The study will be limited to the private sector repetitive residential projects in Egypt. The targeted projects are for well reputed real estate companies and iconic developers in Egypt. Therefore, caution is to be taken concerning the applicability of research findings to repetitive residential projects as a whole.

1.6 Thesis Content

Chapter One: Introduction- Chapter one covers the overall introduction of the research, the problem statement, the need for the study, objectives and methodology to reach these objectives.

Chapter Two: Literature Review - This chapter explores previous studies related to the causes, impact of variation orders and the non value-adding activities associated with variation orders.

Chapter Three: Data Collection– Discussing the survey approach and the method of collecting data, selecting the appropriate causes from the compiled list and confirming this selection through semi-structured interviews. It also discusses the designing of the questionnaire and the sample size.

Chapter Four: Results and Findings - the overall survey results are presented for each project party. The opinion of each party is presented individually and a degree of agreement between parties was concluded

Chapter Five: Conclusion and Recommendation - Conclusion will be drawn based upon data analysis, linking them to the problem statement and to the objectives of study.

Chapter Two

Literature Review

2.1 Introduction

This chapter reviews the literature on variation orders and it covers the following areas:

- Variation orders types.
- Variation order Processes
- Sources of variation orders
- Causes of variation orders
- Effect of variation orders
- Reduction of variation orders
- Waste associated with variation orders
- Principles for waste reduction
- Variation orders and non value-adding activities

Construction projects are carried out through contracts between the project parties. Clauses in the contract concerning changes give the owner the right to make variation orders. These variation orders must be in the same scope of the original contract. Variation orders can be adding, omitting, substituting or changing works in terms of quantity, quality and schedule. The contractual clause that is permitting variation of works is essential for any construction contract because the contractor could not refuse to carry out the varied works under this clause (Ndihokubwayo, 2008). Sunday (2010) stated that it is unable to avoid variation orders totally; changes to the contract scope are expected as the execution process is in progress even if the project is well planned.

2.2 Variation orders Types

Variation orders may be classified as beneficial or detrimental or, as directed and constructive variation orders.

2.2.1 Beneficial variation orders

The first type which is the beneficial variation orders are those issued to help in decreasing the cost, time, or the degree of difficulty of the project. These beneficial variation orders remove the unnecessary costs from a project and raise the owner benefits (Ndihokubwayo and Haupt 2009). Consequently, a variation order is beneficial if it is issued to improve the client's value.

According to Ndihokubwayo (2008), unnecessary cost found in all designs despite of the goodness of the design. This type of variation orders aim to raise the client's benefits by adding value to the project. On the other hand, non value-adding costs can be found. For instance, discrepancies between contract documents resulted in cancelation of work that has been already done. This should not have been done if there were no discrepancies between the contract documents.

2.2.2 Detrimental variation orders

A detrimental variation order is affecting the owner’s value or the project performance negatively (Enshassi et al., 2010). A client may sacrifice the quality of work when he is facing financial problems. For example, in a desert environment the normal exterior paint will not face the abnormal conditions, so it will result in paint failure.

Contract clause allowing variation of works is a necessary clause in any construction contact because it makes the contractor bound to make additional work

(Ndihokubwayo, 2008). Variation orders need a fast approval to not maximize construction delay and to smoothly complete the project (Duaij et al., 2007)

The owner usually has the right to issue variation order pursuant to the contract between the owner and the contractor. On the other hand, the contractor has the right to claim for time and cost compensation. These types of variation order can be directed or constructive variation order (Klee, 2015).

2.2.3 Directed Variation order

The owner instructs the contractor to perform work that differs from that specified in the contract or is an addition to the work specified. Directed variations are usually issued in compliance with the particular clauses in the contract. This type also may be deductive in nature. For example, the scope of work may reduce from the original scope of works defined in the contract. The contractor after the instruction from the owner will evaluate the required works and will agree with the owner on the time and cost impact (Al-Dubaisi, 2000)

2.2.4 Constructive Variation order

The Constructive Variation is an informal authorizing act or directing a modification by an act or failure to act to the contract. As a result, the contractor will carry out different work rather that defined in the original contract. This may increase the contractor's cost and/or time of performance, which will be considered as a variation order. Constructive variation may be instructed orally but the contractor must confirm the oral instruction into formal written instruction within the time specified in the contract documents in order to be considered (Klee, 2015)

Constructive Variations may include:

- Faulty plans and specifications
- Implanting higher standards than specified in the original specifications
- Change in method of performance
- Change in the programme sequence.

2.3 Contract Instructions

According to Ndihokubwayo (2008) change in any contractual terms of a project that is done by the owner or the owner representative is a variation order. Frequently disputes occur due to variation order as the contract does not show a clear meaning of what may be a variation, and no definition for the variation (Ndihokubwayo, 2008).

In practice, site or architect's instructions have been almost understood as variation orders, but not all the site or architect's instructions are formed to be variation orders (Ndihokubwayo and Haupt, 2009). For instance, a site instruction is issued to the contractor to rework the imperfect work.

According to Table 2.1 not all contract instructions are variation orders. The instruction to change approved design, quantity or quality of the works is a variation order. Moreover, instructions to solve conflict between the contract documents are variation orders. Instructions issued to make sure of the work being executed as stipulated in the contract documents are not variation order. Furthermore, financial adjustment instructions are considered as variation order. On the other hand, instructions to maintain the owner's satisfaction are not variation orders as the original contractual agreement does not change.

Table 2.1 Contract Instructions (Ndihokubwayo, 2008)

No	Instruction category	Qualification
1	To vary the design, quality or quantity of the works	Variation order
2	To resolve discrepancies	Variation order
3	To enforce contractual provisions	Not a variation order
4	To deal with financial allowance	It may be a variation order if monetary adjustments are the result of instruction number 1 and 2
5	To protect the client's interest	Not a variation order

2.4 Variation Order Process

The variation order process generally consists of:

- Identification
- Notification
- Documentation
- Variation Order Proposal
- Negotiation
- Agreement

The identification is the first procedure for the variation order and it happens when there is a change in the contractual provision. Secondly, notification for variation order is followed by documentation. After that, the contractor starts to make analysis for the time and cost impact. The contractor will submit the variation order proposal

to the consultant; the final process is negotiations between project parties before reaching an agreement (Awad, 2001).

2.4.1 Identification of variation orders

Identification is the first stage of the variation order process; in which awareness of the contract documents and understanding of legal and technical terms are essential for identification. This identifies the reasons for changes whether the owner is directly asking for change or the contractor is asking for variation order (Levin, 1998).

2.4.2 Notification of variation orders

The contractor must notify the client in a written and official way of his intention to issue a claim asking for a variation order. This can be followed by the escalation in the cost value or a time extension or both (Levin, 1998).

2.4.3 Documentation of variation orders

Documentation is essential to confirm variation orders, documents can be as follows (Awad, 2001):

- Daily reports, including weather conditions, materials delivered, problems, subcontractors, manpower, equipment.
- project schedule submitted by the contractor and approved by the owner, and schedule updates should be maintained
- Request for information (RFI) logs
- Minutes of meeting for the Progress meetings.
- Invoices from the owner.

Documents are very important during any negotiations between owner and contractor as it is the main supports for claims and variation orders.

2.4.4 Variation Order Proposal

The variation orders elements should consist of summary, contract clause reference, letters, schedule analysis and cost analysis. These elements are necessary to be submitted with the variation order as contemporary records to substantiate the variation order (Awad, 2001).

2.4.5 Negotiations

The objective of successful negotiations is to be based on collaboration and respect. Also the contract documents should state the dispute resolution method to solve any dispute that could not be solved by amicable solutions (Awad, 2001).

Mostly, variation orders are issued in written or oral instruction by the owner's representative or the engineer. Consequently, it must be confirmed in a written form (Charoenngam, 2003).

If the variation order is accepted by the contractor, the contractor and the consultant should agree upon the method of valuation of variation order. This method may be in the form of (Ndihokubwayo, 2008):

- Unit Rates adopted from the contracted rates, where the varied works are of similar nature, scope and constructed as similar as items in the contract.
- Payment of executed works on basis of calculating the main cost of works including materials, labor, equipment and percentage addition as agreed between parties to the contract.
- Contractor submits a Quotation to the work in the variation order.
- Quantum meruit is a varied method as the negotiated or agreed rates or payments are made on a reasonable sum.

2.5 Sources of Variations Orders

A research on the potential causes of variation orders found that the main sources of causes are four origin sources. Those are the owner, consultant, contractors and others (Ndihokubwayo, 2008)

2.5.1 Owner

The owner of a project has a major influence on the occurrence of variation orders, starting from the inception design ending to the final execution phase. Owners set up the scope of work, objectives from the projects and quality of work required. Throughout the execution phase, owners issue variation due to many reasons which will be discussed later. Owners can be divided into two categories, the first are owners that have experience and knowledge in the construction industry and the other category are those who have a limited or without experience. Experienced owners are involved from the design phase of the project; this contribution help in decreasing number of variation order during the execution phase (Alsuliman et al., 2012).

Many unnecessary variations take place due to poor involvement from the owner and designer at design phase (Chan & Yeong, 1995). Owners with limited or without experience in construction industry will not be able to follow the design with designer to be sure their requirements are completely met. The project objectives must be adequately defined; this will decrease the variation orders resulting from owners changing their minds (Ndihokubwayo, 2008).

2.5.2 Consultant

Normally, consultant responsibilities in a construction project are identified in an agreement between the owner and the consultant. Consultant team may include architects, specialist engineers, and cost consultants (Ndihokubwayo, 2008). Design

defects increase the prevalence of project variation order and eventually lead to client's dissatisfaction (Acharya et al., 2006). Problems found by the contractor due to confusing design and insufficient details must notify the consultant for clarification. The respond from the consultant should not exceed the specified time mentioned in the contract. According to Ndihokubwayo (2008), it is not possible that the consultant is aware of all new materials and products continuously entering the market. This can be a variation when such new material or products are selected and instructed to the contractor.

2.5.3 Contractor

In traditional construction delivery method, the contractor is obliged to build according to the design done by the design professional. The contractor is liable for all the costs related to achieve the project as mentioned in the specifications. Moreover, the contractor is responsible for informing the consultant when a technical problem is detected that can lead to a variation order (Ndihokubwayo, 2008). Alternative construction methods may be proposed by the contractor from his experience to inform the consultant that the original method will not perform the desired design. This can be a variation order. For example, a roof leakage resulted from design problem in school building would have been avoided if the contractor was aware and gave alternatives to the consultant (Acharya et al., 2006).

2.5.4 Other Sources

These are situations beyond the control of the contractual parties that give a rise of variation orders such as conditions of weather, change of country regulations and unforeseen problems (Ndihokubwayo, 2008).

2.6 Causes of variation order

Variation orders cannot be avoided completely. Previous studies related to variation orders have mainly focused on the causes. A study was performed by preparing a wide-ranging list of 26 factors responsible for variation causes from a review of previous works and survey views of various specialists and experts of more than 20 years' experience in the field, to identify the causes and impacts of variation orders in roadway construction projects south of Iran. The overall rankings of top causes were determined by evaluation of the mean rank score through the use of Statistical Package for Social Science (SPSS) version 18 (Ismail et al., 2012). It was found that the top cause of variation was changing the scope or plan by the employer. Also design errors and owner's financial problems were on the top causes found for variation orders (Ismail et al., 2012).

According to Sunday (2010) 53 causes of variation order were identified. A questionnaire survey listed the 53 causes and distributed among 58 participants. The survey was distributed among different project parties representing 25 projects, only 48 responded. The respondents were 30 respondents representing the employer, 10 representing consultants and 18 representing contractors. This study has shown that the most causes of variation orders due to consultants were inadequate workings drawing details, design discrepancies, and conflicts between contract documents. Furthermore, the most contributed causes of variation orders by the owners were change of scope, slow decision process and insufficient project objectives. Moreover, the causes of variation orders due to contractors were lack of skilled labor, different site conditions and contractor's desired profitability.

A study conducted by Mohammad et al. (2010) to identify the significant causes of variation order through a questionnaire survey in States of Selangor Malaysia in

construction building projects. The first section was obtaining the respondent information and the second was focusing on identifying causes of variation orders. The respondents were requested to rank the causes of variation orders according to their knowledge and experience in the construction industry for projects completed between years 2000 to 2005. It was found that the most important causes were caused by the owner as 65% of the respondents ranked the change of plan by owner as their first cause, followed by 47% respondents for client substitution of materials. Also design changes by consultant were ranked as third important cause.

Enshassi et al. (2010) investigate the top causes of variation orders in construction projects in Gaza Strip. This was done through a questionnaire survey which includes 64 well recognized causes of variation order in Gaza strip. The questionnaire was given to 20 clients, 30 consultants, and 50 contractors as to start ranking the importance of each cause. The first top important cause of variation order in Gaza strip was the lack of materials and spare parts of equipment because of closure. The design change by consultant was the second important cause. Thirdly, was the lack of consultant's knowledge of available materials and equipment.

Halwatura and Ranasinghe (2013) conducted a study as to be able to reveal the significant possible variation orders causes in road construction projects in Sri Lanka. This was done through a questionnaire survey for experts in the road construction industry. There were 50 participated respondents were asked to rank 33 identified causes. It was found according to the survey that the first ranked cause was the poor estimation as the consultants do not carry out enough investigation and estimation in the design stage. The second cause was the unforeseen site condition. Moreover, during the construction stage the political pressure was identified as the third cause. The case study found the top three important causes same as the questionnaire survey.

A research was done in Oman to be able to identify the most important causes of variation orders (Alnuaimi et al., 2010). This research was done by field survey through questionnaire to find the different project parties opinion. The survey was distributed among respondents in which they were 30 owners, 20 consultants and 25 contractors. The received responses from respondents were collected and ranked according to the relative importance index. It was found that all parties agreed that the first cause was owner instructs further works. Owner instructs adjustment to design was ranked as the second cause. The "Non availability of construction manuals and procedures for project construction in Oman" was the third significant cause ranked by the project parties in Oman.

Based on the literature review there are many causes of variation orders which were identified by many researches. Table 2.2 shows 42 causes of variation order based on the findings of literature review.

Table 2.2 Causes of variation order

Causes of variation order	Sunday (2010)	Memon et al. (2014)	Ndihokubwayo (2008)	Ismail et al. (2012)	Mohammad et al. (2010)	Halwatura and Ranasinghe (2013)
Ambiguous design details	√		√			
Change in design by consultant	√				√	
Change in economic conditions/government regulations			√			
Change in specifications by owner	√					
Change of plans or scope by owner	√			√		
Change of schedule by owner	√					
Complex design and technology	√					
Conflicts between contract documents	√		√			
Consultant's lack of required data	√					
Contractor's desire to improve his financial situation					√	√
Contractor's lack of judgment and experience	√					
Contractor's lack of required data	√					
Defective workmanship	√		√			√
Design complexity	√	√	√			
Differing site conditions	√		√	√	√	
Errors and omissions in design	√		√	√	√	√
Fast track construction	√		√			
Impediment in prompt decision making process	√		√			
Inadequate project objectives			√			
Inadequate scope of work for contractor						
Inadequate shop drawing details			√			
Inadequate working drawing details		√	√			
Lack of a specialised construction management			√			
Lack of communication	√		√			
Lack of consultant's judgment and experience	√					
Lack of consultant's knowledge of available materials and equipment	√					
Lack of contractor's involvement in design	√					
Lack of coordination	√		√			
Lack of modern equipment	√					
Long lead procurement	√		√			

Obstinate nature of one or more of the parties to the contract			√			
Obstinate nature of owner	√	√				
Owner's financial problems	√	√			√	
Poor procurement process	√	√	√			
Replacement of materials or procedures			√			
Safety considerations	√					√
Shortage of skilled manpower	√	√				
Technology change	√		√	√		√
The contractor's financial difficulties					√	√
Unfamiliarity with local conditions	√					
Unforeseen site conditions						√
Weather conditions	√		√	√	√	√

2.7 Effects of variation orders

The effects of variation orders can be categorized into five categories, time, cost, quality, organization-related effects, and other effects (Keane et al., 2010).

Delay in project completion duration because time extension is usually a result of variation orders as the client will give the contractor a time extension approval due to the impact of the variation order. Time is very critical for owner; for example, when a university project is delayed for months, the study will be affected.

A study was performed by Al-Dubaisi (2000) shows that variations in construction projects result in increasing the cost by 6% to 10% from the original contract amount. Also rework and demolition of work as it can be summarized as follows (Al-Dubaisi, 2000):

- Cost for labor to demolish of existing work
- Cost for Equipment to demolish of existing work
- Cost for engineering to demolish of existing work

Variations also affect the labor efficiency, a study was conducted found that it is possible to execute changes without affecting the labor efficiency negatively however,

30% loss of efficiency was due to work progress disruptions (El Nemr, 2001). Moreover, variations can adversely affect the work quality if it was frequently (Keane et al., 2010).

Variations affect the organization due to construction disputes between the owner and the contractor (El Nemr, 2001). Also expert relations on project can be affected which will lead to disputes (Keane et al., 2010). Other effects from variation order include the work progress; the work progress can be affected but without causing time delay. The adverse effect on time because of variation can be compensated by acceleration of work progress.

Table 2.3 summarizes the effects of variation orders in the construction projects.

Table 2.3 Effects of variation orders (Keane et al., 2010)

Cost-related effects	Increase in overhead expenses
	Additional payment for contractor
	Rework and demolition
Quality-related effects	Quality degradation
Time-related effects	Delay in payment
	Procurement delay
	Rework and demolition
	Completion schedule delay
Organization and its reputation-related effects	Poor safety conditions
	Poor professional relations
	Dispute among professionals
Other effects	Progress affected without delay

Table 2.4 shows the impact of variation orders that affect the project based on the literature review.

Table 2.4 Impact of variation orders

Impact of variation orders
Time overrun
Time reduction
Cost overrun
Additional specialist equipment/personnel
Optimum cost reduction
Degradation of heath & safety
Additional health & safety equipment/measure
Disputes between parties to the contract
Professional reputation of one or more parties adversely affected
Degradation of quality standards
Quality standards enhanced

2.8 Reduction of variations

The reduction of construction variation orders improves the project performance in terms of time and cost. According to Chan and Yeong (1995) variation orders can be reduced as follows:

- Full site investigation improves and increases the chance of completion of the project on time and within budget
- Through clear brief of project as an inadequately prepared project brief is a main source of project performance

- Avoid the nominated subcontractors as for the client it may be the lowest contract price but many conflicts and poor coordination may arise between the general contractor and the nominated subcontractors.
- Risk sharing by use alternative contractual arrangements which will increase the project performance and decrease claims and variations.
- Comprehensive contract documentation so that all the information well be available to the project parties
- Project parties cooperation and good relations will solve project differences and decrease claims appearance.

2.9 Waste associated with variation orders

According to Ndihokubwayo and Haupt (2009) waste in construction is defined as ineffectiveness that affects the use of labor, material, and equipment. This can result in cost increase more than the amount considered for the construction. The non-productive recourses arise from variation order work disturbance are considered waste. The losses of material happened through the construction phase have been referred as a waste. Nevertheless, the contractor considers an acceptable waste percentage in material by his estimator during the tender stage and it differs from material to another (Ndihokubwayo and Haupt, 2009). For instance, the waste percentage in ceramic tile is higher than the percentage assigned for the door frame. Waste related to variation order may be found as follows (Ndihokubwayo, 2008):

- Demolition of an approved work that is due to a variation order will consequently result in waste of time and cost. For example, wall demolition after execution in order to change the design will result in cost and time impact.

- Waste arise when material for a specific use is ordered and to be used for another purpose; this is called a compensate waste. For an example, when external façade paint is used for the internal painting due to shortage in the internal paint.
- Waste resulted from recourses being idle and non-productive due to variation order. The waste from non-productive recourses was estimated to be more than 10% of the project's construction cost.
- Project consultant wrong decision inspection of works will result in material waste.
- Material waste due to incorrect use of material or faulty specified material.

2.10 Principles for waste reduction

Two principles were identified by Koskela and Vrijhoef (2000) regarding waste reduction, the first is time compression and variability reduction is the second. Time and cost overruns are directly proportional with the number of variation orders in construction projects (Awad, 2001). According to Chan and Yeong, (1995) reducing the number of variation orders is fundamental to keep the time and cost of a project as planned. The lean production is a system for the continuous work flow in which every stage depends on the previous stage; waste is decreased by decreasing the no value-adding activities to the product (Ndihokubwayo, 2008). According to Ndihokubwayo (2008), lean production was initially made for companies seeking just-in-time (JIT) system. There are concepts and tools for the construction industry have developed for mitigating the disturbance of workflow. These included the lean construction concept and work techniques for scheduling. The JIT application into the construction is different from the manufacture process as construction has more complex and uncertainty. Also it has been debated that the construction industry still unable to differentiate the

characteristics to distinguish the construction from other industries. There are some characteristics that should be followed as to be able to distinguish construction from other industries; these characteristics are (Ndihokubwayo, 2008):

- The physical nature of the product.
- The product is usually manufactured on the client's site.
- The construction process organization.
- The price determination method.

2.11 Variation orders and Non value-adding activities

The term non value-adding activity issued to differentiate between physical construction waste found on-site and other waste that occurs during the construction process. This type of waste also can be mentioned as intangible waste, in-directs waste. Koskela (2000) stated that every time a task is divided into two subtasks executed by different specialists the non value-adding activities increases; when variation order is issued the inspecting, moving and waiting time increase. Non value-adding activities are changing the product in a way which is not valued by the customer. Those activities are consuming time, resources or space without adding value to the product (Alarcon, 1995). For instance, rework activities because of poor quality are classified as non value-adding activities .These frequent non value-adding activities increase the cost due to the unplanned travelling and communication expenses, labour waiting time, demolitions of work done and the time taken for designers to know the required change and make the necessary design (Ndihokubwayo, 2008). These represent the non value-adding activities with variation orders. Focusing on reducing the variability of work may lead to improve the work performance. Moreover, responding to variability in a flexible way may improve performance by allowing rapid needed changes. Furthermore, trying to eliminate and

control variation order is a significant part of project management in construction (Ndihokubwayo, 2008). According to Alarcon (1995) in a housing project the rework was the top waste found, which was resulted from deficiencies in the quality assurance system, particularly in dealings with subcontractors. Also activity delay and interruption were found to be important as it affects the material process. Table 2.5 shows the non value-adding activities that were found from literature review that can be associated with the variation order.

Table 2.5 Non value-adding activities

DESIGN
Frequent design changes
Redesign due to Design errors
Waiting due to Lack of design information
Waiting due to Slow drawing distribution
Redesign due Complicated design
Redesign due Inexperience designer
Redesign due Interaction between various specialists
Frequent design changes
HANDLING
Damage due to Wrong material storage
Damage due to Poor material handling
Damage during material transportation
Waiting due to Poor quality of materials
Waiting due to Equipment failure
Waiting due to Delay during delivery
Waiting due to Tools not suitable
Labor
Rework due to Labor's mistakes
Idling due to Incompetent Labors
Idling due to Poor attitudes of Labors
Rework due to Damage caused by Labors
Idling due to Insufficient training for Labors
Idling due to Lack of experience
Idling due to Shortage of skilled Labors
Waiting due to Inappropriate use of materials
Too much overtime for workers for non-value adding activities on site
MANAGEMENT
Waiting due to Poor site management/Controlling
Waiting due to Inappropriate construction methods
Waiting due to Poor information quality
Waiting due to Late information flow among parties

Waiting due to Scarcity of equipment
Waiting due to Resources problem
Rework due to varied works
Waiting due to Inspection
Waiting periods for instructions on varied works
Waiting due to Communication problems
Waiting due to old-fashioned equipment
Waiting due to Non availability of equipment
SITE CONDITION
Waiting due to Ordering errors
Extra materials on site
Waiting due to Poor site condition
Waste resulting from packaging
Waiting due to overcrowding of the site
PROCUREMENT
Waiting due to Ordering errors
Waiting due to Error in shipping
Waiting due Mistakes in quantity surveys
Waiting due to Ignorance of specifications
Waiting for Material replacement
EXTERNAL
Waiting due to Effect of weather
Accidents due to Lack of safety
Waiting due to Stolen material or equipment
Waiting due to Damages caused by third parties
Waiting due to Unpredictable local conditions

The literature review was discussed in this chapter presents the most discussed topics in variation orders. The purpose of the literature review is to introduce the topic of variation orders. Moreover, through literature review the variation orders causes, impacts and non value-adding activities were presented. Also the list obtained from the literature review will be presented to the experts through interviews in the next chapter. Through the literature review, it was found that there are few researches for the repetitive units projects. These researches were not considering the variation orders. In addition, there was no research found regarding the repetitive residential projects in Egypt.

Chapter Three

Data Collection

3.1 Introduction

This chapter discusses the data collection in order to achieve the research objective of determining the impact of variation order on the performance of residential receptive unit project through determining the causes of variation order, the non value-adding activities and the effect of variation order on the project. The data was collected through two stages, the first stage was interviewing experts of construction industry in Egypt and the second stage was a questionnaire survey. Interviewing experts designed to adjust the selected list obtained from the literature review for the repetitive units in Egyptian construction industry. Subsequently, the questionnaire survey was conducted to rank the causes of variation order in the repetitive units in Egypt, the significant waste that is associated with the variation order and effect of variation order on the project. The questionnaire design, the sample size and the survey approach are discussed through this chapter.

3.2 Expert Interviews

Interview is a useful method of obtaining information and opinions from experts during the early stages of the research (Ndihokubwayo, 2008). Basically, there are three fundamental types of interviews: structured, semi-structured and unstructured. The structured interview is controlled by the interviewer through asking pre-defined questions and collecting answers with little or no variation. Also there is no following-up questions that warrant further elaboration. In an unstructured interview

the interviewers raise a topic briefly and collect the reflections of the respondent. This type is usually time-consuming (often lasting several hours) and can be difficult to manage. In addition, the lack of predetermined interview questions provides little guidance on what to talk about. Semi-structured interview lies between the two mentioned types, were the interviewer raises a topic and approach it through asking questions that probing more details. This allows the interviewer or interviewee to diverge in order to pursue an idea or response in more detail.

The causes of variation order, impacts and non value-adding activities have previously shown stemming from researches conducted in other countries, a degree of changeability with the Egyptian construction industry and the project type might be expected. Therefore, these had to be reviewed to fit with the scope of the research in Egypt. Seven interviews were conducted with experts in the construction industry to adapt the selected list of causes, impacts and non value-adding activities within various stages of construction projects to the Egyptian context. A further three interviews were conducted to ensure the saturation of sample where new interviews are not developing new ideas. The sample was targeting experts with contracting and consulting experience, each with a minimum experience of 15 years in construction industry. Table 3.1 shows the list of the experts participants.

Table 3.1 Experts Participated in the Interviews

Organization	**Participants Position**	**Years of Experience**
Owner	Quantity Surveyor Manger	Over 20 Years
Owner	Project Manager	Over 20 Years
Owner	Resident Engineer	Over 20 Years
Consultant	Resident Engineer	Over 15 years

Consultant	Quantity Surveyor Manager	Over 15 years
Consultant	Assistance Resident Engineer	Over 15 years
Contractor	Project Control Director	Over 20 Years
Contractor	Project Control Manager	Over 20 Years
Contractor	Project Manager	Over 20 Years
Contractor	Planning Manager	Over 15 years

The format of the interviews was a semi structured interview design to guarantee the consistency of the research while allowing the researcher a degree of flexibility in wording in driving information from the interviewee (Samy 2013). The compiled list obtained from the literature review was subjected to questions like "Do you think, from your experience with variation orders," and "Are there any other causes you might want to add?"The interview outcome of the final list of causes within various stages of construction projects are shown in Table 3.2.

3.2.1 Interviews Outcomes

The interviews resulted in a list of 37 causes of variation order that found to be relevant for the Egyptian repetitive units construction projects. During the interviews, some of the causes and non value-adding activities descriptions were slightly changed and some were removed as they were not fitting to the Egyptian repetitive units construction projects. The interview outcome concerning each cause of variation order in the final list of causes resulting from interviews is shown in Table 3.2.

Table 3.2 Interviews outcomes on causes of variation order in repetitive residential units.

No	Causes of variation order	Expert feedback
1	Change in design by consultant	Suitable
2	Errors and omissions in design	Suitable
3	Conflicts between contract documents	Suitable
4	Inadequate scope of work for contractor	Suitable
5	Technology change	Not Suitable
6	Lack of coordination	Suitable
7	Design complexity	Suitable
8	Inadequate working drawing details	Not Suitable
9	Inadequate shop drawing details	Suitable
10	Lack of Consultant's of judgment and experience	Suitable
11	Lack of consultant's knowledge of available materials and equipment	Suitable
12	Consultant's lack of required data	Suitable
13	Obstinate nature of one or more of the parties to the contract	Suitable
14	Change of plans or scope by owner	Suitable
15	Ambiguous design details	Suitable
16	Change of schedule sequence by owner	Suitable
17	Owner's financial problems	Suitable
18	Inadequate project objectives	Suitable
19	Replacement of materials or procedures	Suitable
20	Impediment in prompt decision making process	Suitable
21	Obstinate nature of owner	Not Suitable
22	Change in specifications by owner	Suitable
23	Complex design and technology	Suitable
24	Contractor's lack of required data	Suitable
25	Lack contractor's involvement in design	Suitable
26	The contractor's financial difficulties	Suitable
27	Contractor's desire to improve his financial situation	Suitable
28	Lack of modern equipment	Suitable
29	Unfamiliarity with local conditions	Suitable
30	Lack of a specialised construction management	Suitable
31	Fast track construction	Suitable
32	Poor procurement process	Suitable
33	Lack of communication	Suitable

34	Contractor's lack of judgment and experience	Suitable
35	Shortage of skilled manpower	Suitable
36	Differing site conditions	Suitable
37	Defective workmanship	Suitable
38	Long lead procurement	Suitable
39	Weather conditions	Not Suitable
40	Safety considerations	Suitable
41	Change in economic conditions/government regulations	Suitable
42	Unforeseen site conditions	Suitable

The causes that were found "Not Suitable" were removed from the questionnaire survey as these causes were found to be not suitable in the Egyptian residential repetitive units construction projects from Expert's opinion because:

1- "Technology change" this cause is not suitable due to the technology needed for this type of projects especially in Egypt is not such high.
2- "Inadequate working drawing details" this cause is not suitable as it cannot be a reason of variation and it should be under the "Shop drawing details".
3- "Obstinate nature of owner" this cause should be removed as it is same as "Obstinate nature of one or more of the parties to the contract" to avoid duplication of causes.
4- "Weather conditions "this cause in not suitable in Egypt as the weather is predictable almost all the year so it will not be a cause of variation order.

The list for variation order impacts and the non value-adding activities obtained from literature review was found to be suitable in Egypt for this type of projects.

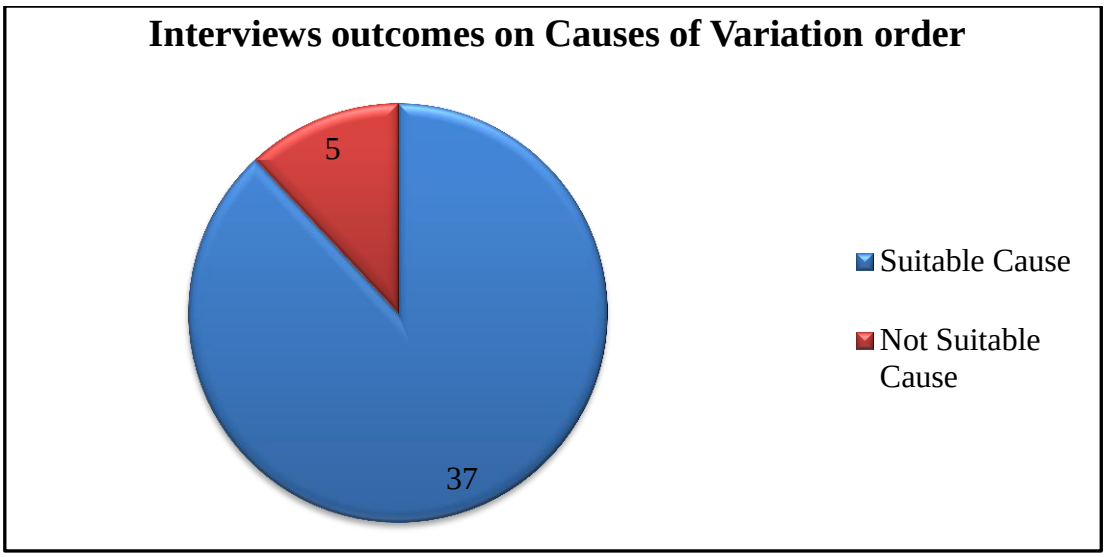

Figure 3.1 Interviews Outcomes on Causes of Variation order

3.3 Questionnaire Survey

One of the methods for research in the field of construction management is obtaining answers for particular survey questions through performing questionnaires and interviews. The research method is selected based on the scope and the depth of the research required, the research can vary from board and shallow to a narrow and deep research, or it could lie in an intermediate position in between the mentioned boundaries (Samy, 2013). A questionnaire enables a researcher to organize the questions and receive replies without actually having to talk to every respondent.

3.3.1 Closed-ended questions

Respondents were restricted in the way they answered the questions as they were required to select one answer from a set of choices. Closed-ended questions, as they give 'ready-made' categories within which respondents answer to the questions asked by the researcher, help to ensure that the information needed by the researcher is obtained (Ndihokubwayo, 2008).

3.3.2 Questionnaire Design

The questionnaire was divided into two parts Part one includes participant personal information i.e. Name, Occupation, Company Name, Type of Organization, Experience, Age and Gender. Part two includes three questions as the causes of variation order, impacts of variation order on project performance and the associated non value-adding activities with variation order.

The first question addresses causes leading to variation orders in the receptive residential units. A list of major causes of variation orders as confirmed from the interview stage is presented. The respondent is asked to state the degree of importance for each cause according to a five-point Likert scale ranging from 1to 5. This was adopted to capture the opinion of respondents, which the participants are asked to choose from five choices the most important corresponds to "Extremely Significant" whereas the least important correspond to "Not Significant".

The second question addresses the possible impacts of variation orders. The respondent is asked to indicate the impact of variation orders on the projects. Responses in this section are given on a 5-point scale starting with "Always" and ending with "Never".

The third question addresses the non value-adding activities associated with variation orders according to their degree of importance using the important scale. A list of non value-adding activities that were confirmed from the interview stage is presented. The respondent is requested to state the degree of importance for each activity according to five-point Liker scale. Participants are asked to choose from five choices the most important activity corresponds to "Extremely Significant" whereas the least important correspond to "Not Significant".

3.3.3 Sampling Approach

The questionnaire was distributed among participants representing the different specializations of owners, consultants and contractors working in different positions. Snowball technique was used in selecting participants where participants were selected based on recommendations of existing participants; such technique is widely accepted in recruiting and selecting participants in focus groups, interviews and surveys (Samy, 2013). The questionnaires were e-mailed or handed to the participants.

A total of 100 questionnaire sample was distributed, Out of the distributed questionnaires, 76 responses were 23 owners, 24 consultants and 29 contractors as shown in Figure 3.2.

The sample size was checked using the following formula where S is the sample size and E is the standard error (Easterby-Smith, Lowe and Thorpe, 2002). This method was adopted for similar studies in Egypt.

$$\mathbf{S = \frac{2500}{E^2}}$$

Where

S = Sample size

E = Standard error

For a sample size equals 76 the standard error would be 5.74 % which could be considered acceptable as the value of the standard error is above 0.05 and below 0.10 (Bassioni.et al., 2007)

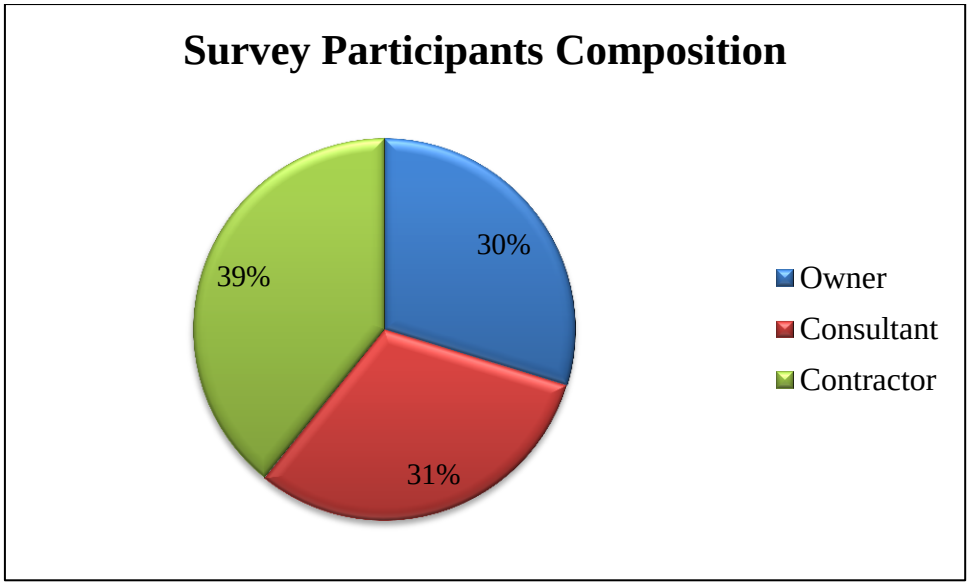

Figure 3.2 Participants Composition

In this chapter, a list was developed based on the literature reviewed to determine the impact of variation order on the performance of receptive residential units project. Through determining the causes of variation order, determining the non value-adding activities and the impacts of variation order on the project performance. The data was collected through two stages, firstly was interviewing with experts of construction industry in Egypt to be able to adapt list for the Egyptian industry. Secondly, was the stage of the questionnaire survey to be able to analysis the data. The developed list was presented to experts through interviews to assess the adaptability towards the Egyptian context based on their perception. The modifications proposed through the interviews were considered to develop a list, which was distributed among participants in a questionnaire survey to collect the data required for the analysis.

Chapter Four

Results and Findings

4.1 Introduction

The purpose of this chapter is to analyze the gathered data from the previous stage of the research. In addition, the analysis methodology and survey results are going to be discussed. Egyptian construction industry practitioners who have participated in the questionnaire were asked to determine level of importance through the survey. Based on the gathered data the variation order causes, impacts and non value-adding activities will be ranked according to their importance index.

4.2 Relative Importance Index (RII)

The Relative Importance Index (RII) method was used for similar studies to determine the relative importance of various factors (Enshassi et al., 2010). The RII method is used for this study to find out the relative importance of the various causes, impacts and non value adding activities of variation orders based on responses from various groups; owners, consultants, and contractors. The five point scale, ranged from 1 (Not Significant) to 5 (Extremely Significant) was adopted and transformed to relative importance index using the following equation:

$$\boldsymbol{RII} = \frac{\sum \mathrm{W}}{AxN}$$

where: *W* is the weight given to each factor by the respondents and ranges from 1 to 5; *A* – the highest weight = 5; *N* = the total number of respondents. The RII was used to rank the different causes, impacts and non value-adding activities of variation orders in order to cross-compare the relative importance of the factors as perceived by

the three groups of respondents. The RII is also used to rank the groups of questionnaire (owner-related, consultant related, and contractor related) by calculating the overall relative importance index of all factors in the group.

4.3 Results of Variation Orders Causes

In order to examine the causes of variation orders by each party individually; the owners, consultants and contractors data were divided and analyzed independently. This process helps determining the level of agreement degree between different parties.

The following subsections show the causes of variation orders from each party's opinion and the overall results.

4.3.1 Owner Results

Table 4.1 presents the RIIs, ranks and standard deviation (SD) of each cause based on owner responses received

Table 4.1 Owner Responses Results

Rank	Causes of variation order	RII	SD
1	Change of schedule sequence by owner	0.861	6.23
2	Change of plans or scope by owner	0.843	4.67
3	Owner's financial problems	0.835	4.45
4	Change in design by consultant	0.774	4.56
5	Impediment in prompt decision making process	0.774	3.78
6	Change in specifications by owner	0.774	4.56
7	Lack of coordination	0.730	3.85
8	Contractor's lack of required data	0.626	4.45
9	Consultant's lack of required data	0.609	3.97
10	The contractor's financial difficulties	0.609	4.45
11	Ambiguous design details	0.600	5.18
12	Inadequate project objectives	0.591	3.05
13	Long lead procurement	0.591	3.85
14	Conflicts between contract documents	0.583	4.10
15	Errors and omissions in design	0.530	4.34
16	Inadequate scope of work for contractor	0.530	4.62

17	Inadequate shop drawing details	0.530	4.34
18	Change in economic conditions/government regulations	0.530	5.18
19	Poor procurement process	0.513	3.65
20	Lack of communication	0.513	4.22
21	Unforeseen site conditions	0.513	3.44
22	Contractor's desire to improve his financial situation	0.504	3.65
23	Contractor's lack of judgment and experience	0.504	5.41
24	Lack contractor's involvement in design	0.487	2.88
25	Shortage of skilled manpower	0.487	3.65
26	Replacement of materials or procedures	0.478	3.85
27	Differing site conditions	0.461	4.98
28	Obstinate nature of one or more of the parties to the contract	0.443	4.56
29	Fast track construction	0.443	3.44
30	Defective workmanship	0.443	3.85
31	Lack of consultant's knowledge of available materials and equipment	0.435	3.36
32	Lack of a specialised construction management	0.435	4.77
33	Design complexity	0.409	3.58
34	Lack of modern equipment	0.400	4.16
35	Safety considerations	0.400	4.67
36	Consultant's of judgment and experience	0.391	4.22
37	Unfamiliarity with local conditions	0.383	4.34

As shown in Table 4.1, the top five most important causes of variation orders in residential repetitive unit construction projects in Egypt as received by respondents include Change of schedule sequence by owner, Change of plans or scope by owner, Owner's financial problems, Change in design by consultant and Impediment in prompt decision making process.

"Change of schedule sequence by owner" is the most important cause of variation order from the owner perspective as it was ranked the first with RII = 0.861. "Change of plans or scope by owner" is ranked the second important cause with RII= 0.843. The fifth important cause is "Impediment in prompt decision making process." With RII=0.774.

4.3.2 Consultant Results

Table 4.2 presents the RIIs, ranks and standard deviation (SD) of each cause based on Consultant responses received.

Table 4.2 Consultant Responses Results**.**

Rank	Causes of variation order	RII	SD
1	Owner's financial problems	0.883	5.63
2	Change of plans or scope by owner	0.867	6.38
3	Change of schedule sequence by owner	0.858	5.89
4	Replacement of materials or procedures	0.842	5.63
5	Contractor's desire to improve his financial situation	0.842	6.38
6	Conflicts between contract documents	0.825	4.55
7	Change in specifications by owner	0.817	5.76
8	Errors and omissions in design	0.583	6.61
9	Lack of coordination	0.567	4.76
10	Obstinate nature of one or more of the parties to the contract	0.558	6.38
11	Contractor's lack of judgment and experience	0.558	5.63
12	Impediment in prompt decision making process	0.542	5.36
13	The contractor's financial difficulties	0.542	5.07
14	Change in economic conditions/government regulations	0.533	5.22
15	Inadequate shop drawing details	0.525	6.22
16	Inadequate project objectives	0.525	4.76
17	Contractor's lack of required data	0.525	5.45
18	Unforeseen site conditions	0.525	5.72
19	Long lead procurement	0.500	6.22
20	Lack of communication	0.483	5.81
21	Poor procurement process	0.475	6.91
22	Shortage of skilled manpower	0.467	5.22
23	Differing site conditions	0.450	4.87
24	Ambiguous design details	0.425	5.45
25	Change in design by consultant	0.417	4.44
26	Consultant's lack of required data	0.417	4.44
27	Inadequate scope of work for contractor	0.400	4.55
28	Lack of consultant's knowledge of available materials and equipment	0.400	5.02
29	Lack of a specialised construction management	0.400	4.55
30	Consultant's of judgment and experience	0.392	4.76
31	Unfamiliarity with local conditions	0.383	4.60
32	Defective workmanship	0.367	4.76
33	Safety considerations	0.367	4.76
34	Design complexity	0.350	5.02

35	Lack contractor's involvement in design	0.333	7.16
36	Lack of modern equipment	0.292	6.61
37	Fast track construction	0.292	6.61

Table 4.2 shows the top five most important causes of variation orders in repetitive residential unit construction projects in Egypt are Owner's financial problems, Change of plans or scope by owner, Change of schedule sequence by owner, Replacement of materials or procedures and Contractor's desire to improve his financial situation.

"Owner's financial problems" is the most important cause of variation order from the consultant perspective as it is ranked the first with RII = 0.883. "*Change of plans or scope by owner"* is ranked the second important cause with RII= 0.867. The fifth important cause is "*Contractor's desire to improve his financial situation*." With RII= 0.842.

4.3.3 Contractor Results

Table 4.3 presents the RIIs, ranks and standard deviation (SD) of each cause based on Contractor responses received.

Table 4.3 Contractor Responses Results.

Rank	Causes of variation order	RII	SD
1	Change of plans or scope by owner	0.890	7.50
2	Change in specifications by owner	0.869	6.57
3	Errors and omissions in design	0.855	9.18
4	Change of schedule sequence by owner	0.834	6.65
5	Change in design by consultant	0.800	4.66
6	Fast track construction	0.800	4.97
7	Lack contractor's involvement in design	0.703	3.42
8	Replacement of materials or procedures	0.621	4.55
9	Unforeseen site conditions	0.593	4.60
10	Conflicts between contract documents	0.586	5.40
11	Lack of consultant's knowledge of available materials and equipment	0.559	4.49

12	Obstinate nature of one or more of the parties to the contract	0.559	3.56
13	Impediment in prompt decision making process	0.552	3.56
14	Change in economic conditions/government regulations	0.552	5.36
15	Consultant's of judgment and experience	0.545	4.66
16	Long lead procurement	0.545	4.76
17	Lack of coordination	0.524	5.89
18	Lack of a specialised construction management	0.524	5.54
19	Lack of communication	0.524	5.97
20	Inadequate project objectives	0.517	3.27
21	Ambiguous design details	0.497	6.22
22	Unfamiliarity with local conditions	0.490	6.94
23	Inadequate scope of work for contractor	0.483	4.66
24	Owner's financial problems	0.483	5.36
25	Differing site conditions	0.476	6.10
26	Poor procurement process	0.469	5.85
27	Defective workmanship	0.455	6.34
28	Consultant's lack of required data	0.434	3.90
29	Contractor's lack of required data	0.434	5.31
30	Design complexity	0.428	5.54
31	Shortage of skilled manpower	0.421	6.65
32	Safety considerations	0.407	5.50
33	Lack of modern equipment	0.386	8.76
34	Inadequate shop drawing details	0.379	5.50
35	Contractor's desire to improve his financial situation	0.372	5.72
36	The contractor's financial difficulties	0.317	6.98
37	Contractor's lack of judgment and experience	0.317	6.98

The results in table 4.3 shows that contractors top significant causes of variation orders in repetitive residential unit construction projects in Egypt are Change of plans or scope by owner, Change in specifications by owner, Errors and omissions in design, Change of schedule sequence by owner and Change in design by consultant.

"Change of plans or scope by owner" is ranked the first cause by RII= 0.890 followed by "*Change in specifications by owner*" with RII= 0.869 and fifth important cause is "*Change in design by consultant*" With RII= 0.800.

4.3.4 Top Five Most Important Causes

Table 4.4 shows the rank and the relative importance index for the top ten most important causes of variation orders according to overall respondents and to each party of the respondents. This has been calculated by adding the owner, consultant and contractor results.

As shown in Table 4.4, the top five most important causes of variation orders in residential repetitive unit construction projects in Egypt as perceived by all respondents include Change of plans or scope by owner, Change of schedule sequence by owner, Change in specifications by owner, Owner's financial problems and Change in design by consultant.

"Change of plans or scope by owner" is the top cause variation orders in residential repetitive unit construction projects in Egypt according to the overall responses with RII = 0.868. This cause ranked the second important according to the owner and consultant responses, and the first in the contractor results. These results are showing that this cause is the most significant cause among all project parties in residential repetitive unit construction projects in Egypt.

"*Change of schedule sequence by owner*" is the second top cause of variation order with RII = 0.85 according to the overall results. This cause is ranked first cause as the overall results, and it was ranked the first from the owner point of view.

The third important cause is "*Change in specifications by owner*" with RII = 0.824 and it is the second from the contractor point of view and ranked as seventh and eighth according to consultant and owner results respectively.

"Owner's financial problems" is forth significant cause with RII = 0.716 and according to owner and consultant results is the third and first respectively. This cause was not listed within the ten important causes in the contractor's result.

The fifth important cause of variation order is "*Change in design by consultant*" RII= 0.671. This was ranked fourth and fifth important cause as owner and contractor results respectively. These results show that the owner is dominate source of variation orders in the repetitive residential unit projects.

Figure 4.1 summarizes the top five important causes of variation orders in residential repetitive unit construction projects in Egypt as perceived by all respondents.

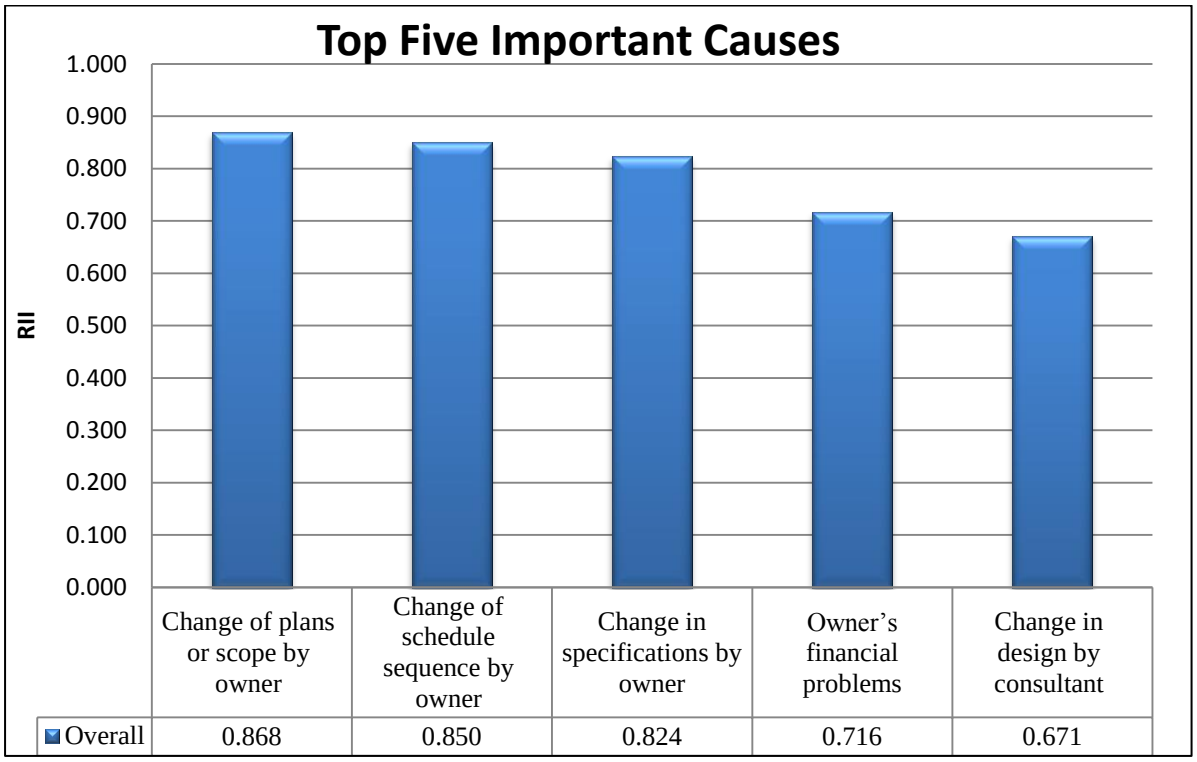

Figure 4.1 Overall Top Five Important Causes

Table 4.4 Overall Responses Results.

No	Causes of variation order	Owner		consultant		Contractor		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
1	Change of plans or scope by owner	0.843	2	0.867	2	0.890	1	0.868	1
2	Change of schedule sequence by owner	0.861	1	0.858	3	0.834	4	0.850	2
3	Change in specifications by owner	0.774	6	0.817	7	0.869	2	0.824	3
4	Owner's financial problems	0.835	3	0.883	1	0.483	24	0.716	4
5	Change in design by consultant	0.774	4	0.417	25	0.800	5	0.671	5
6	Errors and omissions in design	0.530	15	0.583	8	0.855	3	0.671	6
7	Conflicts between contract documents	0.583	14	0.825	6	0.586	10	0.661	7
8	Replacement of materials or procedures	0.478	26	0.842	4	0.621	8	0.647	8
9	Impediment in prompt decision making process	0.774	5	0.542	12	0.552	13	0.616	9
10	Lack of coordination	0.730	7	0.567	9	0.524	17	0.600	10
11	Contractor's desire to improve his financial situation	0.504	22	0.842	5	0.372	35	0.561	11
12	Unforeseen site conditions	0.513	21	0.525	18	0.593	9	0.547	12
13	Long lead procurement	0.591	13	0.500	19	0.545	16	0.545	13
14	Inadequate project objectives	0.591	12	0.525	16	0.517	20	0.542	14
15	Change in economic conditions/government regulations	0.530	18	0.533	14	0.552	14	0.539	15
16	Fast track construction	0.443	29	0.292	37	0.800	6	0.532	16
17	Obstinate nature of one or more of the parties to the contract	0.443	28	0.558	10	0.559	12	0.524	17
18	Contractor's lack of required data	0.626	8	0.525	17	0.434	29	0.521	18
19	Lack contractor's involvement in design	0.487	24	0.333	35	0.703	7	0.521	19
20	Lack of communication	0.513	20	0.483	20	0.524	19	0.508	20
21	Ambiguous design details	0.600	11	0.425	24	0.497	21	0.505	21

22	Poor procurement process	0.513	19	0.475	21	0.469	26	0.484	22
23	Consultant's lack of required data	0.609	9	0.417	26	0.434	28	0.482	23
24	The contractor's financial difficulties	0.609	10	0.542	13	0.317	36	0.476	24
25	Inadequate scope of work for contractor	0.530	16	0.400	27	0.483	23	0.471	25
26	Inadequate shop drawing details	0.530	17	0.525	15	0.379	34	0.471	26
27	Lack of consultant's knowledge of available materials and equipment	0.435	31	0.400	28	0.559	11	0.471	27
28	Differing site conditions	0.461	27	0.450	23	0.476	25	0.463	28
29	Lack of a specialised construction management	0.435	32	0.400	29	0.524	18	0.458	29
30	Shortage of skilled manpower	0.487	25	0.467	22	0.421	31	0.455	30
31	Consultant's of judgment and experience	0.391	36	0.392	30	0.545	15	0.450	31
32	Contractor's lack of judgment and experience	0.504	23	0.558	11	0.317	37	0.450	32
33	Unfamiliarity with local conditions	0.383	37	0.383	31	0.490	22	0.424	33
34	Defective workmanship	0.443	30	0.367	32	0.455	27	0.424	34
35	Design complexity	0.409	33	0.350	34	0.428	30	0.397	35
36	Safety considerations	0.400	35	0.367	33	0.407	32	0.392	36
37	Lack of modern equipment	0.400	34	0.292	36	0.386	33	0.361	37

4.4 Impact of Variation Orders on Performance of Repetitive Residential Projects.

This section will examine the impact of variation orders by each party individually. Results obtained from owner, consultant and contractor results will be analyzed independently. Also overall result combining the project parties results will be shown. This process helps determining the agreement degree between different parties.

The following subsections show the impact of variation orders from each party's opinion and the overall results.

4.4.1 Owner Results

Table 4.5 presents the RIIs, ranks and standard deviation (SD) of each impact based on owner responses received.

Table 4.5 Owner Results of Variation Orders Impacts

Rank	Impact of variation orders	RII	SD
1	Cost overrun	0.826	5.079
2	Disputes between parties to the contract	0.809	4.506
3	Time overrun	0.757	3.715
4	Time reduction	0.670	2.191
5	Professional reputation of one or more parties adversely affected	0.539	2.966
6	Degradation of heath& safety	0.504	4.561
7	Additional specialist equipment/personnel	0.487	5.727
8	Quality standards enhanced	0.478	5.459
9	Degradation of quality standards	0.470	4.393
10	Optimum cost reduction	0.452	4.722
11	Additional health & safety equipment/measure	0.409	4.450

According to table 4.5, "*Cost overrun*" is the most significant impact on project performance from the owner point of view with RII = 0.826. The second and third impact are "*Disputes between parties to the contract*" and "*Time overrun*" with RII = 0.809 and 0.757 respectively. Figure 4.2 summarizes the impact of variation orders according to owner point of view.

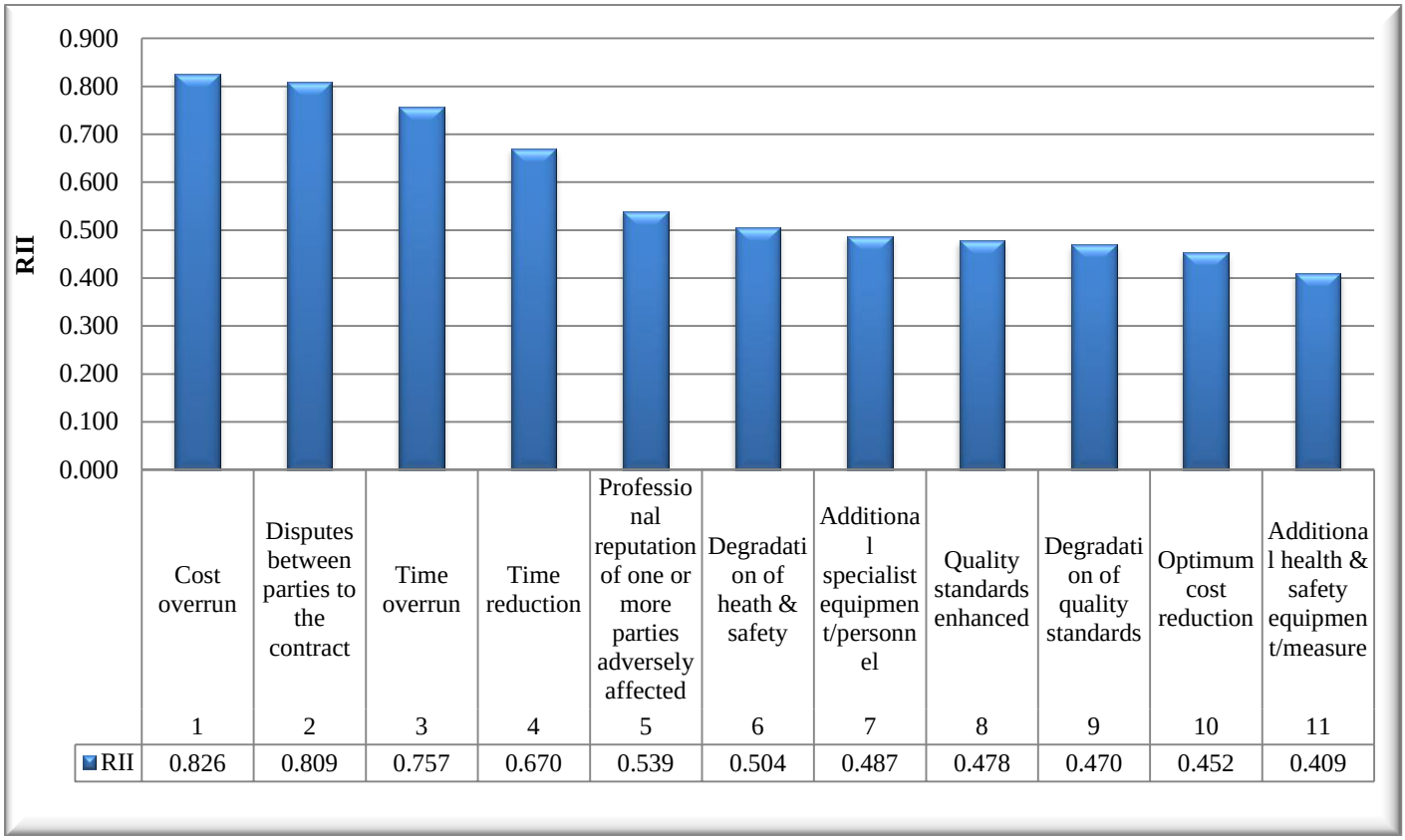

Figure 4.2 Owner Results of Variation Orders Impacts

4.4.2 Consultants Results

Table 4.6 presents the RIIs, ranks and standard deviation (SD) of each impact based on Consultant responses received.

Table 4.6 Consultant Results of Variation Orders Impacts

Rank	Impact of variation orders	RII	SD
1	Cost overrun	0.883	5.762
2	Time overrun	0.858	6.611
3	Disputes between parties to the contract	0.767	5.167
4	Quality standards enhanced	0.567	4.764
5	Degradation of heath& safety	0.533	4.494
6	Degradation of quality standards	0.517	7.050
7	Professional reputation of one or more parties adversely affected	0.492	5.891
8	Additional specialist equipment/personnel	0.433	4.764
9	Optimum cost reduction	0.425	4.868
10	Additional health & safety equipment/measure	0.358	5.070
11	Time reduction	0.275	6.907

Table 4.6 presents that "*Cost overrun*" is the most significant impact on project performance from the consultant point of view with RII = 0.883 same as the owner point of view. The second and third impact are and "*Time overrun*" and "*Disputes between parties to the contract*" with RII= 0.858 and 0.767 respectively. The top three impacts of variation orders from owner and consultants perspectives are the same. Figure 4.3 summarizes the impact of variation orders according to consultant perspective.

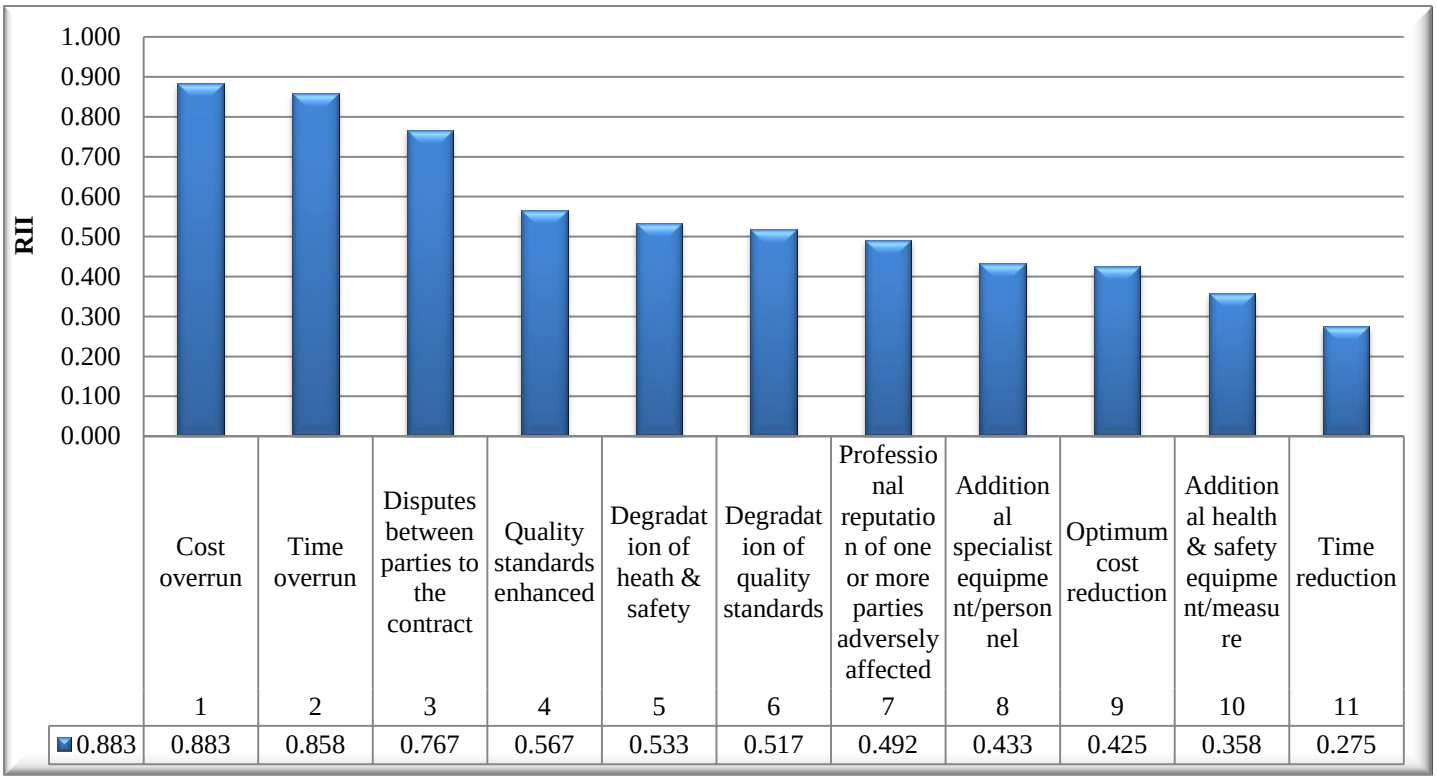

Figure 4.3 Consultant Results of Variation Orders Impacts.

4.4.3 Contractor Results

Table 4.7 presents the RIIs, ranks and standard deviation (SD) of each impact based on Contractor responses received.

Table 4.7 Contractor Results of Variation Orders Impacts.

Rank	Impact of variation orders	RII	SD
1	Disputes between parties to the contract	0.821	5.404
2	Time overrun	0.793	5.310
3	Professional reputation of one or more parties adversely affected	0.766	3.962
4	Additional specialist equipment/personnel	0.641	5.450
5	Quality standards enhanced	0.552	5.167
6	Cost overrun	0.490	2.864
7	Additional health & safety equipment/measure	0.476	6.648
8	Time reduction	0.469	5.495

9	Degradation of quality standards	0.414	4.868
10	Degradation of health& safety	0.393	6.573
11	Optimum cost reduction	0.338	6.723

Table 4.7 shows that "*Disputes between parties to the contract*" is the greatest impact on project performance from the contractor point of view with RII = 0.821. The second impact is "*Time overrun*" with RII = 0.858 followed by "*Professional reputation of one or more parties adversely affected*" as the third important impact with RII = 0.766. According to the top three impacts obtained for project parties "*Time overrun*" is the common impact. Figure 4.4 shows the impact of variation orders according to contractor perspective.

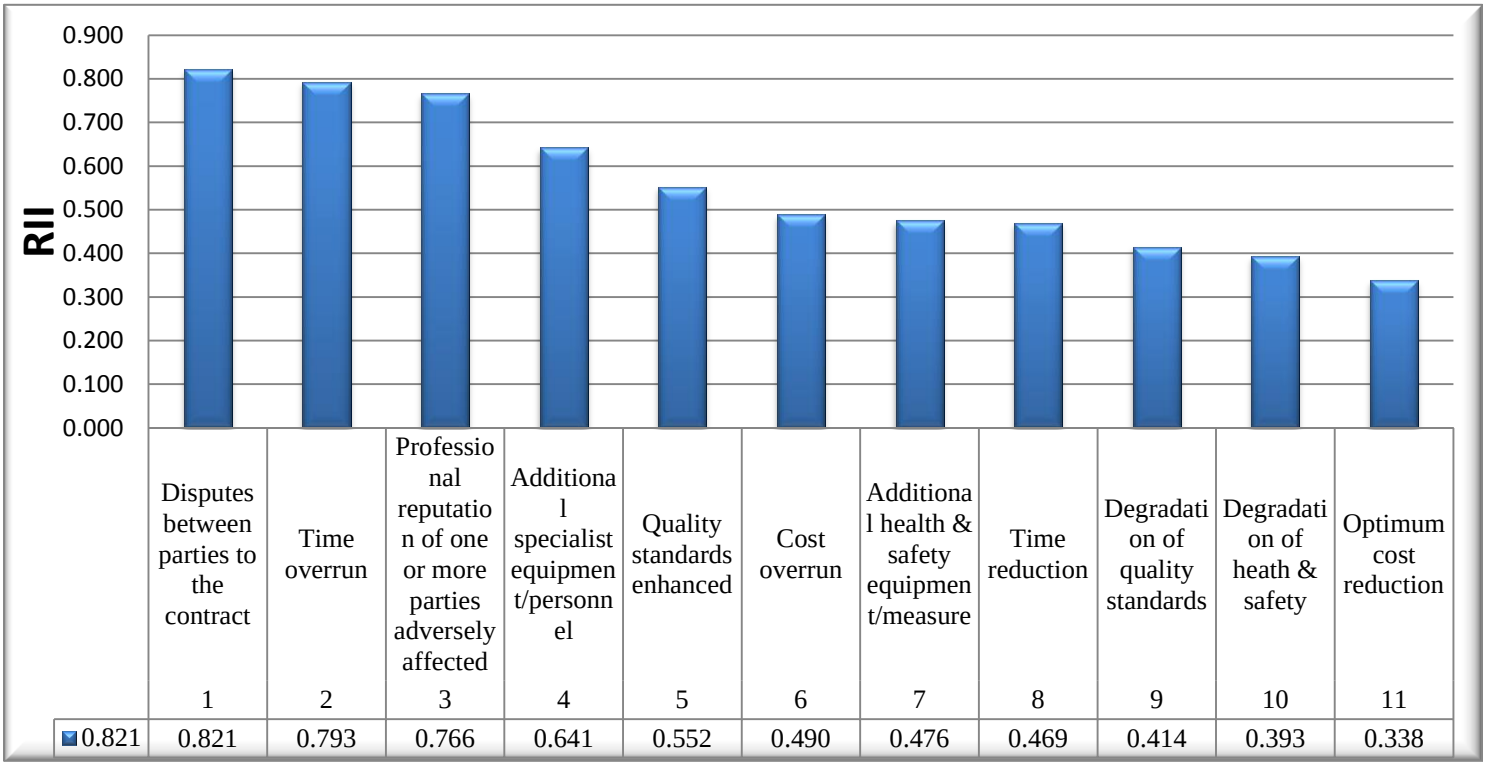

Figure 4.4 Contractor Results of Variation Orders Impacts.

4.4.4 Overall Results.

Table 4.8 presents the RIIs and ranks of each impact based on overall responses.

Table 4.8 Overall Results of Variation Orders Impacts

Rank	Impact of variation orders	RII
1	Time overrun	0.803
2	Disputes between parties to the contract	0.800
3	Cost overrun	0.716
4	Professional reputation of one or more parties adversely affected	0.611
5	Quality standards enhanced	0.534
6	Additional specialist equipment/personnel	0.529
7	Degradation of health& safety	0.471
8	Time reduction	0.468
9	Degradation of quality standards	0.463
10	Additional health & safety equipment/measure	0.418
11	Optimum cost reduction	0.400

As shown in Figure 4.5, the top five most important impacts of variation orders on the repetitive residential unit projects in Egypt as perceived by all respondents. The top impact is "*Time overrun*" with RII = 0.803 and it is ranked in the top three impacts according to owner, consultant and contractor results. The second impact is "*Disputes between parties to the contract*" by RII = 0.800 and it is found the top three impacts according to owner, consultant and contractor results. Third most significant impact is "*Cost overrun*" by RII = 0.716 this was listed in the top three impacts according to owner and consultant results but was not listed in the top causes from the contractor point of view. The fourth and fifth impacts are "*Professional reputation of one or more parties adversely affected*" and "*Quality standards enhanced*" with RII = 0.611 and 0.534 respectively.

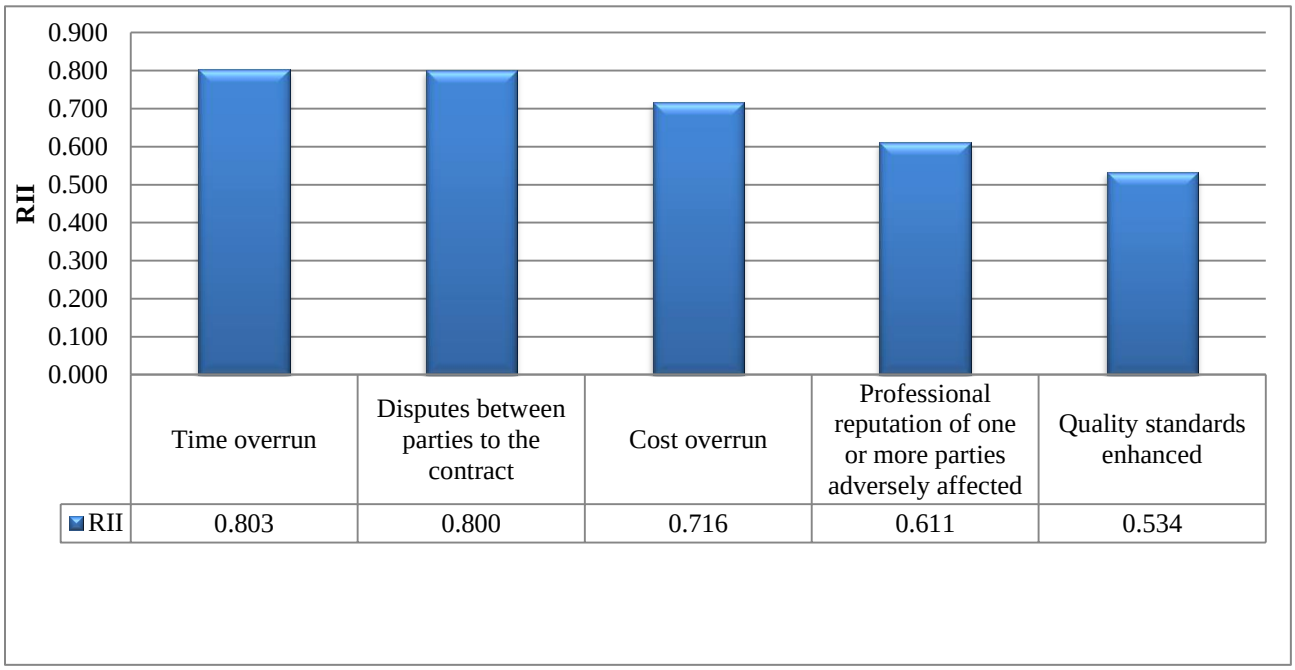

Figure 4.5 Overall Results of Variation Orders Impacts.

These results demonstrate that the variation orders mainly have a negative impact on the project performance.

4.5 Non value-adding activities associated with variation orders

The non value-adding activities associated with variation orders will be examined by each party individually. The results for owner, consultant and contractor will be divided and independently analyzed. In addition, the overall results that combine the owner, consultant and contractor results will be presented. This process helps determining the agreement degree between different parties. The following subsections show the non value-adding activities from each party's opinion and the overall results.

4.5.1 Owner Results

Table 4.9 presents the RIIs, ranks and standard deviation (SD) of each non value-adding activities based on owner responses.

Table 4.9 Owner Non value-adding activities Results

Rank	Non value-adding activities	RII	SD
1	Rework due to Labor's mistakes	0.835	4.879
2	Rework due to varied works	0.835	5.177
3	Frequent design changes	0.817	5.367
4	Waiting due to Ignorance of specifications	0.817	4.159
5	Redesign due to Design errors	0.774	3.435
6	Waiting due to Lack of design information	0.765	3.578
7	Idling due to Poor attitudes of Labors	0.635	3.130
8	Waiting due to Poor site condition	0.600	4.775
9	Idling due to Incompetent Labors	0.574	4.879
10	Waiting due to Poor information quality	0.565	4.159
11	Waiting due to Resources problem	0.557	3.782
12	Redesign due Inexperience designer	0.548	4.722
13	Damage during material transportation	0.548	3.435
14	Waiting due to Non availability of equipment	0.548	4.099
15	Waiting for Material replacement	0.548	4.722
16	Waiting due to Unpredictable local conditions	0.539	2.966
17	Waiting due to Delay during delivery	0.530	4.827
18	Idling due to Lack of experience	0.530	5.459
19	Accidents due to Lack of safety	0.522	5.030
20	Redesign due Interaction between various specialists	0.513	3.286
21	Idling due to Shortage of skilled Labors	0.513	4.980
22	Waiting due to Inappropriate construction methods	0.504	4.219
23	Redesign due Complicated design	0.496	3.286
24	Waiting due Mistakes in quantity surveys	0.487	4.980
25	Too much overtime for workers for non-value adding activities on site	0.478	3.975
26	Waiting due to Scarcity of equipment	0.478	5.273
27	Waiting due to Poor quality of materials	0.470	4.393
28	Damage due to Poor material handling	0.461	3.435
29	Damage due to Wrong material storage	0.452	3.362
30	Waiting due to Tools not suitable	0.452	4.219
31	Rework due to Damage caused by Labors	0.452	3.435

32	Waiting due to Poor site management/Controlling	0.452	4.775
33	Waste resulting from packaging	0.452	5.128
34	Waiting due to Crews interference	0.452	2.966
35	Idling due to Insufficient training for Labors	0.443	2.966
36	Waiting due to Slow drawing distribution	0.435	4.450
37	Waiting due to Inspection	0.435	3.362
38	Waiting due to Equipment failure	0.426	4.561
39	Waiting due to overcrowding of the site	0.426	4.450
40	Waiting due to Inappropriate use of materials	0.417	4.219
41	Waiting periods for instructions on varied works	0.409	4.219
42	Waiting due to Communication problems	0.409	4.450
43	Waiting due to Late information flow among parties	0.400	5.320
44	Waiting due to Ordering errors	0.391	4.450
45	Waiting due to Effect of weather	0.391	4.450
46	Extra materials on site	0.383	4.336
47	Waiting due to Damages caused by third parties	0.365	4.879
48	Waiting due to Stolen material or equipment	0.339	5.550
49	Waiting due to old-fashioned equipment	0.330	6.025
50	Waiting due to Error in shipping	0.330	6.768

According to Figure 4.6, "*Rework due to Labor's mistakes*" and "*Rework due to varied works*" are the most significant non-value adding activities from the owner point of view with RII= 0.835. These non value-adding activities are "*Frequent design changes*" and "*Waiting due to Ignorance of specifications*" with RII = 0.817. The third and fourth are "*Redesign due to Design errors*" and "*Waiting due to Lack of design information*" with RII = 0.774 and 0.765 respectively. The fifth important waste activity is "*Idling due to Poor attitudes of Labors*" with RII = 0.635.

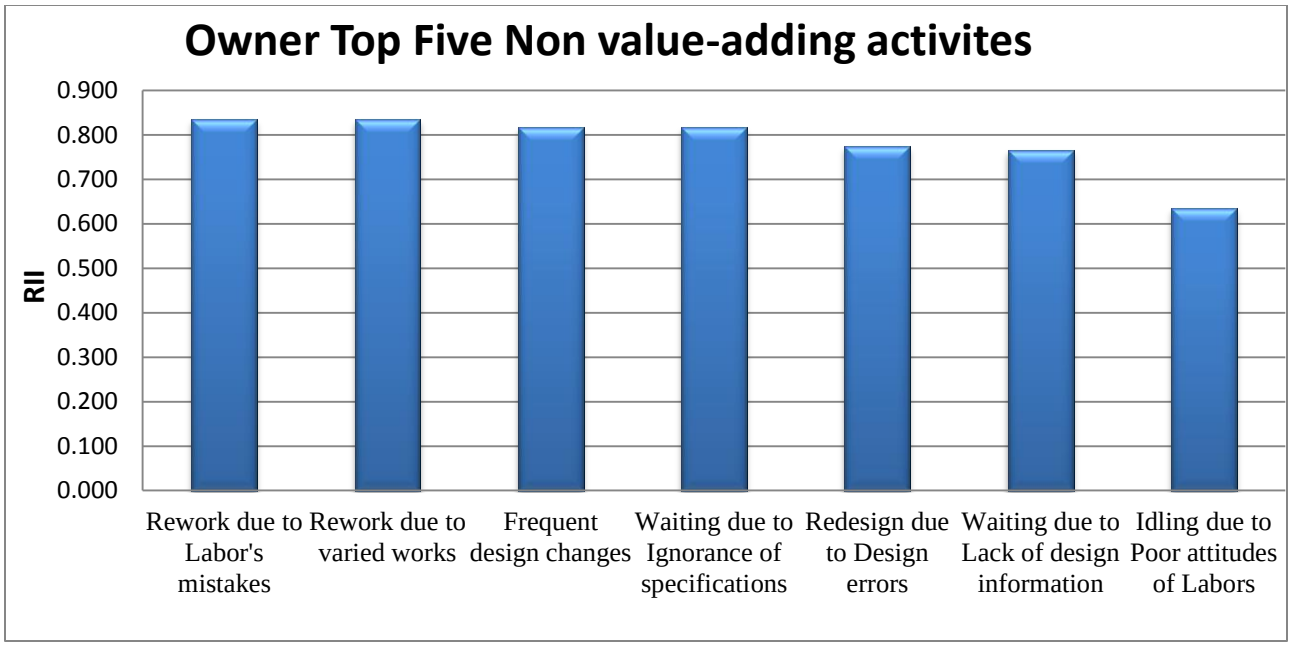

Figure 4.6 Owner Top Five Non value-adding activities

4.5.2 Consultant Results

Table 4.10 presents the RIIs, ranks and standard deviation (SD) of each non value-adding activities based on Consultant responses.

Table 4.10 Consultant Non value-adding activities Results

Rank	Non value-adding activities	RII	SD
1	Waiting due to Resources problem	0.850	4.868
2	Waiting due to Ignorance of specifications	0.833	4.604
3	Waiting for Material replacement	0.817	4.438
4	Rework due to varied works	0.617	4.438
5	Waiting due to Unpredictable local conditions	0.600	5.020
6	Rework due to Labor's mistakes	0.592	5.541
7	Waiting due to Poor site condition	0.592	4.764
8	Damage due to Wrong material storage	0.575	6.221
9	Damage due to Poor material handling	0.558	4.764
10	Waiting due to Poor information quality	0.558	5.357
11	Too much overtime for workers for non-value adding activities on site	0.550	5.450

12	Idling due to Shortage of skilled Labors	0.533	5.357
13	Accidents due to Lack of safety	0.525	4.658
14	Idling due to Incompetent Labors	0.508	6.611
15	Waiting due to Communication problems	0.508	5.718
16	Redesign due Inexperience designer	0.500	5.541
17	Waiting due to Delay during delivery	0.500	5.310
18	Waiting due Mistakes in quantity surveys	0.500	6.573
19	Idling due to Poor attitudes of Labors	0.492	5.718
20	Waiting periods for instructions on varied works	0.492	5.541
21	Idling due to Lack of experience	0.483	6.017
22	Redesign due Interaction between various specialists	0.475	6.458
23	Waiting due to Slow drawing distribution	0.467	5.762
24	Waiting due to Poor quality of materials	0.467	5.215
25	Waiting due to Effect of weather	0.467	5.357
26	Waiting due to Late information flow among parties	0.458	5.357
27	Idling due to Insufficient training for Labors	0.450	5.020
28	Waste resulting from packaging	0.450	5.020
29	Waiting due to Scarcity of equipment	0.442	4.764
30	Extra materials on site	0.442	4.764
31	Waiting due to overcrowding of the site	0.442	4.764
32	Waiting due to Lack of design information	0.433	4.764
33	Damage during material transportation	0.433	4.764
34	Waiting due to Inappropriate construction methods	0.433	4.604
35	Redesign due Complicated design	0.417	4.604
36	Waiting due to Poor site management/Controlling	0.417	4.604
37	Waiting due to Inspection	0.417	4.604
38	Waiting due to Ordering errors	0.417	5.070
39	Redesign due to Design errors	0.392	4.438
40	Rework due to Damage caused by Labors	0.392	4.764
41	Waiting due to Non availability of equipment	0.392	4.438
42	Waiting due to Damages caused by third parties	0.392	4.438
43	Waiting due to Inappropriate use of materials	0.375	4.868
44	Waiting due to Tools not suitable	0.342	6.611
45	Waiting due to old-fashioned equipment	0.333	7.155
46	Waiting due to Stolen material or equipment	0.317	6.140
47	Waiting due to Crews interference	0.300	6.221
48	Waiting due to Equipment failure	0.292	6.611
49	Waiting due to Error in shipping	0.292	6.380
50	Frequent design changes	0.275	6.907

According to Figure 4.7 the "*Waiting due to Resources problem*" ranked the first non value-adding activity with RII = 0.850. The second is "*Waiting due to Ignorance of specifications*" with RII = 0.833 and it is the third in owner results. The third and fourth are "*Waiting for Material replacement*" and "*Rework due to varied works*" by RII = 0.817 and 0.617 respectively. The fifth important waste activity is "*Waiting due to Unpredictable local conditions*" with RII = 0.600

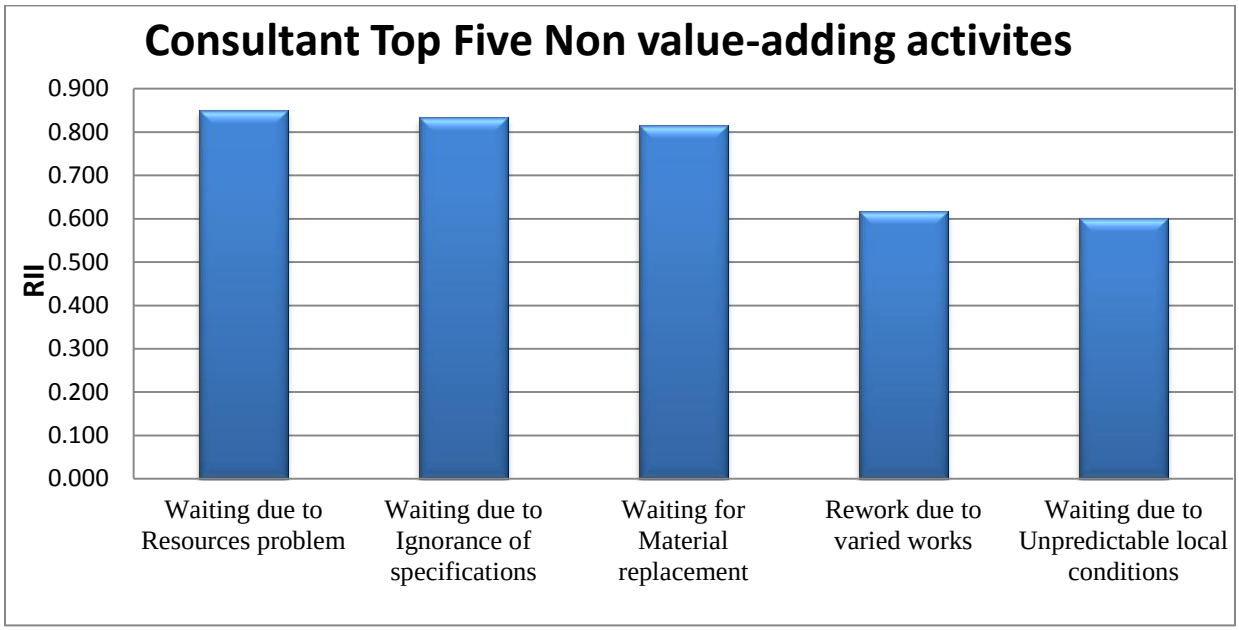

Figure 4.7 Consultant Top Five Non value-adding activities

4.5.3 Contractor Results

Table 4.11 presents the RIIs, ranks and standard deviation (SD) of each non value-adding activities based on Contractor responses.

Table 4.11 Contractor Non value-adding activities Results

Rank	Non value-adding activities	RII	SD
1	Waiting due to Inspection	0.848	6.221
2	Frequent design changes	0.834	5.630
3	Idling due to Shortage of skilled Labors	0.828	5.404
4	Too much overtime for workers for non-value adding activities on site	0.821	5.357
5	Waiting periods for instructions on varied works	0.814	5.630
6	Waiting due to Resources problem	0.800	6.221
7	Redesign due Interaction between various specialists	0.793	6.261
8	Waiting due to Crews interference	0.793	4.919
9	Waiting due to overcrowding of the site	0.772	4.438
10	Waiting due to Ordering errors	0.772	4.207
11	Waiting due to Inappropriate construction methods	0.759	4.147
12	Waiting due to Poor information quality	0.759	4.147
13	Idling due to Insufficient training for Labors	0.738	4.764
14	Rework due to varied works	0.738	5.119
15	Waiting due Mistakes in quantity surveys	0.641	5.310
16	Redesign due to Design errors	0.634	4.658
17	Waiting due to Poor site management/Controlling	0.634	3.899
18	Waiting due to Communication problems	0.607	5.263
19	Waiting due to Delay during delivery	0.600	4.764
20	Waiting due to Inappropriate use of materials	0.600	5.310
21	Waiting due to Lack of design information	0.593	4.550
22	Waiting due to Late information flow among parties	0.579	4.550
23	Redesign due Inexperience designer	0.566	4.025
24	Idling due to Incompetent Labors	0.566	5.630
25	Idling due to Poor attitudes of Labors	0.566	5.450
26	Waiting due to Poor site condition	0.566	2.683
27	Idling due to Lack of experience	0.559	5.848
28	Waiting due to Unpredictable local conditions	0.559	5.505
29	Waiting due to Damages caused by third parties	0.552	2.588
30	Waiting due to Scarcity of equipment	0.545	5.357
31	Waiting due to Error in shipping	0.545	6.017
32	Damage during material transportation	0.510	6.221
33	Rework due to Damage caused by Labors	0.503	3.271
34	Waiting due to Equipment failure	0.497	6.907
35	Waiting due to Tools not suitable	0.497	7.430
36	Damage due to Wrong material storage	0.490	6.261
37	Waiting for Material replacement	0.490	2.683

38	Damage due to Poor material handling	0.483	7.259
39	Waiting due to Effect of weather	0.483	4.550
40	Waiting due to Non availability of equipment	0.462	4.764
41	Waste resulting from packaging	0.462	5.119
42	Waiting due to Ignorance of specifications	0.462	4.025
43	Redesign due Complicated design	0.455	5.263
44	Waiting due to old-fashioned equipment	0.448	4.438
45	Extra materials on site	0.441	4.438
46	Waiting due to Slow drawing distribution	0.434	4.970
47	Rework due to Labor's mistakes	0.428	4.604
48	Waiting due to Stolen material or equipment	0.428	4.087
49	Accidents due to Lack of safety	0.421	4.868
50	Waiting due to Poor quality of materials	0.393	5.167

Figure 4.8 illustrates that the top five non value-adding activities from the contractor side; "*Waiting due to Inspection*" is the first non value-adding activity with RII = 0.848. The second is "*Frequent design changes*" with RII = 0.834. The third and fourth are "*Idling due to Shortage of skilled Labors*" and "*Too much overtime for workers for non-value adding activities on site*" by RII = 0.828 and 0.821 respectively. The fifth important non value-adding activity is "*Waiting periods for instructions on varied works*" with RII = 0.814.

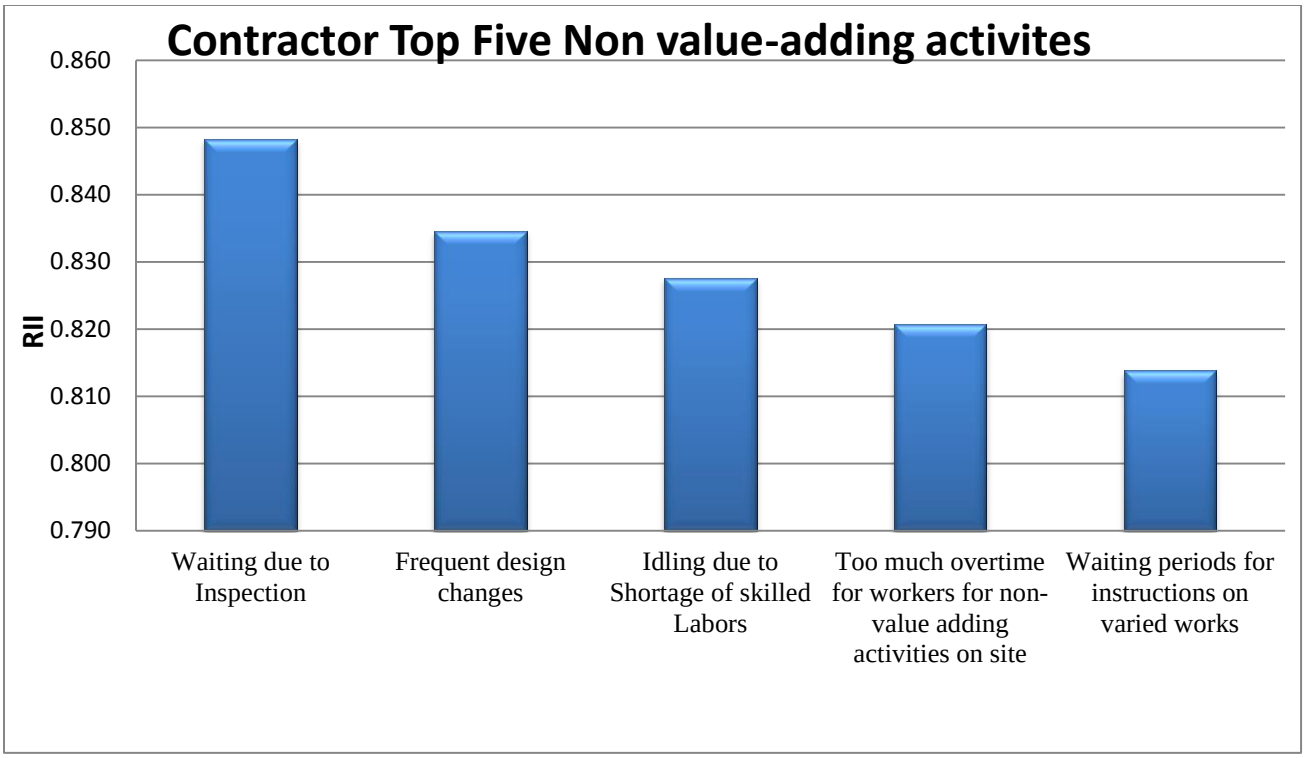

Figure 4.8 Contractor Top Five Non value-adding activities

4.5.4 Overall Results

Table 4.12 presents the RIIs and ranks for the non value-adding activities based on overall responses.

Table 4.12 Overall Results

Rank	Non value-adding activities	RII
1	Waiting due to Resources problem	0.742
2	Rework due to varied works	0.729
3	Waiting due to Ignorance of specifications	0.687
4	Frequent design changes	0.653
5	Idling due to Shortage of skilled Labors	0.639
6	Waiting due to Poor information quality	0.637
7	Too much overtime for workers for non-value adding activities on site	0.632
8	Waiting for Material replacement	0.611
9	Redesign due Interaction between various specialists	0.608

10	Rework due to Labor's mistakes	0.603
11	Redesign due to Design errors	0.600
12	Waiting due to Lack of design information	0.595
13	Waiting periods for instructions on varied works	0.589
14	Waiting due to Inspection	0.587
15	Waiting due to Poor site condition	0.584
16	Waiting due to Inappropriate construction methods	0.579
17	Waiting due to Unpredictable local conditions	0.566
18	Idling due to Poor attitudes of Labors	0.563
19	Waiting due to overcrowding of the site	0.563
20	Idling due to Insufficient training for Labors	0.558
21	Idling due to Incompetent Labors	0.550
22	Waiting due Mistakes in quantity surveys	0.550
23	Waiting due to Delay during delivery	0.547
24	Waiting due to Ordering errors	0.545
25	Redesign due Inexperience designer	0.539
26	Waiting due to Crews interference	0.534
27	Idling due to Lack of experience	0.526
28	Waiting due to Communication problems	0.516
29	Waiting due to Poor site management/Controlling	0.511
30	Damage due to Wrong material storage	0.505
31	Damage due to Poor material handling	0.500
32	Damage during material transportation	0.497
33	Waiting due to Scarcity of equipment	0.492
34	Waiting due to Late information flow among parties	0.487
35	Accidents due to Lack of safety	0.484
36	Waiting due to Inappropriate use of materials	0.474
37	Waiting due to Non availability of equipment	0.466
38	Redesign due Complicated design	0.455
39	Waste resulting from packaging	0.455
40	Rework due to Damage caused by Labors	0.453
41	Waiting due to Effect of weather	0.450
42	Waiting due to Slow drawing distribution	0.445
43	Waiting due to Damages caused by third parties	0.445
44	Waiting due to Poor quality of materials	0.439
45	Waiting due to Tools not suitable	0.434
46	Extra materials on site	0.424
47	Waiting due to Equipment failure	0.411
48	Waiting due to Error in shipping	0.400

49	Waiting due to old-fashioned equipment	0.376
50	Waiting due to Stolen material or equipment	0.366

As shown in the Figure 4.9 the top five non value-adding activities with variation orders in repetitive residential unit construction projects in Egypt. Based on overall responses "*Waiting due to Resources problem*" with RII = 0.742 is the top waste activity and it was the top according to consultant point of view but it was not listed in the top five from the owner and contractor perspective. Secondly, "*Rework due to varied works*" RII = 0.729 and it was listed in the owner and consultant top five but was not found in the contractor top ten. In addition, the third non value-adding activity is "*Waiting due to Ignorance of specifications*" RII = 0.687and it was listed in the owner and consultant top five but was not listed in the contractor top ten. The fourth and the fifth are "*Frequent design changes*" and "*Idling due to Shortage of skilled Labors*" by RII = 0.653 and 0.639 respectively.

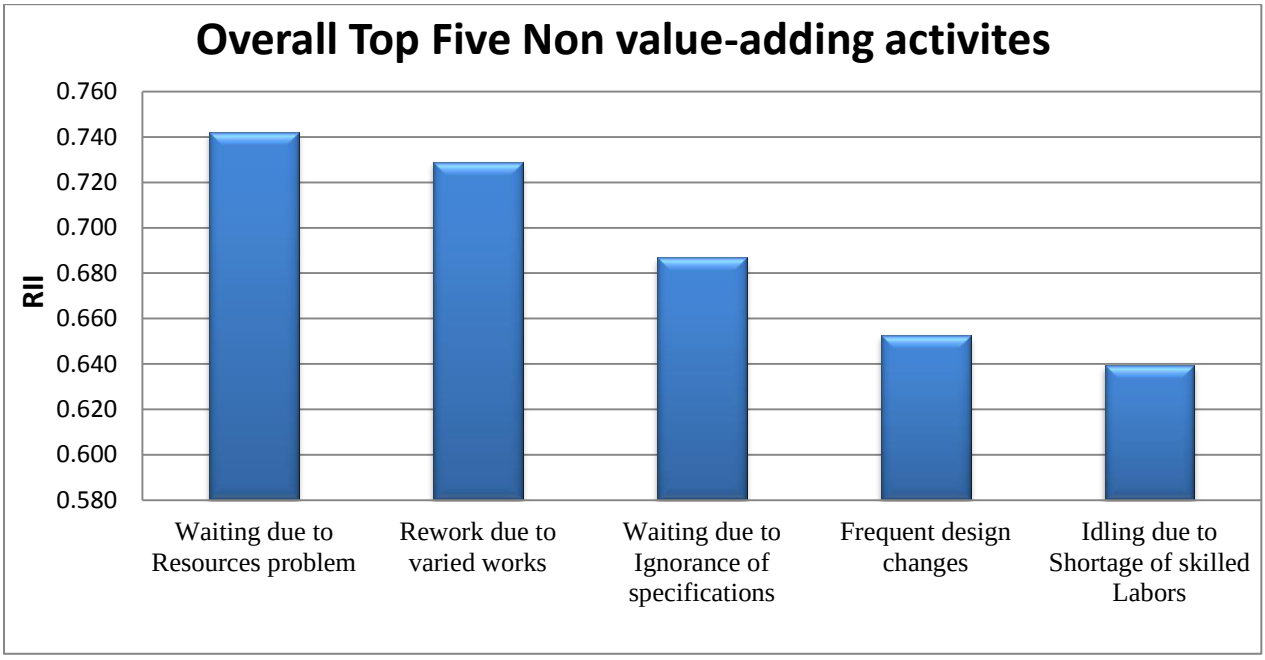

Figure 4.9 Overall Top Five Non value-adding activities

4.6 Spearman Rank Correlation Coefficient

In order to evaluate the correlation variances among parties, the Spearman's correlation coefficient was applied to the ranking of owner with contractor, owner with consultant and consultant with contractor.

Spearman Rank Correlation Coefficient is calculated based on the following formula (Samy, 2013)

Spearman rank coefficient =

$$1 - \frac{6 \sum d^2}{(n^3 - n)}$$

Where “d” is the difference between ranks indicated by the two parties and “n” is the number of records. The values range from (+1) as perfect correlation, (0) no correlation and (-1) as negative correlation. The correlation results between the owner and consultant were calculated for the different parts studied in the research, and it was found to be 0.65, 0.62 and 0.50. Moreover, the contractor and the consultant were 0.24, 0.46 and 0.1. The owner and contractor correlation results were found to be 0.28, 0.55 and 0.12. These results show a low correlation between the owner and contractor and between the contractor and the consultant, which resembles the conflicting views, and thus opposing views between these parties. However, there was a good correlation between the owner and the consultant this shows that the position of the consultant might be seen as more favorable to the owner, because of the contractual relationship between them.

In this chapter the data obtained from the questionnaire survey were analyzed and the causes, impacts and non value adding activities of variation orders were ranked. The data were analyzed to each party independently. According, results were presented and the most significant results were highlighted. Moreover, the spearman rank correlation coefficient has been used to show the degree of agreement between each party and the other.

Chapter Five

Conclusion and Recommendations

5.1 Introduction

This chapter gives the conclusion of the research by highlighting the important points in the previous chapter and summarizes the most significant results reached in the previous chapters. The final section shall pinpoint to recommendations of this research.

5.2 Conclusion

The repetitive residential project is one of the projects that government puts into consideration to expand. This is due to the increase in marriages rate. Hence, the demand for such residential projects increases. This type of projects contains usually repetitive types of buildings. For example, the type of specific unit is 50 units in a housing project that contains10 different other types. Therefore, when there is a variation order issued to change an item in type of units. The variation order will be repeated in many units that will affect more value of work. For instance, variation order issued to change the type of marble in one unit will be repeated in all the other units. Therefore, the impact of variation order for this kind of projects is significant. This research was carried out to study the impact of variation orders on performance of repetitive residential projects in Egypt by identifying variation order causes, non value-adding activities and impacts of variation order.

The previous studies regarding variation order was presented in the literature review. The causes of variation order, impact of variation order and variation order non value-adding activities (waste) were identified. The data collection started with seven Semi structured interviews with

experts in the construction industry. This was carried out in order to adapt selected list for variation order causes, impacts and non value-adding activities within various stages of construction projects in Egypt. Three more interviews were carried out to ensure the saturation of the sample.

A questionnaire incorporated the participation of architects and engineers presenting many engineering consultancies, contractor companies and owner companies. The questionnaire was divided into two parts, part one includes participant personal information i.e. Name, Occupation, Company Name, Type of Organization, Experience, Age and Gender. Part two includes three questions as the causes of variation order, impacts of variation order on the project performance and the associated non value-adding activities with variation order. A total of 100 questionnaire survey was distributed, Out of the distributed questionnaires, 76 responses were including 23 owners, 24 consultants and 29 contractors. The participant was asked to rank each item according to degree of importance from 1 to 5. The gathered data were analyzed for each party independently to get the result from each of them individually. The degree of agreement between each party and the other was calculated using Spearman rank correlation coefficient.

Based on the analysis of results the most three important causes of variation order of repetitive residential projects in Egypt are change of plans or scope by owner, change of schedule sequence by owner and change in specifications by owner. The top five most important impacts of variation orders are time overrun, disputes between parties to the contract, cost overrun, Professional reputation of one or more parties adversely affected and Quality standards enhanced. The survey concluded that the top five non value-adding activities with variation orders are waiting due to resources problem, rework due to varied works, waiting due to Ignorance of specifications, frequent design changes and idling due to shortage of skilled labors.

Accordingly, variation orders adversely affect the repetitive residential projects in Egypt. Also the Egyptian developers should pay attention to several factors to minimize the occurrence of variation orders.

It was found from the correlation and agreement analysis that there is low correlation between the owner and contractor and between the contractor and the consultant. However, there is a good correlation between the owner and the consultant.

5.3 Recommendations

Based on these findings, the owner is the most predominant of variation orders causes due to the unclear briefing of the scope of works. Moreover, design errors and omissions cannot be completely avoided but can be reduced and decrease its negative impact. Recommendations to reduce the occurrence of variation orders are stated as follows:

- Owner should provide a clear brief of the scope of works.
- Enough time should be given to the pre-tender phase.
- All involved parties require in advance adequate planning before works start on site.
- Highly coordination by consultant is required at the design stage
- Commutation by all parties should be enhanced
- Owner should ensure that the design/specifications fall within the approved budget.

In addition, by identifying the non value-adding activities that are time and resources consuming during the construction process, project managers are able to identify easily the best solutions and to apply techniques for reducing the amount of waste. This will lead to improve the project performance.

5.4 Recommendation for Future Studies

Further research can be conducted based light of information provided in this study. It was found that the owner is a predominate source of variation order. Accordingly, a research can be conducted to set of guidelines and recommendations for the owners to avoid variation orders.

This research targeted the repetitive residential projects for private sector. Based on that, a study can be done to investigate variation orders in the national repetitive residential projects and to compare the results.

An interesting and important topic that could be addressed in a thesis research is the management of the non value-adding activities during the construction. This can set of guidelines for the projects mangers to deal with the non value-adding activities.

References

Alarcon, L. F. (1997). Training field personnel to identify waste and improvement opportunities in construction. Lean Construction. Rotterdam: Balkema Publishers, 402-413

Alaryan, A., Emadelbeltagi.(2014). Causes and effects of change orders on construction projects in Kuwait. International Journal of Engineering Research and Applications, 4(7), 01-08.

Al-Dubaisi, A. H. (2000). Change orders in construction projects in Saudi Arabia (Doctoral dissertation, King Fahd University Of Petroleum & Minerals).

Alnuaimi, A. S., Taha, R. A., Al Mohsin, M., & Al-Harthi, A. S. (2009). Causes, effects, benefits, and remedies of change orders on public construction projects in Oman. Journal of Construction Engineering and Management, 136(5), 615-622.

Alsuliman, J., Bowles, G., & Chen, Z. (2012). Current Practice of Variation Order Management in the Saudi Construction Industry. Association of Researchers in Construction Management, 1-10.

Manzoor Arain, F., & Sui Pheng, L. (2005). The potential effects of variation orders on institutional building projects. Facilities, 23(11/12), 496-510.

Awad, M. (2001). Analysis and Management of Change Orders for Combined Sewer Flow Construction Projects. Unpublished Dissertation, Wayne State University.

Bassioni, H. A., El-Razek, M. E. A., & El-Salam, W. A. A. (2007, September). Avoiding Claims in Egyptian Construction Projects: A Quantitative Survey. In Procs 23rd Annual Association of Researchers in Construction Management,(ARCOM) Conference Belfast, UK (pp. 147-156).

Chan, A. P., & Yeong, C. M. (1995). A comparison of strategies for reducing variations. Construction Management and Economics, 13(6), 467-473.

Charoenngam, C., Coquinco, S., &Hadikusumo, B. (2003). Web-based application for managing change orders in construction projects. Construction Innovation: Information, Process, Management, 197-215.

Al Duaij, J., Awida, T., & Kollarayam, A. E. (2007). Performing value analysis on construction project variation orders. Cost engineering, 49(6), 23-27.

El Nemr, W. (2001). Management of Change Order Claims in the Egyptian Industrial Construction Sector: Analysis and Means of Improvement.

Enshassi, A., Arain, F., & Al-Raee, S. (2010). Causes of variation orders in construction projects in the Gaza Strip. Journal of Civil Engineering and Management, 16(4), 540-551.

Gunduz, M. (2002). Change orders impact assessment for labor intensive construction.

Halwatura, R. U., & Ranasinghe, N. P. (2013). Causes of Variation Orders in Road Construction Projects in Sri Lanka. *ISRN Construction Engineering, 2013*, 1-7.

Ismail,A., Pourrostam,T., Soleymanzadeh,A., and Ghouyounchizad,M.(2012). Factors Causing Variation Orders and their Effects in Roadway Construction Projects.*Research Journal of Applied Sciences, Engineering and Technology,4,(23),4969-4972.*

Keane, P., Sertyesilisik, B., & Ross, A. (2010). Variations And Change Orders On Construction Projects. Journal of Legal Affairs and Dispute Resolution In Engineering and Construction, 2(2), 89-89.

Koskela, L. (2000). An exploration towards a production theory and its application to construction. VTT Technical Research Centre of Finland..

Koskela, L, & Vrijhoef, R.. (2000). The prevalent theory of construction is a hindrance for innovation. In IGLC Conference, Brighton, UK, 17-19 July, 11.

Koushki, P. A., Al-Rashid, K., & Kartam, N. (2005). Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics*, *23*(3), 285-294.

Kuprenas, J. A. (1988). Use of influence diagrams to assess the cost and schedule impact of construction changes. (Order No. 8902012, University of California, Berkeley). ProQuest Dissertations and Theses, , 180-180 p.

Klee, L. (2015). International Construction Contract Law.John Wiley & Sons.

Levin, P. (1998).Construction contract claims, changes & dispute resolution (2nd ed.). Reston, VA: ASCE Press.

Mohammad, N., Ani, A. C., Rakmat, R. A. O. K., & Yusof, M. A. (2010). Investigation on the causes of variation orders in the construction of building project–a study in the state of Selangor, Malaysia. *Journal of Building Performance*, *1*(1).

Mohanna, R., Qedra, M. A., Kurd, R. A., & Agha, S. (2010) Quantifying lean construction effects: a discrete system simulation approach. International Journal of Rapid Manufacturing, 1(3), 292-307.

Memon, A. H., Rahman, I. A., & Hasan, M. F. A. (2014). Significant Causes and Effects of Variation Orders in Construction Projects.

Moselhi, O., & El-Rayes, K. (1993). Scheduling of repetitive projects with cost optimization. Journal of Construction Engineering and Management, 119(4), 681-697.

Nagapan, S., Abdul Rahman, I., & Asmi, A. (2011). A review of construction waste cause factors. University Tun Hussein Onn Malaysia.

Ndihokubwayo, R. (2008). An analysis of the impact of variation orders on project performance.

Ndihokubwayo, R., & Haupt, T. (2009) Variation orders on construction projects: value adding or waste?. International Journal of Construction Project Management.

Osman, Z., Omran, A. and Foo, C.K. (2009).The potential effects of variation orders in Construction Projects. Journal of Engineering, 2, 141–152.

Real estate sector to grow by 70% by 2020. (2015). Retrieved April 28, 2016, from http://www.theworldfolio.com/news/real-estate-sector-to-grow-by-70-by-2020/3671/

Samy,A.(2013). Identifying and assessing the causes of cost overrun at the design and preconstruction stages in the Egyptian construction industry.

Semple, C. A. (1996). Construction change order impacts. (Order No. MM18814, University of Calgary (Canada)). ProQuest Dissertations and Theses, , 278-278.

Sunday, O. A. (2010). Impact of variation orders on public construction projects. In 26th Annual ARCOM Conference, Leeds, UK.

Sweeney, N. (1998). Who Pays for Defective Design?." J. Manage. Eng., 14(6), 65–68.

Wambeke, B. W., Hsiang, S. M., & Liu, M. (2011). Causes of variation in construction project task starting times and duration. Journal of Construction Engineering and Management, 137(9), 663-677..

The American University in Cairo
School of Science and Engineering Department
Of Construction Engineering and Architectural Engineering

Issue Date:

Response Date:

"Impact of Variation Orders on Performance of Repetitive Residential Projects in Egypt"

Dear Respondent,

Thank you for volunteering your valuable time and experience in answering this questionnaire that will be a main component on my research: "Impact of Variation Orders on Performance of Repetitive Residential Projects in Egypt". Before proceeding to fill the questionnaire, may you please provide the following information related to yourself, your company, and permission for disclosure/non-disclosure of your personal information for the sole purpose of this questionnaire.

1. **Name:**

2. **Designation: Engineer**

3. **Work Address:**

4. **Work Tel.:** **Mobile:**

5. **E-mail: heshamhamed@aucegypt.edu**

(Please Put Tick or Yes in front of the selected cell for the following items)

6. Education back ground:

- ☐ **Bachelor degree**
- ☐ **Master degree**
- ☐ **Doctoral Degree**
- ☐ **Other (Kindly Specify)**

7. Professional:

- ☐ **Architect**
- ☐ **Mechanical engineer**
- ☐ **Electrical engineer**
- ☐ **Civil engineer**
- ☐ **Other (Kindly Specify)**

8. Number of years of work experience:

- ☐ **Less than 5 years**
- ☐ **5-10 years**
- ☐ **10-15 years**
- ☐ **15-20 years**
- ☐ **More than 20 years**

9. Role

(Note: Type of respondent while filling the questionnaire; which party you are responsible):

- ☐ **Owner**
- ☐ **Designer**
- ☐ **Consultant**
- ☐ **Project Manager**
- ☐ **Contractor**
- ☐ **Sub- contractor**
- ☐ **Other (Kindly specify)**

10. Position:

- ☐ **Executives**
- ☐ **Project Managers**
- ☐ **Department Heads**
- ☐ **Architect/ Engineer**
- ☐ **Other (Kindly specify)**

11. Company Name:

12. Company Nationality:

14. Projects on which you have the most experience can be categorized as:

- ☐ **Residential**
- ☐ **Commercial Projects**
- ☐ **Institutional Projects**
- ☐ **Industrial**
- ☐ **Infrastructure Projects**

I authorize the disclosure of my personal information for the sole purpose of this questionnaire.

I do not authorize the disclosure of my personal information.

Thank you for your anticipated cooperation.

Note:

Using a scale of 1 to 5, rate the following according to their importance of occurrence as to be ranked aaccording to their significances in the boxes bellow. Finally, when you complete the questionnaire please remember to save before sending it via email.

Important (Scale of 1 to 5)
1=Not Significant
2= Slightly Significant
3=Significant
4=Very Significant
5=Extremely Significant

Q1.	**The following are examples of causes of variation orders, please indicate the degree of importance for each cause according to the scale of 1 to 5 from your opinion as for the repetitive residential projects in Egypt.**					
No	Causes of variation order	Important Scale 1 To 5				
		1	**2**	**3**	**4**	**5**
1	Change in design by consultant					
2	Errors and omissions in design					
3	Conflicts between contract documents					
4	Inadequate scope of work for contractor					
5	Lack of coordination					
6	Design complexity					
7	Inadequate shop drawing details					
8	Consultant's of judgment and experience					
9	Lack of consultant's knowledge of available materials and equipment					
10	Consultant's lack of required data					
11	Obstinate nature of one or more of the parties to the contract					
12	Change of plans or scope by owner					
13	Ambiguous design details					
14	Change of schedule sequence by owner					
15	Owner's financial problems					
16	Inadequate project objectives					
17	Replacement of materials or procedures					
18	Impediment in prompt decision making process					
19	Change in specifications by owner					
20	Contractor's lack of required data					
21	Lack contractor's involvement in design					
22	The contractor's financial difficulties					
23	Contractor's desire to improve his financial situation					
24	Lack of modern equipment					
25	Unfamiliarity with local conditions					
26	Lack of a specialised construction management					
27	Fast track construction					
28	Poor procurement process					
29	Lack of communication					
30	Contractor's lack of judgment and experience					
31	Shortage of skilled manpower					
32	Differing site conditions					
33	Defective workmanship					
34	Long lead procurement					
35	Safety considerations					
36	Change in economic conditions/government regulations					
37	Unforeseen site conditions					

Q2 .From your experience, what was the impact of variation orders on construction projects?

No	Nature of variation orders	Never	Seldom	Sometimes	Often	Always
1	Time overrun					
2	Time reduction					
3	Cost overrun					
4	Additional specialist equipment/personnel					
5	Optimum cost reduction					
6	Degradation of heath & safety					
7	Additional health & safety equipment/measure					
8	Disputes between parties to the contract					
9	Professional reputation of one or more parties adversely affected					
10	Degradation of quality standards					
11	Quality standards enhanced					

Non value-adding activities associated with variation orders.

Q4. From your experience with variation orders, indicate the Non-adding value activities associated with variation orders using the important scale.

A	DESIGN	Tick in the box 1 To 5				
		1	**2**	**3**	**4**	**5**
	Frequent design changes					
	Redesign due to Design errors					
	Waiting due to Lack of design information					
	Waiting due to Slow drawing distribution					
	Redesign due Complicated design					
	Redesign due Inexperience designer					
	Redesign due Interaction between various specialists					
B	**HANDLING**					
	Damage due to Wrong material storage					
	Damage due to Poor material handling					
	Damage during material transportation					
	Waiting due to Poor quality of materials					
	Waiting due to Equipment failure					
	Waiting due to Delay during delivery					
	Waiting due to Tools not suitable					

C	**LABOR**					
	Rework due to Labor's mistakes					
	Idling due to Incompetent Labors					
	Idling due to Poor attitudes of Labors					
	Rework due to Damage caused by Labors					
	Idling due to Insufficient training for Labors					
	Idling due to Lack of experience					
	Idling due to Shortage of skilled Labors					
	Waiting due to Inappropriate use of materials					
	Too much overtime for workers for non-value adding activities on site					
D	**MANAGEMENT**					
	Waiting due to Poor site management/Controlling					
	Waiting due to Inappropriate construction methods					
	Waiting due to Poor information quality					
	Waiting due to Late information flow among parties					
	Waiting due to Scarcity of equipment					
	Waiting due to Resources problem					
	Rework due to varied works					
	Waiting due to Inspection					
	Waiting periods for instructions on varied works					
	Waiting due to Communication problems					
	Waiting due to old-fashioned equipment					
	Waiting due to Non availability of equipment					
E	**SITE CONDITION**					
	Extra materials on site					
	Waiting due to Poor site condition					
	Waste resulting from packaging					
	Waiting due to overcrowding of the site					
	Waiting due to Crews interference					
F	**PROCUREMENT**					
	Waiting due to Ordering errors					
	Waiting due to Error in shipping					
	Waiting due Mistakes in quantity surveys					
	Waiting due to Ignorance of specifications					
	Waiting for Material replacement					
G	**EXTERNAL**					
	Waiting due to Effect of weather					
	Accidents due to Lack of safety					
	Waiting due to Stolen material or equipment					
	Waiting due to Damages caused by third parties					
	Waiting due to Unpredictable local conditions					

Q5. Do you have any further comment, suggestion or contribution relative to variation orders?

.....

.....

Thank you