Faculty of Postgraduate Studies and Scientific Research

German University in Cairo

Modeling to Reduce Variation Order in Construction Projects in Egypt

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering

(Structure Engineering)

By

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Supervised by

Dr. Ayman H. Nassar

Lecturer of Construction

and Project Management

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I, Omar Magdy Hassan Abdelhalem Fadl

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Thesis Title: Modeling to reduce variation order in Construction Projects in Egypt

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Abstract

Variation order is common phenomena in the construction field all over the world. These phenomena usually happen during any construction project which leads to dispute between the parties which are involved in the construction project. Also, the construction field is one of the main creations of any nation's wealth as it is the backbone of most industries for developing economics. Variation in many cases causes problems and disputes among the parties which are involved in construction projects. Thus, it is very important to study the main causes of variation order and to figure out and control variation. As if no agreement is reached between the parties of the project, it turns into a claim and dispute that may negatively affect the progress of the project and reduce its ability to be successfully completed in time within the project budget. Variation order is mainly caused due to unavailability of equipment, poor workmanship, design complexity and changing project scope etc. Variation order mainly effects on increasing project cost and delay in completion time.

The aim of this research is to produce a software modeling to help in reducing vary of variation orders causes and effects in construction projects. So, modeling eases the job and helps reducing the troubles that come along and solving problems. Modeling in the construction engineering field will act like a simulator which will help in solving that kind of variations that might be found in the construction projects. So, this research was made by evaluating questionnaire and developing the model. This model will act as a tool, which can show how to avoid variation or how to solve variation to minimizing the variation order causes in the construction field. This research discovered that variation order has a high impact on the construction field. As a fact variation order is unwanted as if we dream to have the construction field free of variations, but it is impossible to have a construction field free from variation order in reality, but it can be developing tools to assist in reduce and solve variations and this was the main aim of this research.

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1.1 Background:

A study conducted that all parties involved in the construction project have a direct proportion benefits, as if the owner wants to operate his project to start gaining profit, the consultant want to finish the project within the specification of the owner and the contractor wants to execute the project within time and budget.

So they all have to work and collaborate together to achieve a successes project. A successful project is the project which can be executed as planned on time and within budget while obtaining the required objectives and quality of the project. In a perfect construction world, there would be no variation orders, but there is no perfect construction world. Variation order is all about time overrun and cost overrun in construction projects (Arian and Pheng 2006) [1].

Time overruns is the delay in the planned schedule that can happen and it could be defined as finishing after completion date which is known in a term, or after the due date for submitting the project that the parties were agreeing on. Also, controlling time is really very important because time and cost are direct proportion where if the time increased the cost increased as well and this what can be called parallel relationship.

Cost overrun is one of the most serious problems in construction field and it could be defined as finishing the project with more cost than the planned cost or not within the budget. Cost is mainly one of the important aspects within the project management execution cycle and it is also the driving force which leads to a success project, so it is an important parameter of a project cycle. Regardless its proven importance, usually it is the one of the main reasons of failing the project from achieving its specification within the budget.

1.2 Research Problem Statement

The main problem of this research is variation order in our construction field, which leads to the failure of achieving quality, objectives and technical performance of the project within the planned time and budgeted cost will reflects and affect negatively on the project circumferences and this is the reason of a nonsuccess project. Normally, if the project time delayed an increase in cost will happen due to extending time or by crashing the project. Then the claims and problems starts between parties for who will be charged for the increase in cost. So, by making a model the project engineers or even the contractors can use this model to be aware of the causes and factors which effects the project and how avoid it or solve it in future.

1.3.1 Aim and Objectives

The aim of this research is to conduct a model by identifying and figuring out the factors that causes variation order in the construction projects in Egypt. In addition of studying the effect of variation order on the completion of the construction project within schedule and budget.

The objectives is to maintain the aim, presenting the main factors that drive time delaying and cost variation, analysis for the factors which have the biggest effect and impact on overall the project progress and finally evaluate the solutions and possible alternatives to reduce variation order by avoiding it from the beginning or quick solution for solving the issue.

1.3.2 Contributions to Knowledge

The research achieved that variation order is a serious problem in the construction field and establishing the model in a website to be a guide for anyone involved in the construction field.

Chapter Two: Literature Review

2.1 General Introduction

The variation order in constructing any kind of projects is usually linked to the performance of quality, time, and cost. Which means for a project free of variation usually will fail in achieving quality within planned time and budget. So, overrun in time and cost is a common issue that is happening every day in the construction field worldwide and the percentage of time overruns is higher compared with percentage of cost overruns but both of them facing overrun more than 50%. For the public sector, only 20.5% of the projects completed within stipulated time and 46.8% of projects completed within the budget (Ismail, Abdul Rahman and Memon 2013) [2].

Variation order is a result from the lack of management system and lack of ability to prevent time and cost overruns or to control time and costs which makes the construction companies to fail.

2.2 Time Delay

2.2.1 Introduction

Time delay is defined to be the finishing of the project after the planned time schedule and can be defined also as finishing the project beyond its completion date, which is known in the contract terms and conditions or after the agreed time of submitting the project which the parties were agreeing on.

Time delay in the construction projects are usually expensive for example if there is a construction loan involved which charges interest, staff which are involved into the project such as managers, engineers and labor all of this are costs which is time dependent, and ongoing inflation in wage and materials prices. And also, time delay has a negative effect on clients, contractors, and consultants in terms of, claims, adjudication, cash flow inflations, and some irritation feelings between each other.

2.2.2 Types of Delay

The basics of project management is to determine while planning the project is to figure out which activities are critical and non-critical. Delay in a critical activity needs to be crashed if possible if not it will affect the project duration and will require extending of time, while in non-critical activity needs a detailed analysis to check if this delay can be reduced from its float or will require additional time.

Additional time can be classified into three types of delays: [3]

1. An accepted delay with compensation.
2. An accepted delay without compensation.
3. A non-accepted delay.

2.2.2.1 An Accepted Delay with Compensation

This type of delay which is an accepted delay with compensation is also called excusable delays with compensation (entitling the contractor to additional compensation from cost and time) and usually this kind of delay is mainly occur from the owner side such as changing or adding extra work clause, suspension of work clause and stopping the work by the owner.

2.2.2.2 An Accepted Delay without Compensation

This type of delay which is an accepted delay without compensation is also called excusable delays without compensation (nether of the owner nor the contractor is responsible for the time delay for that additional compensation for time only) and usually this kind of delay is mainly occur due to force majeure reasons such as unexpected late delivery of equipment or material, unexpected whether and kind of protest from labor.

2.2.2.3 A Non-Accepted Delay

This type of delay which is non-accepted delay is also called non-excusable delays (this type of delay will be on the contractor responsibility without additional compensation in time or cost) and usually this kind of delay is mainly occur due to delay caused by the main contractor or their sub-contractor, lack in site management, unavailability of labor, failing in executing the work within the schedule, contractor financial problems and failing in achieving owner's requirements.

2.2.3 Factors That Cause Delay in Construction Projects

A questionnaire to investigated the top ten causes of delays to investigate what are the factors that causes delays in time from which could be related to owner, consultant, contractor, material, labor, equipment or project. The researcher used three method severity Index, frequency index and importance index to analyze the questionnaire results. Severity Index analyzes shows that low productivity level of labors, shortage of construction materials in market, difficulties in financing project by contractor, fluctuations in cost/currency, unqualified workforce, during construction, finance and payments of completed work by owner, inadequate experience of consultant, effects of subsurface conditions, shortage of labors and changes of scope by owner. While, frequency index shows that the top ten factors that causes delay are slow in decision making, changes of scope by owner during execution, ineffective planning and scheduling of project, late in revising and approving design documents or finance and payments of completed work by owner, poor site management and supervision, low productivity level of labors, difficulties in financing project by contractor, effects of subsurface conditions (e.g., soil, high water table, etc.) and type of project bidding and award (negotiation, lowest bidder) (Marzouk 2014) [4].

Another research shows the causes of project delay in the construction industry, that carried out a survey to get the most important and critical reasons that can cause delay in time of the project. The researcher used both primary and secondary data, and that data which had been collected through two primary ways, which are desk research and questionnaire. The authors found that many factors for causing delay can be categorized it into groups. Causes related to the owner as it could be delay due difficulties in financing project and changing the project scope, causes related to the contractor change of sub-contractors because of their inefficient work, poor site management, poor supervision and poor qualification of the contractor technical staff and lack of security, causes by the consultant are delay in approving major changes in the scope of work, inadequate design-team experience, late in reviewing and approving design documents and delay in performing inspection and testing. The authors found that there are external causes of delaying related to materials, market and government. Late procurement of materials, delay in manufacturing special building materials, damage of sorted material, delay in material delivery, changes in material types and specifications during construction are material related causes. Late in selection of materials because of the variety in market and inflation in market are causes related to the market. Poor judgment in the construction claims and disputes, regulation and laws of government and permit from order of engineers are causes related to government (Niazai and Gidado) [5].

Designed questionnaire survey was made up to figure out the causes of delay which are related to consultants and contractors point of view. The questionnaire was about 28 construction delay factors and the respondents have to identify their organization. The study identified 10 of the most critical causes of delay. The point of view of contractors and consultants tried to rank the causes of delays based on their relative importance index. The most ten critical causes of delay were time overrun in progress payment by owner, change orders by owner during execution of the construction project, poor site management, late in taking decision process by owner, financial problems by contractors, slowness in reviewing and approving design documents by owner, changing subcontractors during execution of work, poor planning and scheduling by contractor, mistakes and conflict in design documents and changing of weather (Pourrostam and Ismail 2012) [6].

A questionnaire was made to evaluate the perception of the national and multinational construction organizations based on the 52 causes of time overrun. The questionnaire was splitted into four different parts. The first part was to the respondents to identify their

background information. The second part was about the factors that cause delay in the construction projects, while the third part was on the effects of the delay and the fourth part was the methods of minimization time delay. The result showed the fifty- two factors causing construction time overrun were identified from the respondents' opinion poll which are selected stakeholders in the construction industry. The results also showed that two organization believed that financial problems which is the cash flow problems, shortage in materials, difficulties in financiering by the owner, unqualified project team, lack of consultant experience, lack of contractor experience, bad design and delays in submitting design documents, incomplete of required drawing or detail design, poor communication and coordination between all parties, change orders/variation order and problems in financing project are the most important critical causes of construction delay (Abisuga, Amusu and Salvador 2014) [7].

A structured questionnaire was designed and distributed it on engineers working in the construction field for public construction projects in India. 95 responses were valid, this research identified the causes of delay and analyzed the critical and frequency of time overrun. The results showed that “changes in owners' objective and requirement” are the main causes for delaying in the project planning and designing phases. The factors, which caused delay in the construction project, were: preparation and approval of design drawings, late in contractor\'s progress, problems in payment by the owners and changes order. Although from the slow in taking decision by the owner was the most causing for time overrun (Taher, and Pandey 2013) [8].

Another study carried out the causes of delay in executing construction projects in Ghana to figure out the most important and critical cause of time overrun related to each of the parties involved in the project; owners, consultants, and contractors. The study identified thirty-two likely factors of causing time overrun can be categorized into nine important groups. The questionnaire was distributed on 130 respondents, which were 37 owners, 54 consultants and 39 contractors. The groups were calculated and evaluated by their relatively importance of the individual causes. An importance index was the method used in analyzing the questionnaire results. The majority of the results indicate that the respondents are generally agreeing that the highest ranked group is financial group factors among the other groups causing delay or time overrun in construction field in Ghana. The financial group factors contain delay and disrespecting for payment conditions, difficulty in financing the project due to the turning in prices. The second ranked group is the

materials group factors contains shortage of materials and late deliveries of materials, then followed by the third ranked group which is scheduling and controlling factors which contains poor supervision, accidents during construction, poor site management, lack of programing of works, construction methods, underestimation of costs of projects, underestimation of complexity of projects and underestimation of time of completion. Fourth ranked group is contractual relationship factors such as poor professional management, legal disputes, insufficient communication between parties, delay in instructions from consultants and delay by subcontractors. Changes occupy the fifth ranked group such as owner-initiated variations, necessary variations, and mistakes with soil investigations, foundation conditions encountered on site and poor design. Equipment group is the sixth group with unskilled equipment operators and breakdown of equipment. Environment group comes in the seventh place; this group contains bad weather conditions and unfavorable site conditions. The eighth group is the government factors, which are obtaining permit from municipality, discrepancy between design specification and building code and public holiday. Manpower group is the least ranked group its factors are shortage of skilled labor and shortage of unskilled labor (Frank et al. 2007) [9].

Although, a study carried the most important and critical causes of time delay were as shown follows: approval of building permissions, changing in order, Changing in scope and drawings, incomplete in design documents, changing in specifications and objectives, late decision taking in development stage, late in shop drawings approval, inadequate design development and changing in Laws and regulations. The analyzes showed the ranking of each organization involved in causing delays in the construction field from responsibility in percentage as follows: Contractor = 44%, Owner = 24%, Government = 14%. Shared = 12%, Consultant = 6%. Also, the analyzes shows that the most common type of delays are accepted delay with compensation.at 48%, a non-accepted delay 44% and accepted delay without compensation with 8% (Gandhak and Sabihuddin 2014) [10].

2.2.4 Effect of Time Delay

Time overrun usually causes problems, arbitration, dispute, litigation and total conflicts between the different parties who are involved in the project. On the other side, the common reason of causing delaying problem is the loss of time, so a reasonable contract time will help a lot in avoiding higher bid costs, money and utilities. The effect of time overruns on the owner will lead to loss of revenue which is the profit throughout operation and production facilities which is the main aim of the owner and the daily service revenues loses cannot be recovered. While the effect of time overruns on the contractor side will lead to loss of money to be capable to finish the project by paying daily wages for the project staff from managers, engineers and labor and also for the equipment all off these are examples of losing money to the contractor. Beside all of that the public can be also affected by the unavailability of the facilities and buildings, which were expected for use (Shaikh, Muree and Soomro) [11].

A study presents how can time delay effects the project life cycle. Time overrun will lead to increasing in the final cost of project that will exceeds the budget, man-power and resources wastage, financial problem due decreasing of owner capital due to non-finished of project, dispute between involved organization or parties were ranked as highest. Time is common factor that is very important in all activities that has to be observed carefully, in the contract document a specific clause and conditional terms for time is given clearly for finishing of project and if additional time is required it will require more money to be spent on the project which usually lead to increase in budget of the project (James et al.2014) [12].

In another, paper carried out the delay in time that could happen will effect on additional time for the project, increasing of cost due to variation and inflation, increase in the interest rate by accumulations of the rate on the owner capital which finance the project, disputes on the conflicts of normal progress of project life cycle while executing by the main contractor, poor in managing of using and purchasing resources of the project such as equipment and plant, decreasing in confidence level in the contract, thereby imperil the fame of the contractor in the construction market in case of applying in the future for a new project maybe decreases the contractor chance in tendering, delay in returns of revenue, decreases in opportunities for employment, claims, dispute and conflicts between the parties in the project, decrease in economical industry in the nation and more cost due to additional taxes due to time overrun (Akinsiku and Akinsulire 2012) [13].

More effects of time delay that time overruns effects negatively on many different fields and aspects of a construction project such as quality, time, cost and safety. Long-term the projects are critical because once a delay happen or occur all the plan will be effected and lose will conquer its economic plan or its financial path, although these negative effects of delay leads the project to legal argument, claims and disputes between owner, contractor and consultant in addition to decreases of productivity and revenue (Akinsiku and Akinsulire 2012) [13].

2.2.5 Recommendations for Time Delay

A study recommended some solutions to avoid delay in project throughout good planning for quality management, perform quality assurance department to control quality of the project, plan, define and control the project scope, require data management to be responsible for collecting data, create WBS of the project to be able to control the project from the smallest activity, stakeholders should be identified, manage stakeholder's responsibilities, control stakeholders responsibilities, a well communication management to manage communications between parties and to control communications (Alavifar and Motamedi 2014) [14].

Although, causes of project delay in the construction industry, recommended that the project must have an effective management planning and programming, there is an important desire for the owner to develop an obvious mechanism system to accelerate the payment process and from day one until delivering of the project the planning process must be developed (Niazai and Gidado)[5].

To solve delay problems an analysis of time slippage for construction projects in public sector: Owner's Perspective, recommend that the owner should be able to supply all users' needs to avoid re-design or changes, the owner should be definitely able to finance for the project, cost estimation with cash flow and project budget requirements before tendering the project to the market. Planning has many phases first phase is most important phase which is called the initial planning phase which includes preliminary engineering and design. This phase has to take a sufficient time to avoid changing order inadequate design. Anther recommended solution is the owners must take on quick decision about critical and important technical issues (Jamil, Mufti and Dar 2012) [15].

In another construction delay factors solutions recommended a periodic meeting that will help in updating the construction progress, using up to date strategy technology, using the

corrected, proper and recent construction equipment, using of new construction methods, effective management with strategic planning, procurement plan for materials, clear documents and information, periodic coordination between involved parties in the project, goes to past experience, good planning and scheduling for the project, complete and clear design approved on time, supervision and managing for the site, team work is important in construction projects so all have to collaborate together and finally compressing or crashing of the construction durations can decrease time delay in projects (Khadim and Adavi 2014)[16].

2.3 Cost Overrun

2.3.1 Introduction

Throughout history, construction companies have failed to neither deliver its services nor complete its assigned engagements after falling in the cost overrun trap. Giant construction projects for example Highway constructions have been exponentially exposed to major cost overruns, the phenomena when planned costs exceeded the actual costs disbursed which leads to surpassing the settled budget for the project. Detailed Analysis conducted for cost variation indicated that, approximately 95% of constructions projects are subject to overruns and estimated the ratio of actual to planned costs to not exceed 2.00 (Bhargava et al.2010) [17].

However, further research proved that cost overruns is not the only sole element effecting the construction process and slaying its budgets, time delays has always been a fundamental element accompanying cost overruns and in other cases its significant cause. After decades of researching and despite the efforts exerted to prevent these overruns, time and cost overruns have been officially marked as a common issue in construction field worldwide with frequency of both factors to occur exceeding 50% when measured upon the Public Sector scoring 20.5% of its projects accomplished within time while 46.8% of projects completed within its budget (Ismail, Abdul Rahman and Memon 2013) [2].

In an article that carried that with the lack of effective management programs to address this issue, organizations found themselves in constant challenge to deliver its projects within budget over the settled time span from initiation till completion. This issue has been widely known as Cost variation. Despite the complexity of Cost Variation issue, it has been introduced with three major factors that overlap with each other to impact the overall performance. These Factors are Time, Cost and Quality. These primary factors are constantly escalating from sub-factors that hinder performance such as projects complexity, vagueness of scope, inaccessible technology requirements, team requirements and others (Memon and Abdul Rahman 2011) [18].

Furthermore, a study carried the factors affecting the construction process either being avoidable or not are numerous and are derived from different sources. These sources include financial and managerial issues, resources unavailability, outer conditions and performance of construction parties (Mahamid, Dmaidi 2013) [19].

More examples of economies profit margins have slowed down due to cost variation such as Vietnam, India, The United Kingdom (UK), Egypt and Uganda. The economy of Uganda Faced a constant problem of failing to deliver projects on time due to delays in completion and overruns that raised a lot of concern. It was also noted that Uganda's Problems mainly were centralized in the Implementation phase of the project. While on the other hand, the Vietnamese, Indian, Egyptian and British economies faced no different challenges from Uganda during its journey for Urbanization and Developing Infrastructure. For the above-mentioned economies, the end result for both lead to reduction in profit margins, project failure and Citizen's Faith in Governments has been jeopardized.
Study carried out the scored that, 70% of the Indian contracts faced overruns, while 25% of British contracts have been extended (Patil, Ullagaddi and Jugati 2011) [20].

As for Egypt, shows that 45% of the Government's national Funds were allocated for the construction sector (Abd El-Razek, Bassioni and Mobarak 2008) [21].
A study carried out cost overruns and failure of project management despite the complexity of cost variation issue; it has been introduced with three major factors that overlap with each other to impact the overall performance. These factors are time, cost and quality. These primary factors are constantly escalating from sub-factors that hinder performance such as projects complexity, vagueness of scope, inaccessible technology requirements, team requirements and others (Doloi 2013) [22].

2.3.2 Types of Cost

Taking a further look into cost, In Order to clearly measure and identify cost estimated for a construction project in order to mitigate the risks arising from overruns, Cost Has to be fully understood and tackled. In Other words, Cost has to be considered in all its factors such as the differentiation between variable and fixed. The identification of the right variable or fixed cost helps the manager to predict the total costs and to take decisions advisedly. Another cost classification understands the differentiation between direct and indirect types of cost and their remarkable and significant effect on performance (Briciu 1918) [23].

2.3.2.1 Variable Cost

Variable cost is defined as the cost which changes with the amount of production, also it can be defined as unit cost depended which means increase in unit volume increases the variable cost and vice versa (Briciu 1918) [23].

2.3.2.2 Fixed Cost

Fixed cost is defined as the cost, which is unchangeable with the amount of production, also it can be defined as unit cost independent, which means it's the cost that will be paid even if there is no production (Briciu 1918) [23].

2.3.2.3 Direct Cost

Direct cost is defined to be the cost, which is involved in the production such as designing, equipment, material and labor cost etc. In other words, it is the cost that can be distributed on a single activity (Ghanshyam et al.2014) [24].

2.3.2.4 Indirect Cost

Indirect cost is defined to be the cost which is not involved directly in the production such as replacement and maintenance of equipment, security, accidents, supervision and managers cost etc. In other words, it is the cost which cannot be distributed on a single activity (Ghanshyam et al.2014) [24].

2.3.3 Factors That Cause Cost Variation in Construction Projects

The tendency of a project to be a subject to cost overruns differs according to the inherent factors and construction practices surrounding it and associated in accordance to project's genre. Even conditions affecting the process are not standardized and vary with their impact, magnitude, force and estimated time. Common occurring conditions could be like harsh weather conditions, project's settled duration, contract's size and contract's biddings are fondly known for their statistically significant impact and extent of impact (Anastasopoulos et al.2010) [25].

The factors affecting construction projects and eventually leading to delays and overruns could be wither external or internal. Internal factors are a nascent of construction attributes such as contracts, materials, communication and others. These internal factors could take place or not and can be avoidable in some cases. On the other side, External factors are macro ones that affect cannot be evaded and in some countries its impact can be severe and hinder the workflow or lead to terminations or losses such as: political instability, inflation rates, unfair contract biddings to lowest prices, high cost skilled labor and difficulty in attaining work permits (kholif, Hosny and Sanad 2013) [26].

As mentioned in the above sections, the internal variables prompting cost variation vary across the construction stages from planning, implementing or completion. Experts hunted down these variables to eight main ones that could assist contractors in predicting the percentage of cost variation that could occur from each variable if taken into consideration to provide a predictable estimated picture of cost escalations or delays that could occur if such variables were not adequately addressed. These variables are simplified into: Misleading construction drawings, lack of coordination between contractors and design teams, inappropriate or inexperienced contractors for certain projects, additional works, work suspensions arising from conflicts, constant changes in design plans after the project's inception, funding problems and insufficient or inadequate environmental location (working site) Investigations (Aziz 2012) [27].

However, their chances of occurrence vary from a construction phase to another or if carefully monitored could be avoided in some projects. Two factors have been noted to occur in all phases, which are constant changes in projects scoping and lack of communication between different parties working on the same project (Ismail, Abdul Rahman and Memon 2013) [2].

A survey conducted among a population of contractors, clients and consultants highlighted eight attributes from a total of overall pool of 36 attributes based on the recipients' responses could help balance the cost overruns equation if tackled correctly could aid in diminishing the embedded impact of cost overruns and delays. These 8 attributes are: accurate planning with monitoring for the project, feasible site management, increase design efficiency, enhancing communication among all involved parties, due diligence, adequate assessment of market competition, Proper and equipped contractors with required expertise and for assigned projects and fair evaluation of all project characteristics that could act as a future obstacle (Doloi 2013) [22].

More in depth, SHAs Experts reasoned cost escalation's outcomes and stimulators into several points: (Shane 2015) [28].

- As a consequence of cost escalation, dismissing of experienced staff and replacement with less experienced staff leading to poor results and more time usage.
- Engineering and construction complexities arising from lack of environmental understanding of the nature of projects working site (accomplished by coordinating with environmental agencies) that eventually leads to major changes of project's scoping, procurement and delivery quality and timing.
- Overlapping of development standards leading to poor projections and estimates for construction projects.
- Lack of coherency and division of large projects into small separate projects raising higher cost expenditure and lower quality of projects display instead of proper coherent combined project with better funding.

2.3.4 Effect of Cost Variations

A study conducted that cost variation has mainly five common effects in variation order which are project cost increase, failure of project cash flow, failure of project completion schedule, additional money for contractor and delay in payment of invoices (Alaryan et al.2014) [29].

Although, study carried out the effect of cost variation there are six critical effects which are dispute between owner and contractor, increase in project cost, additional money for contractor, delay in payment, decrease in quality and decrease in productivity (Abdulghafoor 2000) [30].

- Dispute between owner and contractor: cost overruns are mainly the common problem, which always leads to conflicts, disputes and claims. Cost of all work is being stated in the contract and both parties agreed on. However, changing in cost due to any reason must go through official discussing and negotiation then evaluating after moves to estimating and all of these stages leads to uncomfortable feelings with strains and stress in the relation among the parties, although if this claims and disputes did not peacefully solve in the official negotiation they will move to end it up by legal litigation issues which maybe stops the whole project.
- Increase in project cost: this is very obvious effect due to cost changes.

- Additional money for contractor: executing of additional work or changing in scope will often leads to an extra money to be paid to the contractor will affect negatively on the project. The owner and contractor must be aware of direct and indirect effects of cost variation otherwise they should be willingness and ready to accept this cost variation fact.
- Delay in payment: if a delay happens in contractor invoice or milestone it may lead to delaying in that milestone or coming milestones of the project.
- Decrease in quality: Sometimes cost variation effects quality by hiring unqualified workmanship and changing material to low standers.
- Decrease in productivity: cost overrun and change orders have negative impact on workmanship, so their productivity rate decreases.

2.3.5 Recommendations to Control Cost Variation

A study recommended some solutions to avoid cost variation in project to control successfully the cost variation and cost overruns issues, also it recommended to study and understood well all cost circumstance and plan the method of treating it well by a professional techniques and modern methods throughout good finance planning for accurate budget, perform quality control department to avoid re-executing work, define and control the project scope, create cash flow studies for the project to be able to control the project budget, a well communication system between involved parties (Madhura and Desale 2013) [31].

Chapter Three: Methodology

3.1 Introduction

As the literature review carried out the factors from previous studies causing variation order from the two main aspects, which are time overrun and cost overrun, in construction projects, so this chapter will show the design of methodology used to conduct the research in order to achieve the study aims from developing the variation order model, moreover the model will show the critical effective factors that cause variation order in the construction project and provide how to avoid it or how to solve it if happened. Although, this chapter introduce the features of the study research and the methods of collecting and analyzing data.

3.2 Modeling and Research Method

To develop a model there are too many methods to model there are a verity available nowadays in the world due to the new technology methods found as well as the research method. Different modeling types have also different type of methods from programming and designing as well as different research types have also different type of methods from collecting and analyzing data. The method used in modeling was in form of a website to be used by easily in any place worldwide without needing source, permission or something from the author to use it, while the research method used was reading more than eighty-five paper from articles or case studies and by collecting data from a designed questionnaire, this questionnaire was designed and published and have been send to respondents from engineers and non-engineers working in the construction field organization such as contractor, consultant and owner. Most data were collected from this questionnaire. Using website questionnaire method made the results more accurate as it never allows the respondents to skip any of the questions and beside this method the author made interviews with the respondents to introduce the questionnaire were easily understood and well defined, so this method gives the author more accurate results, so the research methodology depended on: literature review, interviews, questionnaire to develop a modeling software to assist in reducing variation order.

3.3 Modelling Design

The method used to design the model was about developing a website model to be used anytime from any place by using a WordPress method to develop a professional website to act as a guide for all parties involved in the construction field by presenting the factors leads to variation order in construction projects and to achieve mainly the objectives in Egypt, but it can be used worldwide, if more researches done on the different factors due to the location of the project. The domain which is the website link of the model is been bought for three years and will be extended. The model was designed by using WordPress to build the website in shape of model. All data and results in the model was obtained from the research method.

3.4 Research Design

This research was designed and made to figure out the factors which lead to variation order for construction projects and to fulfill all the objectives and requirements in the Egyptian construction industry. The research was settled in a logical sequence to be simple, specific on its aims and to avoid any kind of misunderstanding. In order to be sure of the research aim, objective and stating the problem for a clear perspective about the factors causing variation order were stated in the outset problem statement, aims and objectives of the research were therefore stated at the outset of the research. So, the study was designed to undertake four stages. The first stage was a global literature review. This stage was parallel to all other stages as it was an important stage to provide the newest information on the research subject. Second stage was data collection which was collected through questionnaire surveys and meetings, while the third stage was the results obtained from data analysis of the collected data, finally was the data entry stage by inserting the results, which was obtained from the previous stages, so the users can easily use the model.

3.5 Research Factor

The research factors that were identified and obtained from the second chapter which was the lecture review chapter, which was probable to be relative in studying factors causing variation order is the main objective. So, in order to obtain that objective, the organized literature review was made. The objective was to:

- Clarify and define the aim of the research
- Historical perspective should be taken in the study consideration
- Recognize the research design and methodology
- Presents the upcoming direction of the study in the future

More than thirty main factors of causing variation order in the construction field were conducted and obtained from different sources such as journal articles, researches magazines and internet, which are gained from literature review are classified by each party as contractor, consultant and owner. Contractor factors were complex design and technology, unavailability of equipment, difficulties in financing project by contractor, delay in site mobilization due to unfamiliarity with local conditions, rework due to errors during construction, unqualified workforce, unavailability of skills, shortage of labors, differing site conditions, frequent change of sub-contractors because of their inefficient work, poor site management and supervision, poor workmanship, shortage of material and high cost of skilled labor. Consultant factors were inadequate working drawing details, inadequate design, design complexity, delays in producing design documents, conflicts among contract documents, change in specification by the consultant, errors and omissions in design, change in design by the consultant, un-use of advanced engineering design software, poor knowledge of available materials and equipment, quality assurance/control, delay in performing inspection and testing by consultant and delays in approving shop drawings. While, change of scope obstinate nature of owner, inadequate project objectives, owner's financial problems, change in specifications by the owner, interference of employer, impediment to prompt decision-making process replacement of materials or procedures, poor communication and coordination by owner and other parties and unrealistic contract duration.

3.6 Questionnaire and Data Collecting

3.6.1 Questionnaire Content

The questionnaire includes the objective and the aim of the research to help the respondents answer the research questions. The questionnaire starts with some personal information about the respondents to identify himself/herself like asking about their names, emails, engineers or not, kind of organization whether it was owner, contractor or consultant, job title, and years of experience. Then the questionnaire was divided and categorized into three section each organization: owner section, consultant section and contractor section. The participants were gently requested to choose one choices for each cause of variation order which is very low, low, moderate, high and very high and the chooses were numbered from 1 to 5 respectively. At the end of the questionnaire, a submission message pop up to ask to the participant if there was any variation order factor missing or for any information send email to the website email address that was written in the message.

3.6.2 Data Analysis Method

Qualitative and quantitative data were made throughout analyzing the data and was prepared in the clearest format to be easily understood by using the most valuable techniques in well-organized form. The data collected and results were presented in a clear form of tables, graphs and figures. Two methods of analysis were used in finding and obtaining an accurate result, first method is the Descartes equation, while the second method is using the SPSS to show the value and percentage of the mean, median, mode, stander deviation and other parameters for each factor.

Chapter Four: Collecting and Analyzing Data

4.1 Introduction

The methodology chapter focused on carrying and showing out the modeling and research methods which used to make the model and to analyze the collected data. So, this chapter includes the data analysis which is obtained from the collected data of the questionnaires. A hundred participant have done the questionnaire 92 were accepted and 8 were rejected. The rejected questionnaire was figured that 5 were spam due to incorrect personal information such as name, email, job title or major by writing non-readable words, while the other 3 were choosing more than one choice for each factor. Also, this chapter will present the percentage and the rank of each factor.

4.2 Participants General Information

The participants were 92 all of them was working in the construction field 63 were males and 29 females as shown in (Figure 1). They were about 78 engineers and 14 non-engineer such as accountant, supervisors etc. as shown in (Figure 2). Also, there were different majors such as 61 civil engineering, 13 architecture engineering, 9 management such as account and finance and 9 were named as others such as politics, institutes and mass com as shown in (Figure 3). There was a verity in their experience 52 were from 1 to 5 years, 15 were from 6 to 10 years, 11 were from 11 to 15 years and 14 were more than 15 years as shown in (Figure 4). Last the participants were asked what type of organization they are related to as shown in (Figure 5) 50 were working in a contractor organization, 17 were working in consultant organization, 15 were working in owner organization and 10 were located as others such as working in academic field, government or anther organization related to the construction field.

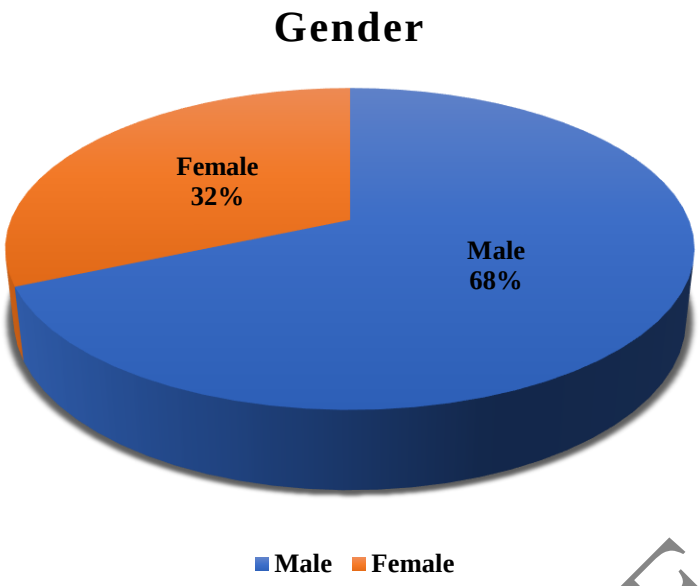


Figure 1: Participant's Gender Percentage

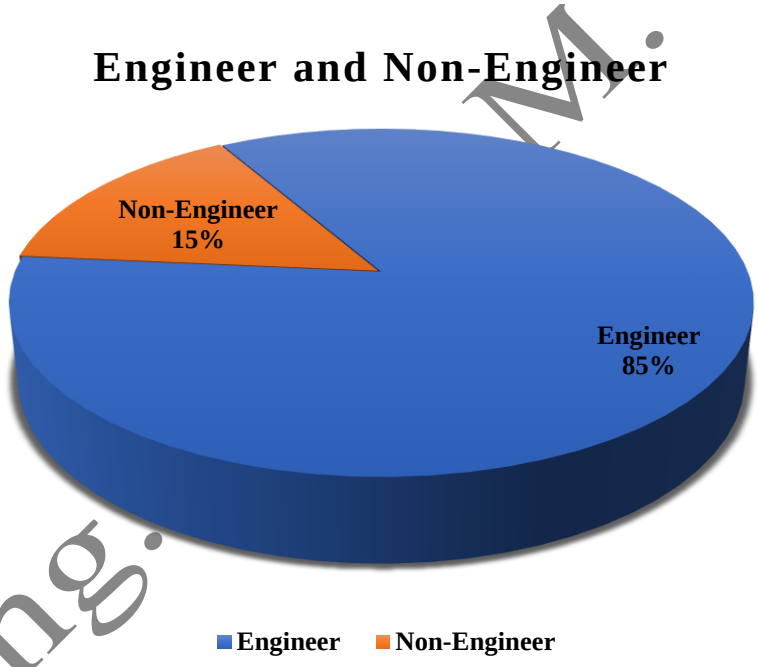


Figure 2: Participant's Engineer and Non-Engineer Percentage

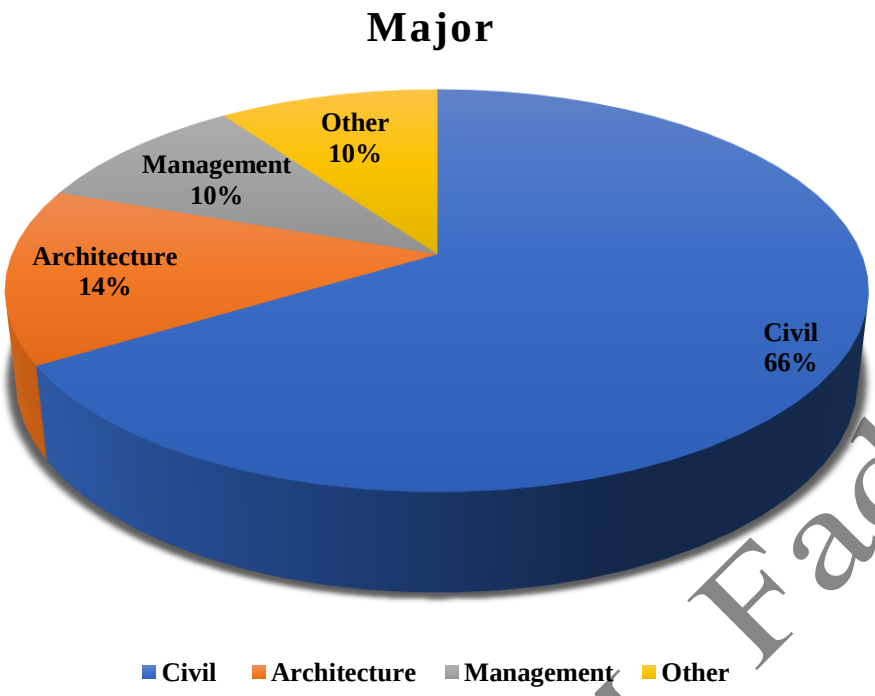


Figure 3: Participant's Major Percentage

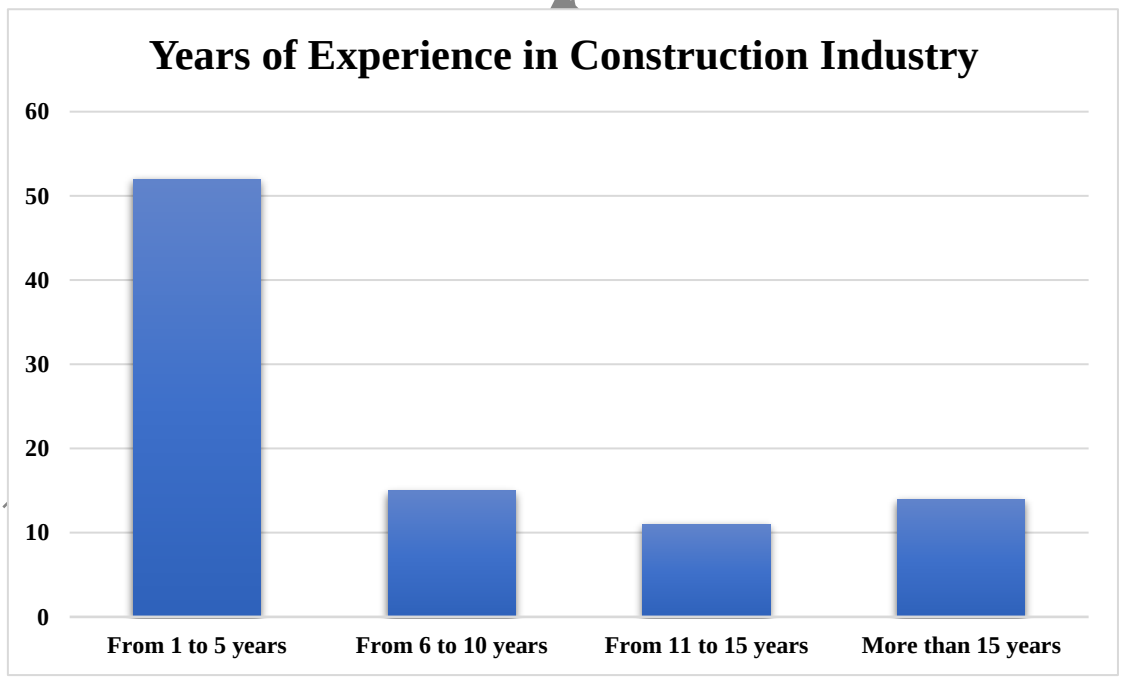


Figure 4: Participant's Years of Experience in Construction Industry

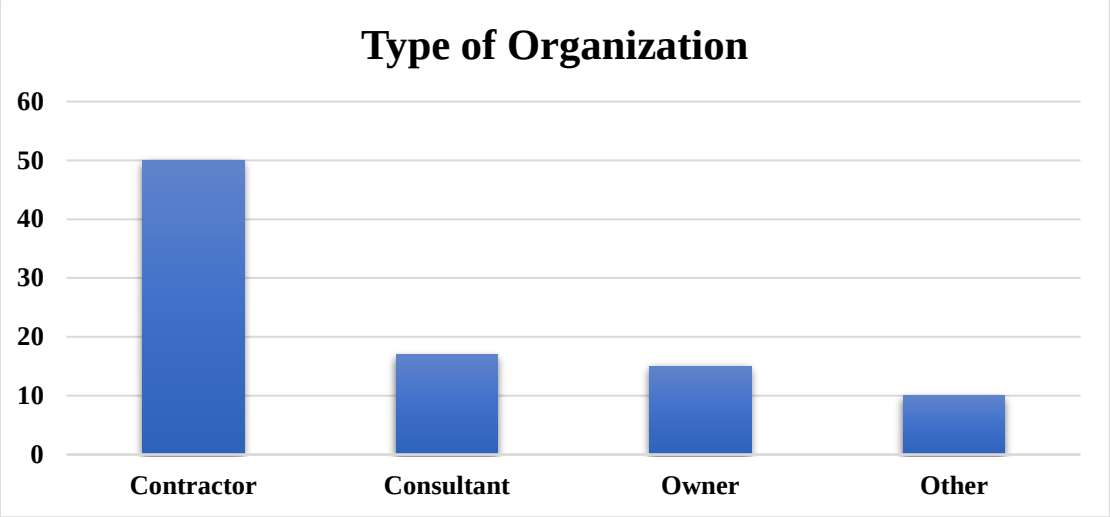


Figure 5: Participant's Type of Organization Working in

4.3 Methods of Analyzing Data

Two methods were used to analysis the data, Descartes equation and the SPSS. The SPSS program is statistics analysis software that is well known for all researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners and others. SPSS is widely used program due to its easily interference and its user friendly. SPSS calculate and plot graphs for the analysis results by showing mean, median, mode, standard deviation and other parameters by using excel spreadsheet and SPSS program to represent the collected data in table, to calculate and to conduct graphs and figures.

- The Mean is the average, which is the sum of total choices and divided by their numbers.
- The Median is the choice number, which comes in the medal of the total choices.
- The Mode is the choice number, which is most repeated.
- Standard deviation represents the allowances and whether there is a gap between the participants choice or not.

4.3.1 Descartes Equation Method

$$W\% = (A+2B+3C+4D+5E)/5$$

Where:

A = total of choice of (1) “very low”

B = total of choice of (2) “low”

C= total of choice of (3) “moderate”

D = total of choice of (4) “high”

E = total of choice of (5) “very high”

4.3.1.1 Owner Section Results

The result that obtained from the owner section by using Descartes Equation showed that the top ranked factor is owner's financial problems by weight of 70.4 %, while the lowest factor was unrealistic contract duration by weight of 53.8 % and in between impediment to prompt decision-making process by weight of 69.2%, change of scope by weight of 69 %, change in specifications by the owner by weight of 64.8 %, inadequate project objectives by weight of 63.8 %, replacement of materials or procedures and interference of employer are in the same rank by weight of 59.6 %, obstinate nature of owner by weight of 58.8 % and poor communication and coordination by owner and other parties by weight of 58.2 % respectively from high to low ranked factor as shown in (Table 1) (Figure 6).

Owner's Factors	1	2	3	4	5	Weight %
Owner's financial problems	11	9	10	17	45	70.4
Impediment to prompt decision-making process	4	7	19	39	23	69.2
Change of scope	7	14	15	15	41	69
Change in specifications by the owner	4	14	21	36	17	64.8
Inadequate project objectives	6	13	22	34	17	63.8
Interference of employer	6	19	27	27	13	59.6
Replacement of materials or procedures	4	14	36	32	6	59.6
Obstinate nature of owner	10	14	26	32	10	58.8
Poor communication and coordination by owner and other parties	9	17	26	30	10	58.2
Unrealistic contract duration	18	20	17	25	12	53.8

Table 1: Result of Owner's Section and its Weight by Descartes Equation

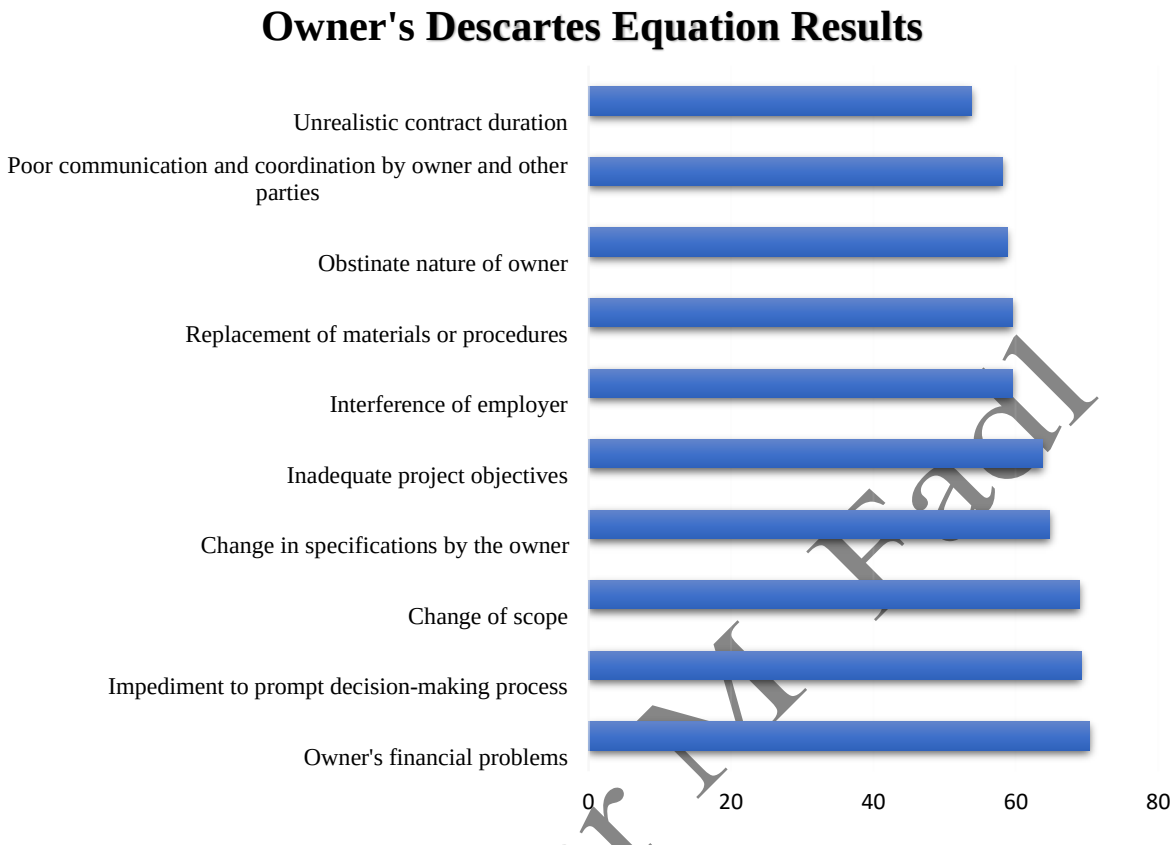


Figure 6: Owner's Descartes Equation Results

4.3.1.2 Consultant Section Results

The result that obtained from the consultant section by using Descartes Equation showed that the highest ranked factor is delays in approving shop drawings with weight of 68.4 % and the lowest ranked factor was design complexity with weight of 55.8 %. While in between comes respectively as shown in (Table 2) (Figure 7) delays in producing design documents with weight of 68 %, conflicts among contract documents and errors and omissions in design have the same rank with weight of 67.4, change in design by the consultant and inadequate design have the same rank with weight of 67.2 %, then comes change in specification by the consultant and inadequate working drawing details with weight of 64.6 %, quality assurance/control comes with weight of 64.4%, delay in performing inspection and testing by consultant with weight of 64.2 %, poor knowledge of available materials and equipment with weight of 61.6 % and un-use of advanced engineering design software comes with weight of 58.4 %.

Factors	1	2	3	4	5	Weight
Delays in approving shop drawings	5	7	23	31	26	68.4
Delays in producing design documents.	5	7	19	41	20	68
Conflicts among contract documents	4	7	23	40	18	67.4
Errors and omissions in design	5	14	14	33	26	67.4
Change in design by the consultant	4	13	16	37	22	67.2
Inadequate design	11	6	13	36	26	67.2
Change in specification by the consultant	7	10	22	35	18	64.6
Inadequate working drawing details	6	8	22	45	11	64.6
Quality assurance/control.	6	13	23	29	21	64.4
Delay in performing inspection and testing by consultant	3	10	30	37	12	64.2
Poor knowledge of available materials and equipment	11	9	22	37	13	61.6
Un-use of advanced engineering design software	12	21	20	17	22	58.4
Design complexity	16	11	32	20	13	55.8

Table 2: Result of Consultant's Section and its Weight by Descartes Equation

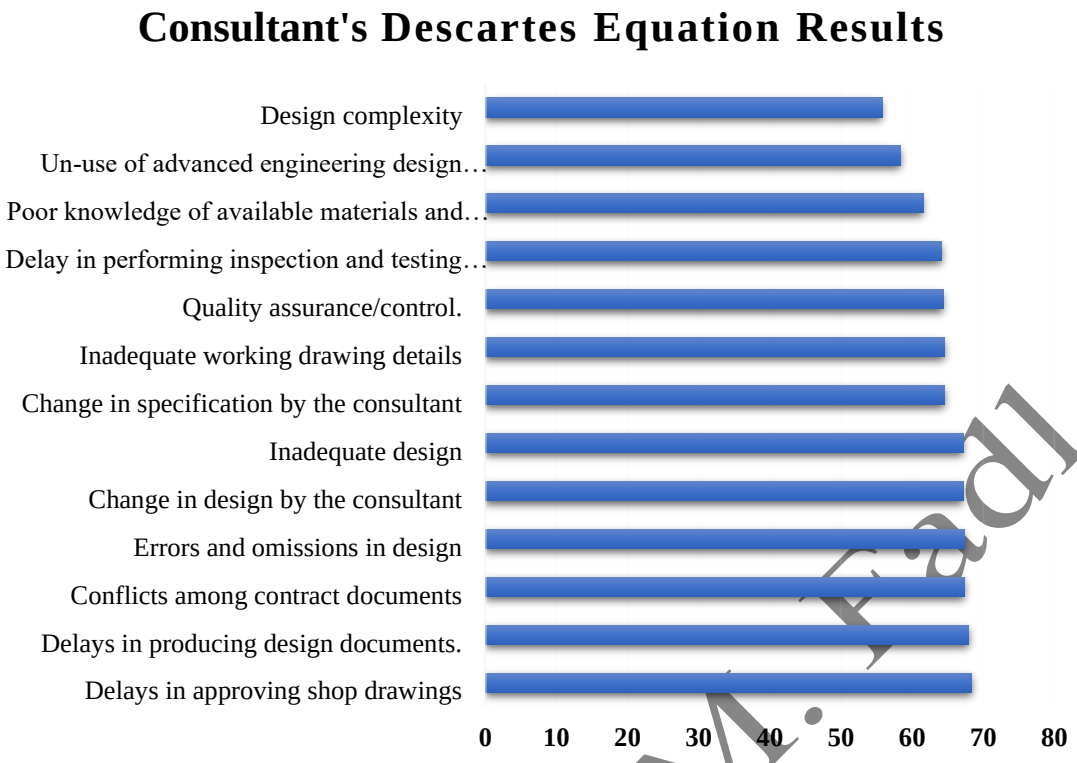


Figure 7: Consultant's Descartes Equation Results

4.3.1.3 Contractor Section Results

The result that obtained from the contractor section by using Descartes Equation showed that the highest ranked factor is difficulties in financing project by contractor with a weight of 71.6 % and the lowest ranked factor is complex design and technology with weight of 55.8 %. While in between comes respectively as shown in (Table 3) (Figure 8) rework due to errors during construction with weight of 71.4 %, poor site management and supervision with weight of 69.6 %, unavailability of skills with weight of 65.8 %, poor workmanship with weight of 64.6 %, shortage of material with weight of 64 %, delay in site mobilization due to unfamiliarity with local conditions with weight of 63.8 %, frequent change of sub-contractors because of their inefficient work with weight of 63 %, unqualified workforce with weight of 62.4 %, shortage of labors and differing site conditions share the same rank with weight of 60.8 %, unavailability of equipment with weight of 60.8 % and high cost of skilled labor scored weight of 57.4%.

Factors	1	2	3	4	5	Weight
Difficulties in financing project by contractor	5	8	16	26	37	71.6
Rework due to errors during construction	5	9	15	26	37	71.4
Poor site management and supervision	8	6	15	32	31	69.6
Unavailability of skills	4	15	11	48	14	65.8
Poor workmanship	4	13	22	38	15	64.6
Shortage of material	9	9	20	37	17	64
Delay in site mobilization due to unfamiliarity with local conditions	9	7	20	44	12	63.8
Frequent change of sub-contractors because of their inefficient work	4	13	29	32	14	63
Unqualified workforce	10	12	18	36	16	62.4
Shortage of labors	8	12	26	36	10	60.8
Differing site conditions	9	14	23	32	14	60.8
Unavailability of equipment	7	15	28	30	12	60.2
High cost of skilled labor	11	19	24	24	14	57.4
Complex design and technology	15	14	25	29	9	55.8

Table 3: Result of Contractor's Section and its Weight by Descartes Equation

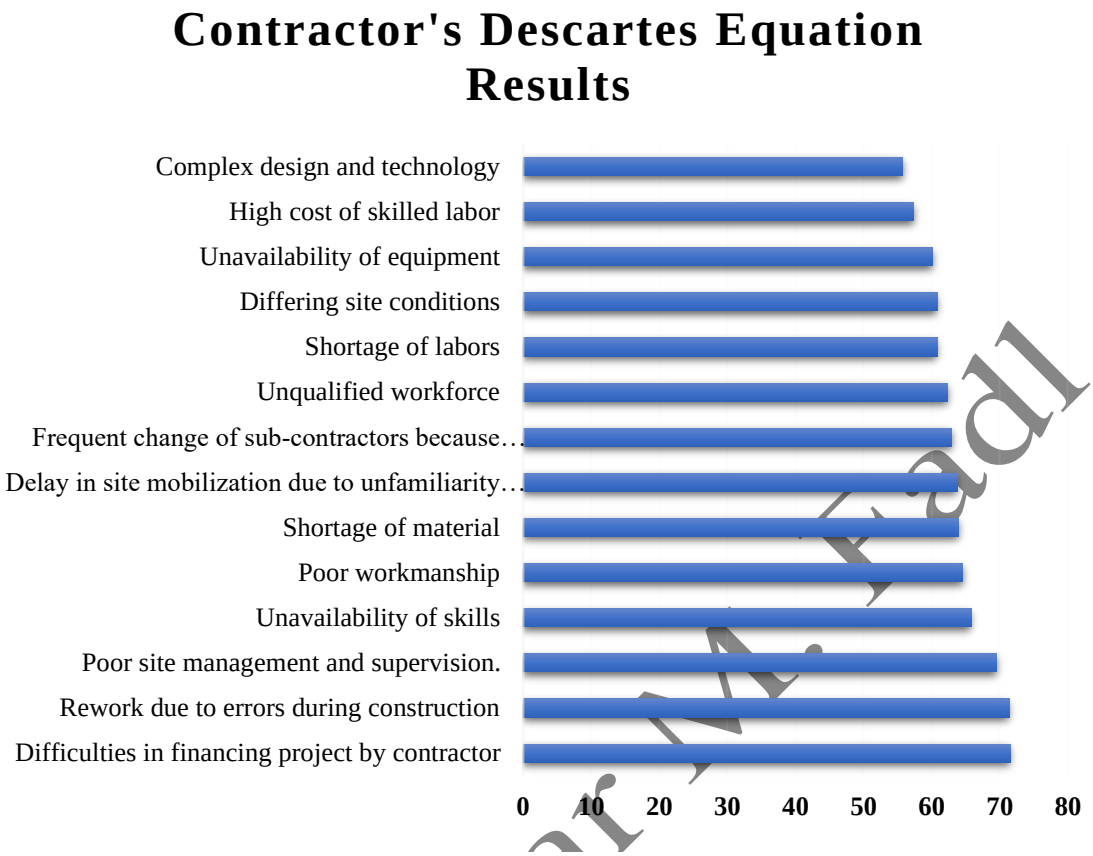


Figure 8: Contractor's Descartes Equation Results

4.3.1.4 Final Results Top Ten Ranked Factors

The top ten factors obtained from the all section by using Descartes Equation showed that number 1 is difficulties in financing project by 71.6 % weight and it is related to contractor, number 2 is rework due to errors during construction by scoring 71.4 % it's also a contractor related factor, number 3 is financial problems owner's related factor by weight of 70.4 %, number 4 is poor site management and supervision again contractor related factor by weight of 69.6 %, number 5 and 6 are owner's related factors which are impediment to prompt decision-making process and change of scope by weighting of 69.2 % and 69% respectively, number 7 to 10 are consultant relating factors which are delays in approving shop drawings, delays in producing design documents, conflicts among contract documents and errors and omissions in design with weight of 68.4 %, 68 %, 67.4 % and 67.4% respectively as shown in (Table 4) (Figure 9).

Rank #	Factors	Weight	Related to?
1	Difficulties in financing project by contractor	71.6	Contractor Related
2	Rework due to errors during construction	71.4	Contractor Related
3	Owner's financial problems	70.4	Owner Related
4	Poor site management and supervision	69.6	Contractor Related
5	Impediment to prompt decision-making process	69.2	Owner Related
6	Change of scope	69	Owner Related
7	Delays in approving shop drawings	68.4	Consultant Related
8	Delays in producing design documents	68	Consultant Related
9	Conflicts among contract documents	67.4	Consultant Related
10	Errors and omissions in design	67.4	Consultant Related

Table 4: Top Ten Factors and its Weight by Descartes Equation

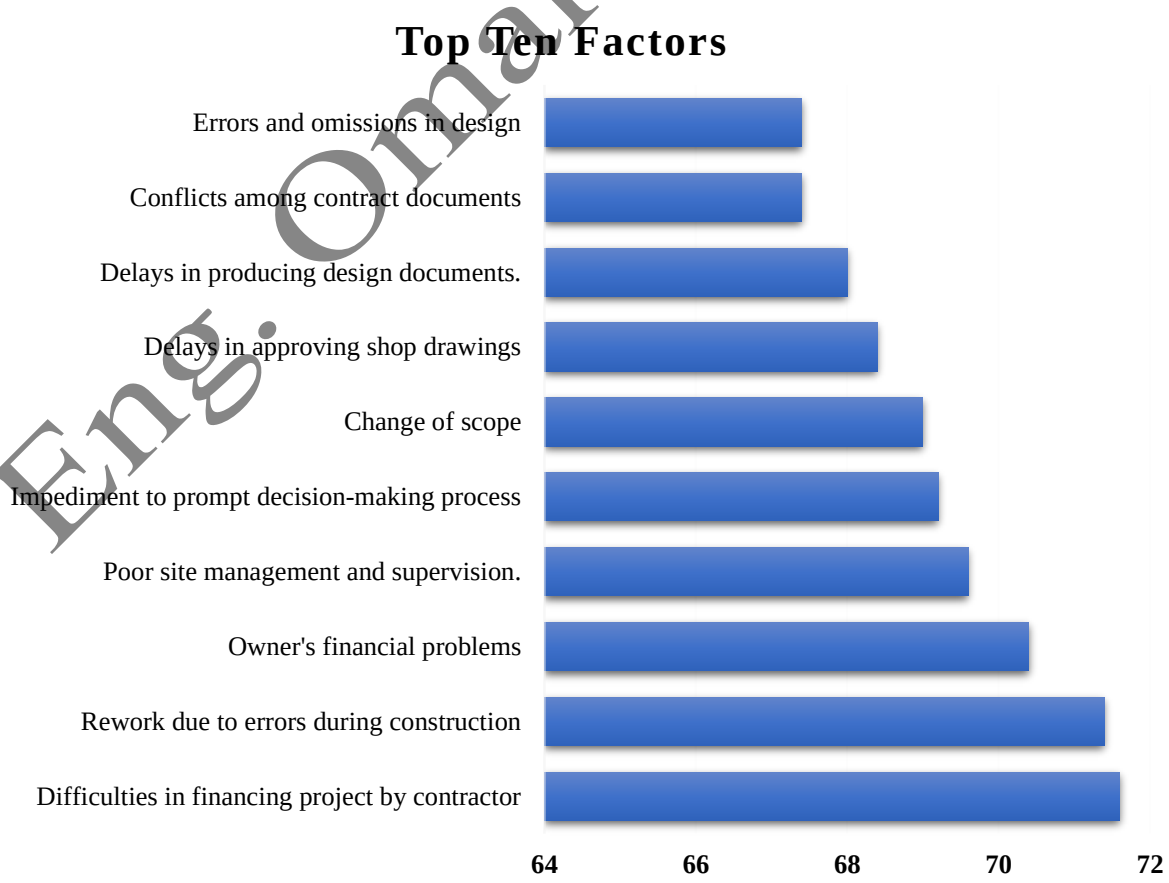


Figure 9: Top Ten Factors and its Weight by Descartes Equation

4.3.2 SPSS Method

The SPSS program is statistics analysis software that is well known for all researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners and others. SPSS is widely used program due to its easily interference and its user friendly. SPSS calculate and plot graphs for the analysis results.

4.3.2.1 Owner Section Results

Factors	Number of participants	Mean	Median	Mode	Std. Deviation	Percentiles		
						25	50	75
Owner's Financial Problems	92	3.8261	4	5	1.43434	3	4	5
Impediment to prompt decision-making process	92	3.760870	4	4	1.05215	3	4	4.75
Change of Scope	92	3.75	4	5	1.36378	3	4	5
Change in specifications by the owner	92	3.5217	4	4	1.09422	3	4	4
Inadequate Project Objectives	92	3.4674	4	4	1.14307	3	4	4
Interference of Employer	92	3.2391	3	3	1.13263	2	3	4
Replacement of Materials or Procedures	92	3.2391	3	3	0.94194	3	3	4
Obstinate Nature of Owner	92	3.1957	3	4	1.16014	2	3	4
Poor Communication and Coordination by Owner and Other Parties	92	3.163	3	4	1.15099	2	3	4
Unrealistic Contract Duration	92	2.9239	3	4	1.34437	2	3	4

Table 5: Mean, Median, Mode and Standard Deviation for Owner's Results

4.3.2.2 Consultant Section Results

Factors	Number of participants	Mean	Median	Mode	Std. Deviation	Percentiles		
						25	50	75
Delays in approving shop drawings	92	3.7174	4	4	1.12246	3	4	5
Delays in producing design documents	92	3.6957	4	4	1.06636	3	4	4
Conflicts among contract documents	92	3.663	4	4	1.01934	3	4	4
Errors and omissions in design	92	3.663	4	4	1.19777	3	4	5
Change in design by the consultant	92	3.6522	4	4	1.12352	3	4	4
Inadequate design	92	3.6522	4	4	1.2876	3	4	5
Change in specification by the consultant	92	3.5109	4	4	1.15306	3	4	4
Inadequate working drawing details	92	3.5109	4	4	1.03238	3	4	4
Quality assurance/control	92	3.5	4	4	1.18136	3	4	4
Delay in performing inspection and testing by consultant	92	3.4891	4	4	0.96641	3	4	4
Poor knowledge of available materials and equipment	92	3.3478	4	4	1.19922	3	4	4
Un use of advanced engineering design software	92	3.1739	3	5	1.37168	2	3	4
Design complexity	92	3.0326	3	3	1.27055	2	3	4

Table 6: Mean, Median, Mode and Standard Deviation for Consultant's Results

4.3.2.3 Contractor Section Results

Factors	Number of participants	Mean	Median	Mode	Std. Deviation	Percentiles		
						25	50	75
Difficulties in financing project by contractor	92	3.8913	4	5	1.19022	3	4	5
Rework due to errors during construction	92	3.8804	4	4	1.20295	3	4	5
Poor site management and supervision	92	3.7826	4	4	1.22990	3	4	5
Unavailability of skills	92	3.5761	4	4	1.07144	3	4	4
Poor workmanship	92	3.5109	4	4	1.06384	3	4	4
Shortage of material	92	3.4783	4	4	1.19042	3	4	4
Delay in site mobilization due to unfamiliarity with local conditions	92	3.4674	4	4	1.12368	3	4	4
Frequent change of sub-contractors because of their inefficient work	92	3.4239	3.5	4	1.05073	3	3.5	4
Unqualified workforce	92	3.3913	4	4	1.23107	3	4	4
Shortage of labors	92	3.3043	3.5	4	1.10681	3	3.5	4
Differing site conditions	92	3.3043	3.5	4	1.19283	2.25	3.5	4
Unavailability of equipment	92	3.2717	3	4	1.12028	3	3	4
High cost of skilled labor	92	3.1196	3	3	1.24779	2	3	4
Complex design and technology	92	3.0326	3	4	1.23547	2	3	4

Table 7: Mean, Median, Mode and Standard Deviation for Contractors Results

Chapter Five: The Model

5.1 Introduction of VORS

Variation Order reducing by solutions (VORS) is the model name. VORS was being chosen from a different types of software programing methods such as coding by java, c++ or any other coding language otherwise to be on a website form. A comparison was made between software programing and website form to obtain the best for the users. The comparison was revolving about four axes, which are independency, availability, integrity and be updated easily. Independency cannot be in software program because every operating system for any kind of devices from computers to smart phones has his own coding language, while for the website independency can be exist because it doesn't require specific operating system it can be accessed from any web browsing application. Availability is not found in a software program because a software program needs searching for getting the source then to be installed not easy such as a website form it is only about click and the user are in any time without suffering from non-working source or crashing while installing the software. Integrity in software program is not as in a website form because in a website form everyone using the VORS has the same information and the least update, rather than the software program if a user has an old version without knowing that a new version is out this user will not be up to date, while in the website form all users are seeing the same thing. Be updated easily is one of the important axes in the comparison in software program it will need more coding and complex languages to develop and update the software, while in the website is much easier it's all about data entry and sometimes it needs simple coding.

So, the VORS was designed a guild for anyone involved in the construction field by presenting the factors and results that leads to variation order in construction projects and to achieve mainly the objectives in Egypt, but it can be used worldwide. The domain which is the website link of the VORS is been bought for three years and will be extended. The model was designed by using WordPress to build the website to develop VORS. All data and results in VORS is obtained from the research method. VORS link is www.variationorder.com.

5.2 How to Use the VORS

To use the model and start there are five steps:

5.2.1 First step:

Write the website domain URL in the URL place in any web browsing application (*www.variationorder.com*), then click on the double arrow facing down in the middle of the page.

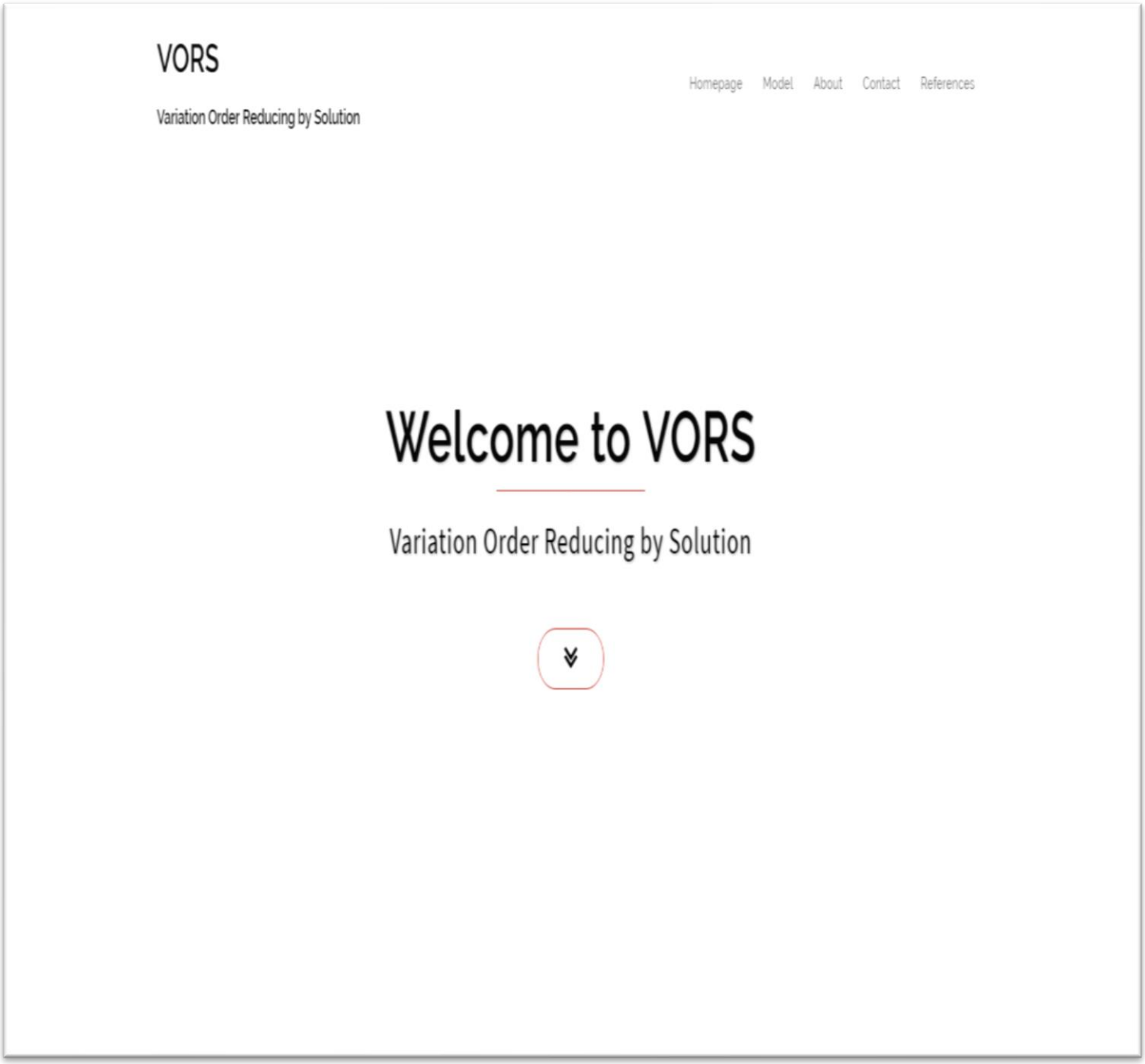


Figure 10: Homepage of VORS

5.2.2 Second step:

The page will move downward to introduce the model and to give a brief definition about variation order in the construction field, then to start the model click on start in the oval-shape.

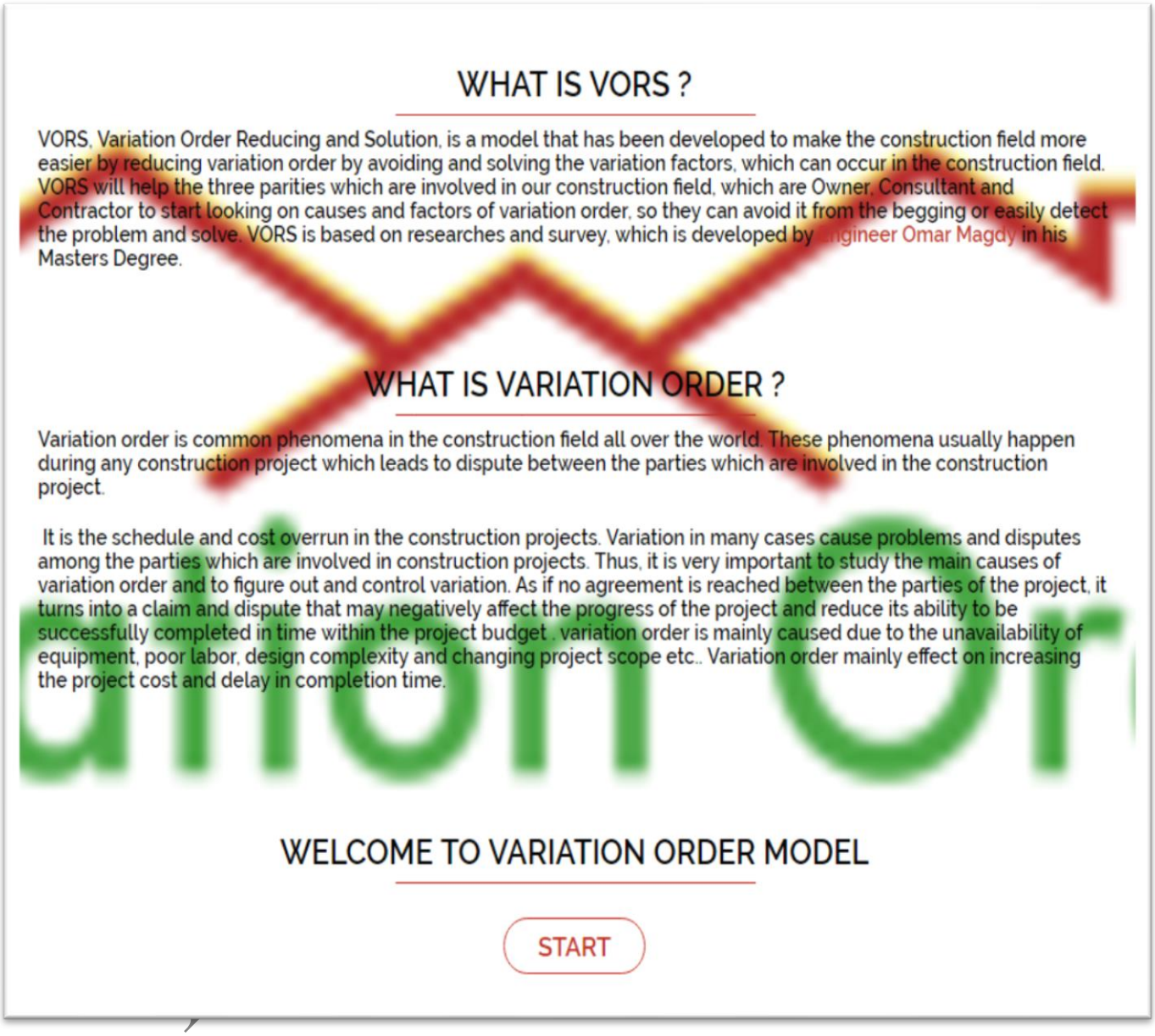


Figure 11: Introduction for VORS and Variation Order

5.2.3 Third Step:

The page will move to new page asking the user for what type of organization would like to see its factors, so just one click on the required organization, then a new page will open for the chosen organization.

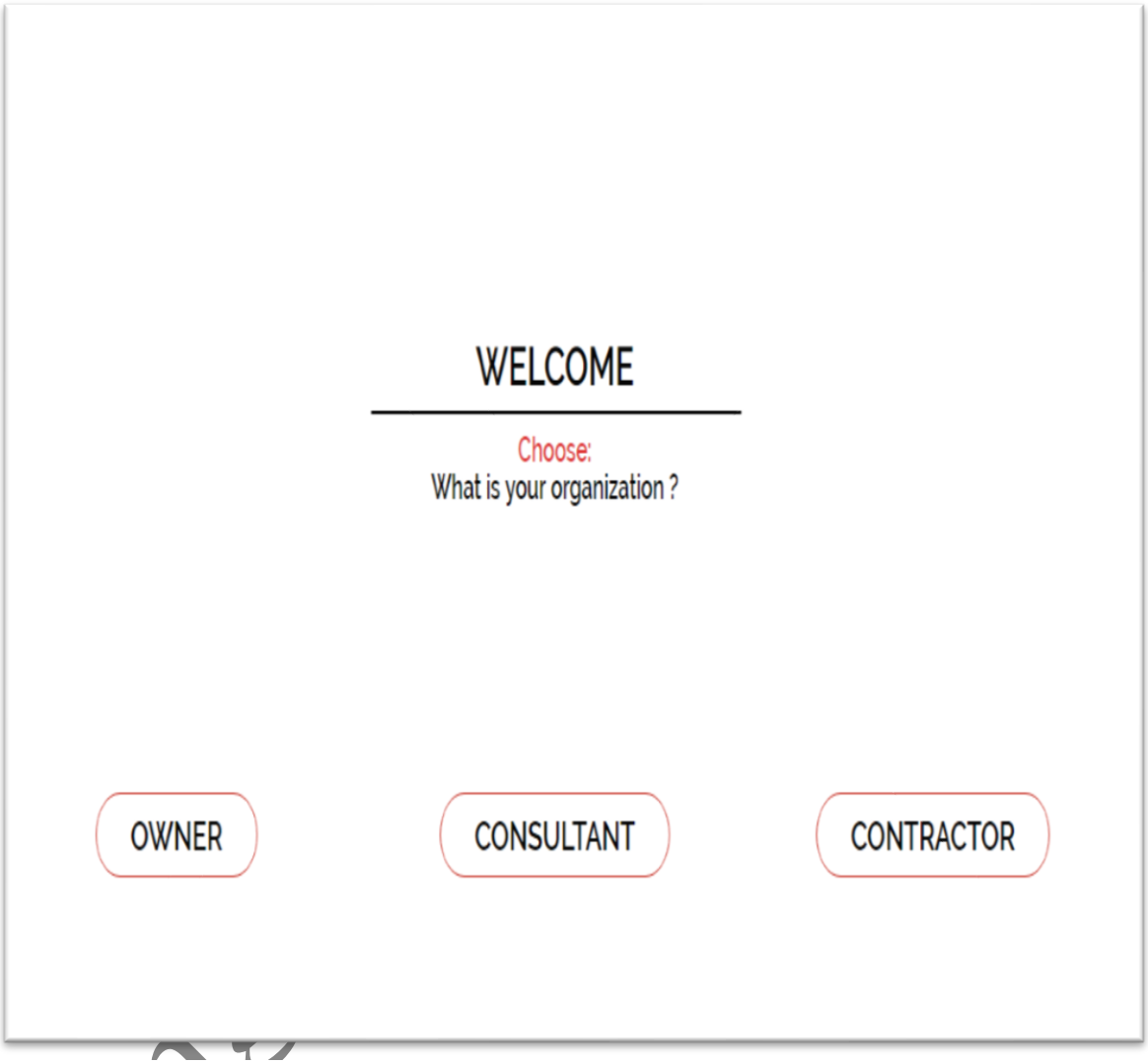
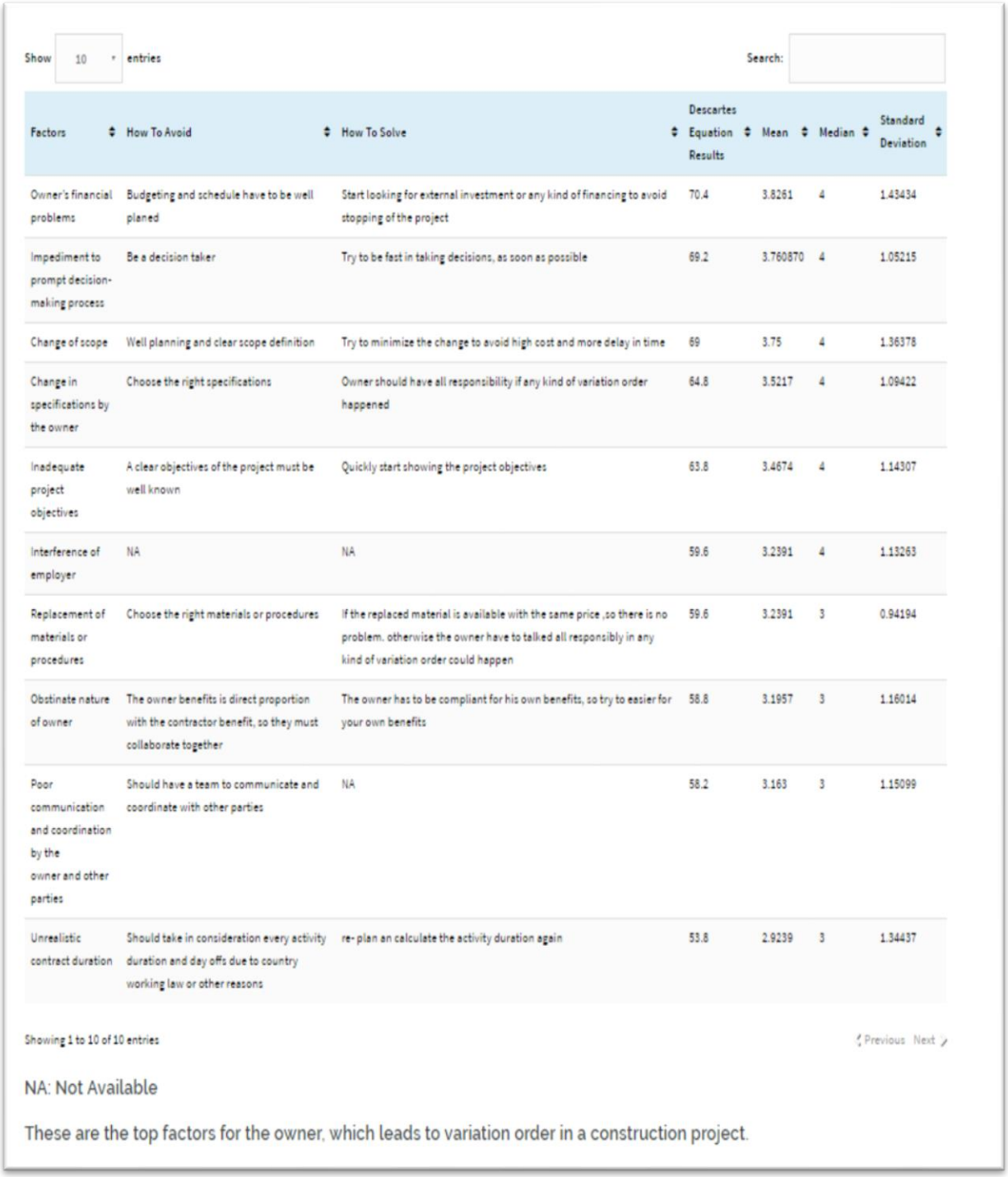


Figure 12: Welcoming page of VORS

5.2.4 Fourth Step:

A new page will open showing a table which presents the factors and analysis results for the chosen organization and the weight of Descartes equation, mean, median, mode and standard deviation.



Show 10 entries Search:

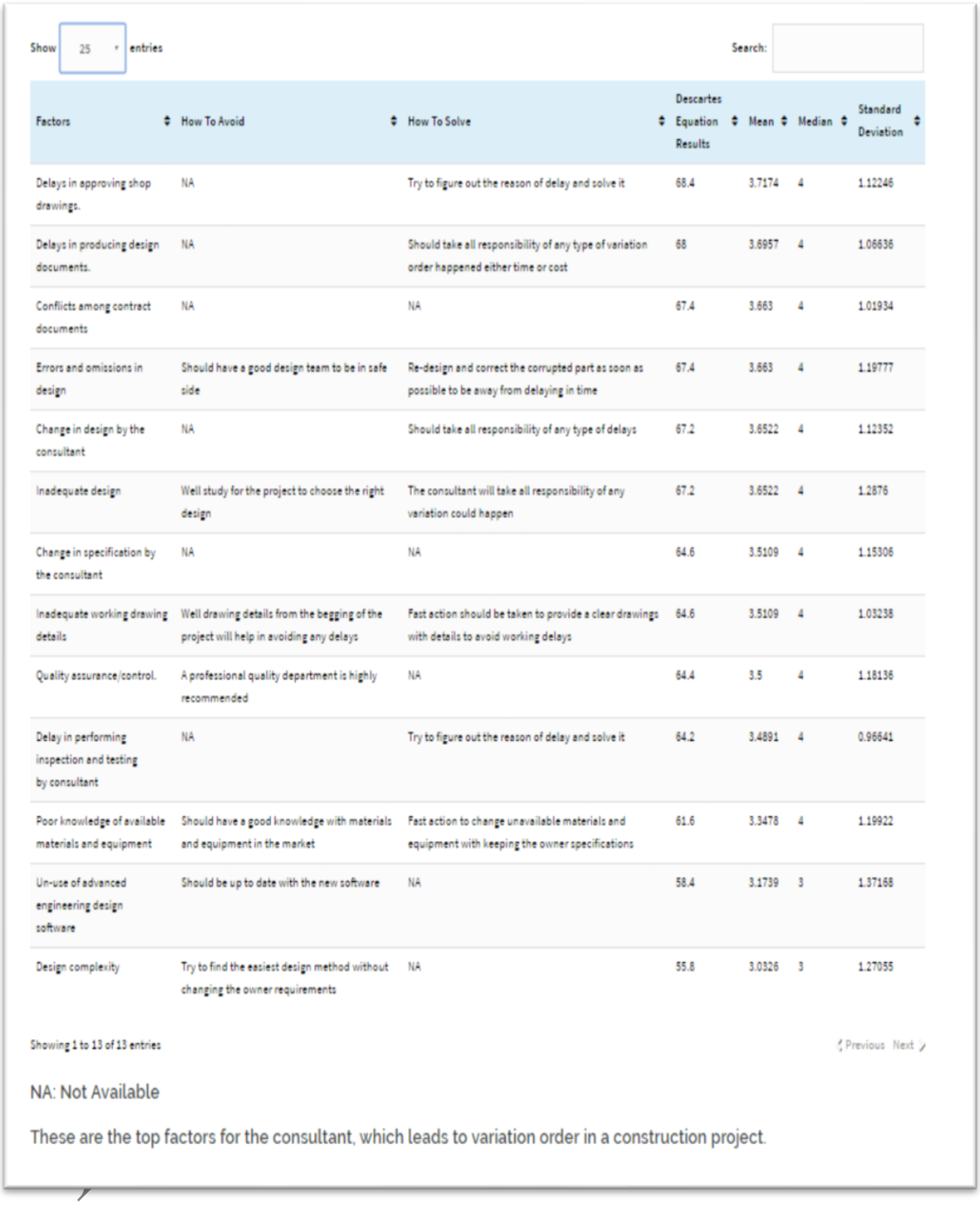
Factors	How To Avoid	How To Solve	Descartes Equation Results	Mean	Median	Standard Deviation
Owner's financial problems	Budgeting and schedule have to be well planed	Start looking for external investment or any kind of financing to avoid stopping of the project	70.4	3.8261	4	1.43434
Impediment to prompt decision-making process	Be a decision taker	Try to be fast in taking decisions, as soon as possible	69.2	3.760870	4	1.05215
Change of scope	Well planning and clear scope definition	Try to minimize the change to avoid high cost and more delay in time	69	3.75	4	1.36378
Change in specifications by the owner	Choose the right specifications	Owner should have all responsibility if any kind of variation order happened	64.8	3.5217	4	1.09422
Inadequate project objectives	A clear objectives of the project must be well known	Quickly start showing the project objectives	63.8	3.4674	4	1.14307
Interference of employer	NA	NA	59.6	3.2391	4	1.13263
Replacement of materials or procedures	Choose the right materials or procedures	If the replaced material is available with the same price ,so there is no problem. otherwise the owner have to talked all responsibly in any kind of variation order could happen	59.6	3.2391	3	0.94194
Obstinate nature of owner	The owner benefits is direct proportion with the contractor benefit, so they must collaborate together	The owner has to be compliant for his own benefits, so try to easier for your own benefits	58.8	3.1957	3	1.16014
Poor communication and coordination by the owner and other parties	Should have a team to communicate and coordinate with other parties	NA	58.2	3.163	3	1.15099
Unrealistic contract duration	Should take in consideration every activity duration and day offs due to country working law or other reasons	re- plan an calculate the activity duration again	53.8	2.9239	3	1.34437

Showing 1 to 10 of 10 entries Previous Next

NA: Not Available

These are the top factors for the owner, which leads to variation order in a construction project.

Figure 13: Owner's Factors and Results: Descartes Equation Weight, Mean, Median, Mode and Standard Deviation.



Show 25 entries Search:

Factors	How To Avoid	How To Solve	Descartes Equation Results	Mean	Median	Standard Deviation
Delays in approving shop drawings.	NA	Try to figure out the reason of delay and solve it	68.4	3.7174	4	1.12246
Delays in producing design documents.	NA	Should take all responsibility of any type of variation order happened either time or cost	68	3.6957	4	1.06636
Conflicts among contract documents	NA	NA	67.4	3.663	4	1.01934
Errors and omissions in design	Should have a good design team to be in safe side	Re-design and correct the corrupted part as soon as possible to be away from delaying in time	67.4	3.663	4	1.19777
Change in design by the consultant	NA	Should take all responsibility of any type of delays	67.2	3.6522	4	1.12352
Inadequate design	Well study for the project to choose the right design	The consultant will take all responsibility of any variation could happen	67.2	3.6522	4	1.2876
Change in specification by the consultant	NA	NA	64.6	3.5109	4	1.15306
Inadequate working drawing details	Well drawing details from the begging of the project will help in avoiding any delays	Fast action should be taken to provide a clear drawings with details to avoid working delays	64.6	3.5109	4	1.03238
Quality assurance/control.	A professional quality department is highly recommended	NA	64.4	3.5	4	1.18136
Delay in performing inspection and testing by consultant	NA	Try to figure out the reason of delay and solve it	64.2	3.4891	4	0.96641
Poor knowledge of available materials and equipment	Should have a good knowledge with materials and equipment in the market	Fast action to change unavailable materials and equipment with keeping the owner specifications	61.6	3.3478	4	1.19922
Un-use of advanced engineering design software	Should be up to date with the new software	NA	58.4	3.1739	3	1.37168
Design complexity	Try to find the easiest design method without changing the owner requirements	NA	55.8	3.0326	3	1.27055

Showing 1 to 13 of 13 entries Previous Next

NA: Not Available

These are the top factors for the consultant, which leads to variation order in a construction project.

Figure 14: Consultant's Factors and Results: Descartes Equation Weight, Mean, Median, Mode and Standard Deviation.

Show 10 entries Search:

Factor	How To Avoid	How To Solve	Descartes Equation Results	Mean	Median	Standard Deviation
Difficulties in financing project by contractor	A cost control is highly recommended to avoid problem like this	Should find a way to finance the project as soon as possible to minimize the cost of delays	71.6	3.8913	4.0000	1.19022
Rework due to errors during construction	Quality control will help to reduce errors	A correction action should be made as if crushing to be on schedule	71.4	3.8804	4.0000	1.20295
Poor site management and supervision.	A good Planing for the project will help in avoiding problems like this	Try to provide a supervision manager for the project to minimize problems	69.6	3.7826	4.0000	1.22990
Unavailability of skills	The company staff should be highly trained for the project tybe	NA	65.8	3.5761	4.0000	1.07144
Poor workmanship	Change poor workmanship to increase the rate of work and avoid any delay	Add more workmanship or change poor workmanship to increase the rate of work	64.6	3.5109	4.0000	1.06384
Shortage of material	The procurement department should be aware of the market	Try to find substitution for material and get approved from the other parties	64	3.4783	4.0000	1.19042
Delay in site mobilization due to unfamiliarity with local conditions	A site visit is needed and is very important in planning	Quick respond to solve the problem	63.8	3.4674	4.0000	1.12368
Unqualified workforce	The company should be selective for its workforce	Replace unqualified workforce with qualified one	62.4	3.4239	3.5000	1.23107
Frequent change of sub-contractors because of their inefficient work	The contractor should be selective for the sub-contractors	The project manager should have a fast correction action to avoid work delay	63	3.3913	4.0000	1.05073
Shortage of Labor	The Company should hire more labors to avoid this factor	The company have to try to find labor	60.8	3.3043	3.5000	1.10681

Showing 1 to 10 of 14 entries Previous Next

NA: Not Available

These are the top factors for the contractor, which leads to variation order in a construction project.

Figure 15: Factors and Results: Contractor's Descartes Equation Weight, Mean, Median, Mode and Standard Deviation.

5.2.5 Fifth Step:

Every page on the website contain a button " Contact" at the bottom of the page beside a sentence contain "Happy To Hear Any Suggestion, Missing Data Or Any Question!" by clicking on the button a new page will load with the author contact information to send any suggestion, point of view, rating, any question and if there any missing data.

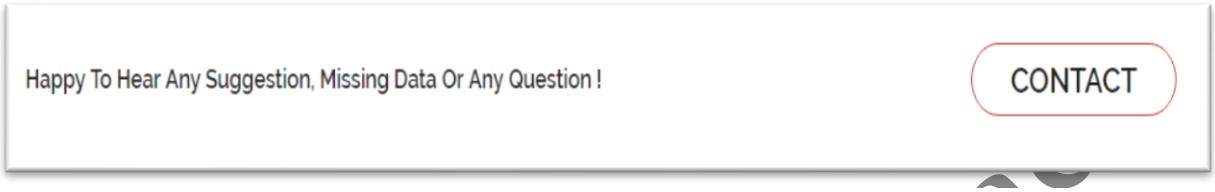


Figure 16: Contact Button

Figure 17: Contact page

Chapter Six: Case Study

Case study chapter is an important chapter in the thesis it presents and show the users review after using the VORS. Five different companies tried VORS and send a certificate (Appendix C) with their opinions and point of view with some recommendation from them. Two companies were Consultant organization one of them is from Egypt and the other one is from Emirates. Another two companies were Contractor organization one of the is from Egypt and the other one is from China but its working in Egypt. Last company was not from the construction field it is a software and we designer, so it's a computer field company from Saudi Arabia.

Benaa Consulting Company the Egyptian consulting company said:

"Dear VORS

Our company would like to congratulates for the good job you have made in your website VORS. VORS is user friendly its easily to use and move from page to page a well design made it's a professional website by using new techniques for developing your model.

All factors listed in VORS are highly effective as well as their weights and ranking, these factors are the most important factors which effect the construction field, beside the solutions are highly effective and on point on solving the problem or avoiding the problem. VORS can make a new revolution in the construction projects by reducing the variation order causes.

The company recommend:

1. More research required to be able to develop VORS
2. Never stop researches and working on reducing variation order
3. Make a way to companies to sign in with their information to share knowledge and help in reducing variation order"

Al Nahda Eng Consultants the Emirates consulting company said:

" Your web site *'Variation Order'* is quite interesting and it would be useful to reduce dispute among different parties involved in construction fields.

In future if you required any suggestion or help please do hesitate to call to Al Nahda Eng. Consultant. "

Tanjin For Contracting the Chinese contractor company said:

" First, the company would like to congratulate you for your model VORS a new way for reducing variation order in our field, VORS is unique a new way to reduce variation easily used a friendly interface.

Second, VORS model own a unique characterize from design to accessibly of use, and VORS from our point of view is developed by a professional methods and techniques.

Third, factors and their solutions are highly effective and we recommend a further more researches to develop VORS and reduce variation order.

Finally, if you need any help in your model or research contact us directly we can help you."

Al Arabia Trading and Development Construction the Egyptian contracting company said:

"Dear VORS

Al-Arabia Trading and Development Construction Company would like to thank the developer for the great job in VORS model, which help in reducing the variation order in the construction field.

VORS website is well design and is compatible and responsive with all devices plus it can be used from any place without searching for a source to install the model and this shows how the model is well developed.

In additional to the data analysis, which was analyzed by weighting every factor form the questionnaire and using SPSS software in analyzing the data."

ASCON the computer company from Saudi Arabia said:

"Dear VORS

ASCON has received an invitation from the developer to check and rate the VORS website, furthermore he asked if we can recommend any improvements to develop a professional website model.

ASCON would like to congratulate the developer for his VORS website that is made by professional WordPress and well-designed website.

VORS is a smart responsive website using bootstamp technique, a modern design layout, a good tie-loading period and a user friendly interface.

ASCON recommends for VORS website:

- Using more keywords for website engine search
- Buy a website security software (if VORS doesn't use one)
- A daily update to avoid website down or crashing"

Chapter Seven: Conclusion

7.1 Conclusion

- The main aim of this study is to produces a model to guide all parties involved in the construction field by identifying the most important and common causes of variation order in the construction projects in Egypt.
- The thesis tried to analysis the causes of variation order with the help of reading old researches and by the help of the experts, where the expert's feedback and experience were obtained through questionnaire survey.
- Variation order affect the performance, time and cost of any construction project, so that the main causes of the variation order should be identified to achieve projects goals successfully.
- Descartes equation was used to obtain the weight of each cause and by getting the mean, median and standard deviation.
- The top three factors are difficulties in financing project by contractor, rework due to errors during construction and owner's financial problems with weight of 71.6, 71.4 and 70.4 respectively.
- The solutions for the top three factors was obtained from an academic research and from the participant of the questionnaire for the first factor difficulties in financing project by contractor the solution was to have a good budget planner to be avoid any financing problems as well as the third factor owner's financial problems, while for rework due to errors during construction needs a correction action should be made as if crushing for the schedule if it needs to be crashed to avoid any type of variation order.

7.2 Recommendations

In order to successfully solve and eliminate arbitration, litigation, disputes and total abandonment between different organization parties of the project, the factors that cause delay should be well known and figure out. On the other hand, it's important to be sure that owner's satisfaction will be achieved throw out project objectives which should be completed as required and as owner's specification and to check that everything is moving in the right way. The model of the study included in this dissertation can help owners, project managers and other parties to monitor the project perfectly by defining every cause and its weight and how to solve or how to avoid especially for the top causes of variation order.

7.3 Recommendations for Future Studies

More research on construction variation order should be made to create more guidelines, or to improve the model by improve the methods of eliminating the effects of construction variation order in Egypt. Moreover, similar research should be implemented in various locations. It is required to carry out studies for each specific type of construction projects, including highways, dam construction projects, utilities and etc.

More researches are needs to improve VORS to be an official guide in the construction field and to solve the claims. VORS will be develop to be a worldwide model not only for Egypt, but for a worldwide guide in the construction field, in additional to some more features will try to develop and add to VORS.

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Appendix A:

Appendix A contains the questionnaire sections, which was published for participants

- ## First Section

  Variation Order in Construction

Name *	
Phone Number	
Email *	
Are you Engineer (Yes - No) *	
Job Title *	
Major *	
Years of Experience in Construction Industry *	
What is your Organization? (Owner-Consultant-Contractor - Other) *	

Next »

- **Second Section**

  Owner's Section

* Change in specifications by the owner

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Inadequate project objectives

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* "Poor communication and coordination by owner and other parties"

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Interference of employer

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Owner’s financial problems

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Change of scope

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐

* Obstinate nature of owner

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Unrealistic contract duration.

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Impediment to prompt decision-making process

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Replacement of materials or procedures

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

Next »

- # Third Section

  Consultant Section

* Delays in approving shop drawings

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Inadequate working drawing details

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* "Delay in performing inspection and testing by consultant

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Inadequate design

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Change in specification by the consultant

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Change in design by the consultant

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Poor knowledge of available materials and equipment

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Conflicts among contract documents

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Errors and omissions in design

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Quality assurance/control.

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Design complexity

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* "Un-use of advanced engineering design software"

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Delays in producing design documents.

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

Next »

- **Fourth Section**

  Contractor Section

* Shortage of labors

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Differing site conditions

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Poor site management and supervision.

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Unavailability of equipment

- 1
- 2
- 3
- 4
- 5

* "Frequent change of sub-contractors because of their inefficient work."

- 1
- 2
- 3
- 4
- 5

* Complex design and technology

- 1
- 2
- 3
- 4
- 5

* Unqualified workforce

- 1
- 2
- 3
- 4
- 5

* Unavailability of skills

- 1
- 2
- 3
- 4
- 5

* Poor workmanship

- 1
- 2
- 3
- 4
- 5

* Rework due to errors during construction

- 1
- 2
- 3
- 4
- 5

* Difficulties in financing project by contractor

- 1
- 2
- 3
- 4
- 5

* Delay in site mobilization due to unfamiliarity with local conditions

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* Shortage of material

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

* High cost of skilled labor

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

Submit

Appendix B:

Appendix B contains the results of the questionnaire sections, which was published on the same website of the model.

- ## First Part

  Owners Organization Results

  There were 15 participants out of 92 participants from owner organizations this is there point pf view on all questionnaire sections.

Owner's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Change in specifications by the owner	3	3	2	2	1	3	3	2	4	5	2	4	5	1	4
Obstinate Nature of Owner	3	2	2	4	1	3	3	5	3	4	1	4	4	5	2
Inadequate project objectives	2	5	2	2	1	3	3	4	4	4	2	4	4	4	3
Change of scope	3	5	2	3	1	4	4	1	5	5	1	3	5	5	4
Interference of employer	4	4	2	3	1	4	2	3	4	3	2	3	4	2	3
Unrealistic contract duration	5	1	2	3	1	2	2	4	2	3	2	1	3	3	5
Owner’s financial problems	4	5	2	3	1	5	4	1	5	5	4	5	5	1	1
Replacement of materials or procedures	1	3	3	2	1	3	3	1	3	4	3	2	4	4	4
Poor communication and coordination by owner and other parties	4	4	3	2	1	4	2	3	4	4	3	4	4	2	2

Table 8: Presents Owner's Organization Participants Answers in Owners Questionnaire Section

Consultant's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quality assurance/control	4	3	4	2	5	2	2	2	4	5	3	3	4	1	1
Poor knowledge of available materials and equipment	4	4	4	2	1	4	3	2	4	5	3	4	3	5	2
Un-use of advanced engineering design software	2	4	3	2	5	2	3	5	4	1	2	5	5	5	2
Change in design by the consultant	4	4	4	2	5	4	3	5	4	5	3	4	4	2	3
Change in specification by the consultant	4	3	4	3	3	3	3	5	4	4	4	4	4	4	4
Delays in producing design documents	4	4	4	3	1	5	2	5	4	5	2	4	4	3	5
Conflicts among contract documents	3	4	5	2	5	4	2	5	4	5	3	4	4	3	3
Design complexity	3	3	4	2	4	3	4	4	4	3	1	1	3	1	3
Inadequate working drawing details	3	4	4	3	3	3	4	5	4	2	2	4	4	1	3
Errors and omissions in design	4	4	4	2	1	4	4	2	2	5	4	5	4	2	5
Delay in performing inspection and testing by consultant	5	4	3	2	4	4	2	5	3	4	4	4	3	4	4
Delays in approving shop drawings	3	4	4	3	5	3	4	3	4	4	2	4	5	4	1
Inadequate design	4	5	4	2	3	3	2	5	4	5	1	5	4	5	1

Table 9 Presents Owner's Organization Participants Answers in Consultant Questionnaire Section

Contractor's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Shortage of labors	2	4	3	3	5	2	4	2	3	4	3	3	3	1	2
Complex design and technology	3	4	3	3	2	4	4	2	3	2	2	1	1	3	5
Frequent change of sub-contractors because of their inefficient work	3	4	3	3	5	3	2	3	2	3	2	3	5	3	3
Delay in site mobilization due to unfamiliarity with local conditions	4	5	3	3	5	4	3	3	4	4	4	4	4	4	1
Difficulties in financing project by contractor	5	4	3	2	5	5	2	2	4	5	3	5	5	5	3
Poor site management and supervision	4	3	4	4	1	4	3	2	4	4	4	5	4	5	2
Rework due to errors during construction	4	4	3	3	5	5	3	2	4	5	2	5	4	4	4
Unavailability of equipment	4	4	3	4	5	2	3	2	3	4	3	3	4	1	1
High cost of skilled labor	4	3	4	3	1	3	3	2	3	5	3	4	2	1	3
Differing site conditions	4	3	4	4	5	4	2	4	3	2	2	3	4	2	4
Shortage of material	4	4	3	3	1	4	4	2	4	4	3	2	4	5	3
Unavailability of skills	4	5	4	4	2	4	3	4	4	4	3	4	4	3	4
Poor workmanship	3	5	3	4	2	4	4	4	4	5	2	4	4	2	3
Unqualified workforce	4	3	4	4	1	3	3	4	4	4	2	5	4	2	2

Table 10 Presents Owner's Organization Participants Answers in Contractor Questionnaire Section

- **Second Part**

Consultant Organization Results

There were 17 participants out of 92 participants from consultant organizations this is there point of view on all questionnaire sections.

Owner's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Change in specifications by the owner	3	3	5	5	4	1	3	4	5	3	4	2	4	4	5	5	5
Obstinate Nature of Owner	4	5	2	1	2	1	3	4	4	3	4	1	3	3	4	4	4
Inadequate project objectives	3	4	5	3	3	1	5	4	4	5	5	2	5	4	5	4	4
Change of scope	4	3	4	5	2	5	2	5	4	4	5	2	5	5	5	5	5
Interference of employer	3	4	2	1	2	5	5	3	3	3	4	3	5	4	3	4	1
Unrealistic contract duration	1	4	4	5	3	5	3	1	1	2	2	2	2	4	4	3	4
Owner’s financial problems	5	5	1	2	4	5	4	5	5	5	5	4	5	5	5	5	5
Replacement of materials or procedures	3	2	4	3	2	2	4	4	3	2	4	4	3	3	3	4	5
Poor communication and coordination by owner and other parties	4	4	5	1	3	5	5	3	4	4	4	2	4	3	4	5	4

Table 11: Presents Consultant's Organization Participants Answers in Owners Questionnaire Section

Consultant's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quality assurance/control	3	4	2	1	3	5	4	4	5	5	5	2	1	3	5	5	4
Poor knowledge of available materials and equipment	3	3	5	3	1	5	5	3	4	4	4	1	4	2	4	4	4
Un-use of advanced engineering design software	4	2	4	2	3	1	5	3	4	3	4	1	5	5	5	4	5
Change in design by the consultant	4	4	5	5	2	4	5	4	4	5	3	2	4	3	4	3	4
Change in specification by the consultant	4	3	2	5	3	3	4	3	4	4	5	1	4	4	4	4	5
Delays in producing design documents	4	5	2	2	4	5	5	4	4	4	5	1	4	4	4	4	5
Conflicts among contract documents	4	4	5	5	3	5	3	4	4	3	5	4	3	4	5	3	5
Design complexity	4	4	3	1	4	3	5	5	1	1	3	5	2	3	4	5	5
Inadequate working drawing details	3	2	3	4	4	5	3	4	4	4	3	2	4	4	4	4	4
Errors and omissions in design	3	4	2	5	3	5	5	5	4	4	4	1	5	5	5	4	4
Delay in performing inspection and testing by consultant	3	2	1	2	3	5	3	4	4	4	5	2	3	4	4	4	4
Delays in approving shop drawings	3	5	5	2	3	5	5	5	4	4	4	3	5	5	3	4	4
Inadequate design	4	3	4	4	4	4	4	5	4	4	3	2	4	4	5	5	3

Table 12: Presents Consultant's Organization Participants Answers in Consultants Questionnaire Section

Contractor's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shortage of labors	3	4	2	1	3	5	4	4	5	5	5	2	1	3	5	5	4
Complex design and technology	3	3	5	3	1	5	5	3	4	4	4	1	4	2	4	4	4
Frequent change of sub-contractors because of their inefficient work	4	2	4	2	3	1	5	3	4	3	4	1	5	5	5	4	5
Delay in site mobilization due to unfamiliarity with local conditions	4	4	5	5	2	4	5	4	4	5	3	2	4	3	4	3	4
Difficulties in financing project by contractor	4	3	2	5	3	3	4	3	4	4	5	1	4	4	4	4	5
Poor site management and supervision	4	5	2	2	4	5	5	4	4	4	5	1	4	4	4	4	5
Rework due to errors during construction	4	4	5	5	3	5	3	4	4	3	5	4	3	4	5	3	5
Unavailability of equipment	4	4	3	1	4	3	5	5	1	1	3	5	2	3	4	5	5
High cost of skilled labor	3	2	3	4	4	5	3	4	4	4	3	2	4	4	4	4	4
Differing site conditions	3	4	2	5	3	5	5	5	4	4	4	1	5	5	5	4	4
Shortage of material	3	2	1	2	3	5	3	4	4	4	5	2	3	4	4	4	4
Unavailability of skills	3	5	5	2	3	5	5	5	4	4	4	3	5	5	3	4	4
Poor workmanship	4	3	4	4	4	4	4	5	4	4	3	2	4	4	5	5	3
Unqualified workforce	3	4	2	1	3	5	4	4	5	5	5	2	1	3	5	5	4

Table 13: Presents Consultant's Organization Participants Answers in Contractor Questionnaire Section

- **Third Part**

Contractor Organization Results

There were 50 participants out of 92 participants from Contractor organizations this is there point of view on all questionnaire sections.

Owner's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Change in specifications by the owner	4	5	5	4	2	3	5	4	4	3	4	4	4	4	5	2	3
Obstinate Nature of Owner	3	4	5	4	4	4	1	3	4	4	4	3	2	3	5	4	4
Inadequate project objectives	3	4	5	4	3	1	3	3	2	2	3	3	3	3	4	5	2
Change of scope	5	3	5	3	2	2	5	3	3	2	5	3	4	4	5	5	2
Interference of employer	4	5	5	4	4	3	2	3	5	3	4	3	2	5	5	4	2
Unrealistic contract duration	1	3	2	2	4	3	4	3	4	5	3	4	5	4	4	4	4
Owner’s financial problems	5	3	4	5	2	1	5	1	5	4	2	2	3	5	3	5	4
Replacement of materials or procedures	4	1	4	4	3	2	4	4	4	3	2	3	5	4	4	3	4
Poor communication and coordination by owner and other parties	3	3	2	3	3	2	3	1	3	2	4	3	4	5	5	3	4

Table 14: Presents Contractor's Organization Participants from (1 to 17) Answers in Owners Questionnaire Section

Number of Participants	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Change in specifications by the owner	4	4	4	4	3	5	4	4	5	4	2	3	3	5	2	4	4
Obstinate Nature of Owner	2	1	3	3	4	4	5	5	4	3	4	2	2	4	1	2	3
Inadequate project objectives	4	4	4	4	5	4	4	4	5	4	4	3	5	4	1	5	5
Change of scope	4	2	5	5	2	5	5	5	5	5	5	3	2	5	1	4	4
Interference of employer	4	5	3	4	3	2	4	3	1	2	4	2	5	3	3	2	2
Unrealistic contract duration	4	4	1	4	1	1	1	2	1	1	1	3	3	4	2	2	1
Owner’s financial problems	5	5	4	4	4	5	4	5	5	5	5	2	1	5	3	5	5
Replacement of materials or procedures	5	3	3	5	3	4	3	4	4	3	5	3	3	4	2	3	4
Poor communication and coordination by owner and other parties	3	3	4	4	5	4	5	4	3	5	3	3	1	4	2	3	4

Table 15: Presents Contractor's Organization Participants from (18 to 34) Answers in Owners Questionnaire Section

Number of Participants	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Change in specifications by the owner	4	4	4	3	4	4	5	5	4	4	1	4	4	2	2	4
Obstinate Nature of Owner	4	4	4	3	5	2	2	5	5	3	2	2	4	4	1	4
Inadequate project objectives	4	4	4	4	4	4	4	3	5	4	5	3	3	3	1	3
Change of scope	5	5	5	5	5	5	2	5	4	4	3	5	5	2	5	5
Interference of employer	4	3	4	4	4	4	1	2	4	5	3	3	2	2	2	4
Unrealistic contract duration	3	1	4	5	4	2	5	5	5	4	4	4	4	2	2	5
Owner’s financial problems	5	3	5	4	5	5	5	3	4	5	2	5	5	3	2	4
Replacement of materials or procedures	3	4	4	4	4	3	3	2	4	2	4	4	3	3	3	3
Poor communication and coordination by owner and other parties	4	4	3	2	4	2	4	2	3	3	2	5	2	2	3	4

Table 16: Presents Contractor's Organization Participants from (34 to 50) Answers in Owners Questionnaire Section

Consultant's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quality assurance/control	3	4	2	1	3	5	4	4	5	5	5	2	1	3	5	5	4
Poor knowledge of available materials and equipment	2	2	2	4	4	4	2	3	5	3	4	3	5	4	3	3	5
Un-use of advanced engineering design software	4	3	4	4	3	2	3	3	1	2	3	2	5	5	5	5	4
Change in design by the consultant	2	3	3	2	3	1	2	3	1	2	2	3	3	4	2	2	4
Change in specification by the consultant	4	4	4	4	2	2	4	3	4	3	4	3	3	4	5	5	3
Delays in producing design documents	4	4	5	3	2	2	4	3	1	3	4	2	2	5	4	5	3
Conflicts among contract documents	4	4	4	3	4	3	3	3	5	4	3	4	3	4	4	5	4
Design complexity	3	5	4	3	4	3	5	3	4	4	4	4	4	4	5	4	3
Inadequate working drawing details	3	3	3	4	3	2	3	3	5	3	3	4	4	5	5	3	3
Errors and omissions in design	4	4	5	4	4	2	4	3	4	3	4	3	4	4	4	2	3
Delay in performing inspection and testing by consultant	4	4	4	3	3	2	5	3	3	3	4	4	2	5	5	3	4
Delays in approving shop drawings	4	3	4	3	4	2	3	3	5	3	4	3	4	5	3	4	2
Inadequate design	4	4	4	2	4	3	2	3	5	4	4	3	4	5	3	3	3

Table 17: Presents Contractor's Organization Participants from (1 to 17) Answers in Consultant Questionnaire Section

Number of Participants	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Quality assurance/control	5	4	3	3	4	4	3	5	5	4	5	4	4	4	2	4	4
Poor knowledge of available materials and equipment	4	5	3	3	3	4	3	1	4	4	5	3	4	4	2	4	4
Un-use of advanced engineering design software	3	4	2	3	2	4	3	3	1	2	2	2	1	5	1	4	1
Change in design by the consultant	5	5	4	4	4	5	4	4	5	4	5	2	4	5	2	4	4
Change in specification by the consultant	5	5	4	4	4	4	3	5	5	3	5	2	1	5	2	4	4
Delays in producing design documents	4	5	4	5	4	5	5	5	4	4	4	2	3	4	2	4	4
Conflicts among contract documents	4	5	4	4	3	4	4	4	4	4	3	3	2	4	1	4	4
Design complexity	5	4	1	2	3	1	1	1	1	2	3	1	4	4	3	2	3
Inadequate working drawing details	4	4	4	4	3	4	4	5	4	4	4	2	3	5	2	4	3
Errors and omissions in design	4	4	4	4	5	4	5	4	5	5	5	2	2	4	2	5	5
Delay in performing inspection and testing by consultant	4	3	4	4	3	5	4	4	3	3	5	2	3	4	2	4	4
Delays in approving shop drawings	4	5	4	5	5	4	5	5	4	4	5	3	1	5	2	4	4
Inadequate design	5	5	4	4	5	4	4	4	4	5	4	3	2	5	1	4	5

Table 18: Presents Contractor's Organization Participants from (18 to 34) Answers in Consultant Questionnaire Section

Number of Participants	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Quality assurance/control	3	5	5	5	5	3	2	2	3	1	3	4	4	4	3	3
Poor knowledge of available materials and equipment	4	4	4	3	4	4	3	4	4	4	1	4	1	4	1	5
Un-use of advanced engineering design software	4	5	5	5	4	5	5	2	5	5	5	4	5	5	3	5
Change in design by the consultant	4	5	3	2	3	5	3	2	4	5	2	4	4	1	4	5
Change in specification by the consultant	3	4	4	4	4	4	2	5	3	3	5	5	5	3	4	4
Delays in producing design documents	5	4	5	4	4	2	5	3	4	3	3	4	4	4	3	3
Conflicts among contract documents	5	4	4	4	5	3	5	4	4	4	2	4	4	2	3	5
Design complexity	2	2	1	4	4	5	2	3	1	5	4	4	4	1	3	3
Inadequate working drawing details	4	5	4	5	4	4	4	5	5	4	3	4	5	1	4	3
Errors and omissions in design	4	4	5	4	5	5	5	4	5	4	2	3	4	2	3	3
Delay in performing inspection and testing by consultant	4	5	3	4	4	4	2	3	4	4	3	5	3	4	3	4
Delays in approving shop drawings	5	3	5	5	5	4	4	5	4	3	3	3	5	1	3	5
Inadequate design	4	5	5	4	4	5	5	4	5	5	1	5	5	1	4	4

Table 19: Presents Contractor's Organization Participants from (34 to 50) Answers in Consultant Questionnaire Section

Contractor's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shortage of labors	3	5	4	3	3	4	4	2	5	1	4	2	4	4	3	3	3
Complex design and technology	3	3	4	4	3	3	4	4	1	3	4	4	3	4	4	3	4
Frequent change of sub-contractors because of their inefficient work	4	3	4	2	4	4	5	2	3	2	4	4	4	5	3	2	3
Delay in site mobilization due to unfamiliarity with local conditions	3	4	4	3	3	3	3	1	1	4	4	4	3	4	4	5	2
Difficulties in financing project by contractor	5	5	4	4	4	4	5	2	2	5	2	2	3	5	3	5	3
Poor site management and supervision	4	5	4	4	4	3	5	1	1	5	2	4	5	5	5	5	3
Rework due to errors during construction	5	5	4	4	2	3	4	2	1	3	3	3	5	5	5	3	4
Unavailability of equipment	5	3	4	4	3	2	5	1	3	2	2	3	4	4	5	5	4
High cost of skilled labor	4	2	4	2	4	3	2	2	5	2	5	3	3	4	5	3	3
Differing site conditions	4	4	4	4	4	2	3	3	5	4	3	3	2	4	5	2	3
Shortage of material	5	4	4	4	4	3	5	1	3	3	2	2	4	5	5	5	4
Unavailability of skills	5	4	4	4	4	4	4	2	3	2	2	2	4	4	4	5	4
Poor workmanship	5	4	4	3	4	4	4	1	5	2	2	2	3	4	3	4	4
Unqualified workforce	5	5	4	4	3	3	4	2	1	3	2	3	4	4	3	4	3

Table 20: Presents Contractor's Organization Participants from (1 to 17) Answers in Contractor Questionnaire Section

Number of Participants	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Shortage of labors	4	3	4	4	3	4	3	4	4	4	5	2	2	3	1	3	4
Complex design and technology	2	2	3	3	1	1	1	4	2	1	5	3	3	4	1	4	3
Frequent change of sub-contractors because of their inefficient work	3	3	4	4	3	4	2	4	4	3	3	3	3	4	3	3	4
Delay in site mobilization due to unfamiliarity with local conditions	4	3	4	4	2	3	4	4	4	4	4	2	2	5	4	4	4
Difficulties in financing project by contractor	4	5	5	4	4	4	5	4	5	5	4	2	3	5	1	4	5
Poor site management and supervision	4	5	4	4	5	4	5	4	5	5	5	1	3	4	2	4	4
Rework due to errors during construction	2	5	5	5	5	5	5	3	5	5	5	3	2	4	2	5	4
Unavailability of equipment	4	2	3	4	3	4	3	4	3	4	4	3	2	4	2	5	3
High cost of skilled labor	5	5	3	2	2	2	1	4	4	2	4	3	2	3	3	4	1
Differing site conditions	4	5	4	4	3	2	3	4	3	3	4	3	3	4	2	4	3
Shortage of material	4	3	4	4	3	4	3	4	3	3	3	5	1	4	2	4	4
Unavailability of skills	5	4	5	4	4	4	5	3	5	4	4	2	2	4	2	4	5
Poor workmanship	5	3	4	4	4	4	4	3	4	3	5	3	2	4	2	4	4
Unqualified workforce	4	4	4	4	2	3	4	5	3	4	5	3	1	4	2	4	4

Table 21: Presents Contractor's Organization Participants from (18 to 34) Answers in Contractor Questionnaire Section

Number of Participants	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Shortage of labors	4	3	4	4	3	4	5	4	4	4	1	4	4	4	3	4
Complex design and technology	4	5	4	4	5	2	4	4	4	3	2	5	1	3	2	5
Frequent change of sub-contractors because of their inefficient work	4	4	2	4	2	4	5	4	3	4	3	3	5	3	4	4
Delay in site mobilization due to unfamiliarity with local conditions	5	4	5	4	3	4	4	4	5	5	3	4	3	5	3	4
Difficulties in financing project by contractor	5	4	5	5	3	5	5	5	5	4	4	4	5	3	5	4
Poor site management and supervision	5	5	4	5	4	4	5	5	5	5	2	5	5	4	1	4
Rework due to errors during construction	4	5	5	4	5	5	5	4	4	5	2	4	5	5	4	4
Unavailability of equipment	3	5	3	5	4	3	3	4	4	4	2	4	4	2	4	5
High cost of skilled labor	4	2	1	4	2	1	4	4	4	3	3	2	4	4	1	5
Differing site conditions	5	1	3	4	1	4	2	5	4	5	4	3	3	1	5	5
Shortage of material	3	3	4	4	5	5	4	4	4	3	5	5	4	2	1	4
Unavailability of skills	4	4	4	3	4	4	2	4	4	5	2	4	4	5	2	5
Poor workmanship	3	4	4	5	3	4	4	3	4	4	3	3	5	3	4	5
Unqualified workforce	4	4	5	4	4	4	2	2	4	4	2	5	3	5	2	5

Table 22: Presents Contractor's Organization Participants from (35to 50) Answers in Contractor Questionnaire Section

- # Fourth Part

  ## Other Organization Results

  There were 10 participants out of 92 participants from other organizations this is there point of view on all questionnaire sections.

Owner's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10
Change in specifications by the owner	2	4	2	3	3	3	3	3	2	3
Obstinate Nature of Owner	3	4	3	3	1	3	3	3	3	3
Inadequate project objectives	2	4	2	3	1	2	5	3	2	2
Change of scope	2	4	1	3	3	1	5	3	1	3
Interference of employer	1	4	3	3	5	5	2	3	4	3
Unrealistic contract duration	2	2	1	3	5	2	4	3	3	1
Owner’s financial problems	3	5	1	3	1	5	4	5	1	2
Replacement of materials or procedures	3	4	2	3	3	3	5	2	2	3
Poor communication and coordination by owner and other parties	2	3	1	3	1	2	4	1	1	1

Table 23: Presents Other's Organization Participants Answers in Owner Questionnaire Section

Consultant's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10
Quality assurance/control	5	4	4	3	1	3	4	3	5	4
Poor knowledge of available materials and equipment	3	4	3	3	1	4	5	1	2	1
Un-use of advanced engineering design software	1	2	3	3	1	4	4	3	1	3
Change in design by the consultant	1	5	2	3	1	5	5	1	2	3
Change in specification by the consultant	1	3	2	3	1	3	5	1	2	1
Delays in producing design documents	1	4	3	3	1	3	5	1	3	3
Conflicts among contract documents	2	3	1	3	1	3	4	1	3	2
Design complexity	2	3	2	3	1	5	5	3	3	3
Inadequate working drawing details	1	3	3	3	1	5	4	1	1	3
Errors and omissions in design	2	5	1	3	1	3	4	1	2	3
Delay in performing inspection and testing by consultant	1	5	3	3	1	5	3	3	3	3
Delays in approving shop drawings	2	4	2	3	1	5	4	1	3	3
Inadequate design	2	4	3	3	1	3	4	1	1	1

Table 24: Presents Other's Organization Participants Answers in Consultant Questionnaire Section

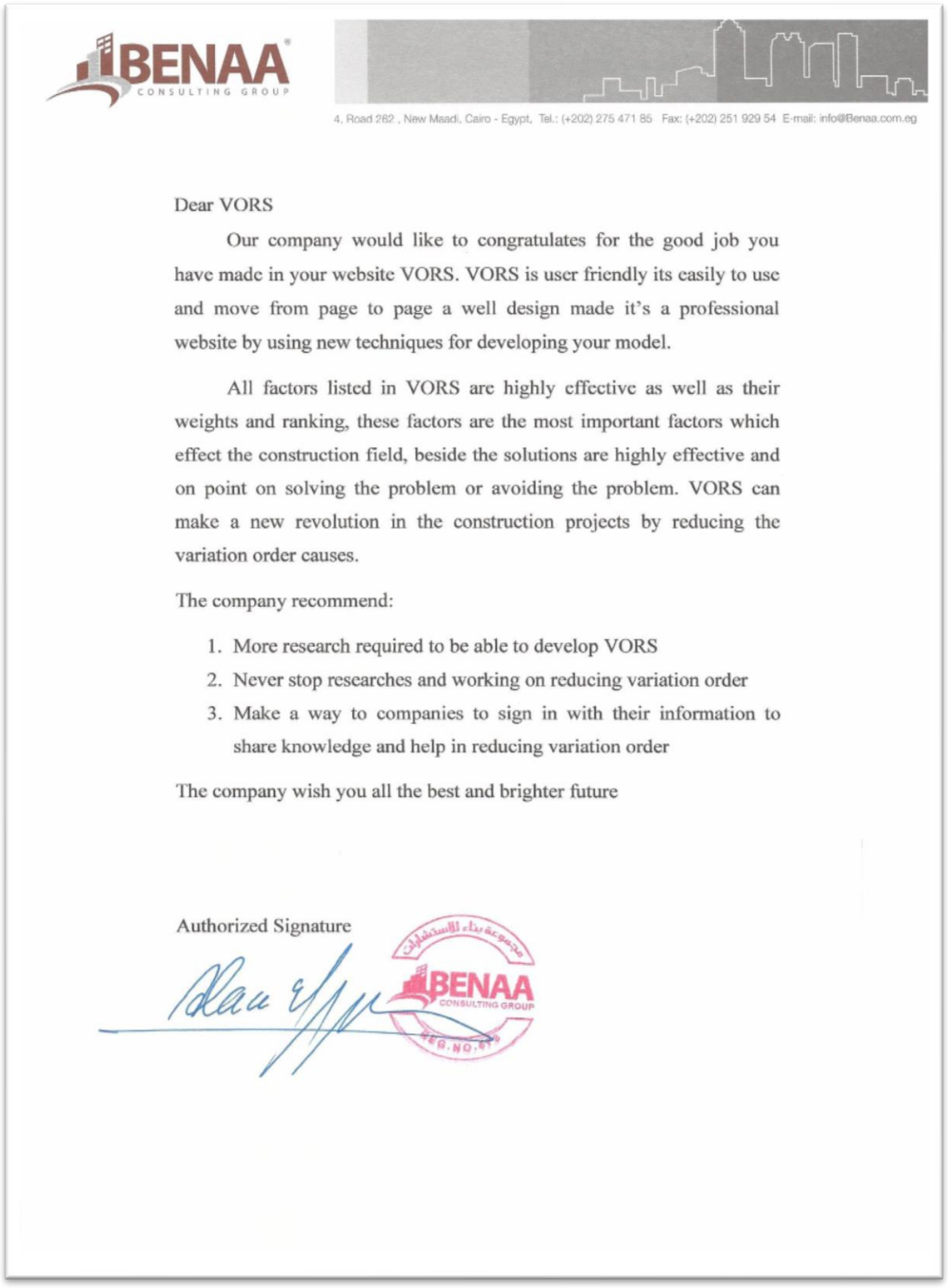
Contractor's Section:

Number of Participants	1	2	3	4	5	6	7	8	9	10
Shortage of labors	2	5	2	3	1	5	4	1	4	3
Complex design and technology	2	3	3	3	1	5	4	1	1	3
Frequent change of sub-contractors because of their inefficient work	3	2	1	3	1	5	4	1	4	2
Delay in site mobilization due to unfamiliarity with local conditions	1	5	1	4	1	2	5	1	4	3
Difficulties in financing project by contractor	1	4	1	3	1	5	3	3	4	3
Poor site management and supervision	3	4	1	3	1	5	5	1	2	3
Rework due to errors during construction	3	4	2	3	1	3	4	1	1	3
Unavailability of equipment	4	3	1	3	1	3	5	1	2	3
High cost of skilled labor	5	2	3	3	1	5	5	1	3	3
Differing site conditions	1	4	1	3	1	3	4	1	5	3
Shortage of material	2	4	1	3	1	2	4	1	1	3
Unavailability of skills	2	3	1	3	1	2	4	1	3	3
Poor workmanship	2	2	3	3	1	2	5	1	3	2
Unqualified workforce	1	3	1	3	1	5	4	1	1	3

Table 25: Presents Other's Organization Participants Answers in Contractor Questionnaire Section

Appendix C:

This appendix contents certificates of case studies



BENAA CONSULTING GROUP

4, Road 262 , New Maadi, Cairo - Egypt, Tel.: (+202) 275 471 85 Fax: (+202) 251 929 54 E-mail: info@Benaa.com.eg

Dear VORS

Our company would like to congratulates for the good job you have made in your website VORS. VORS is user friendly its easily to use and move from page to page a well design made it's a professional website by using new techniques for developing your model.

All factors listed in VORS are highly effective as well as their weights and ranking, these factors are the most important factors which effect the construction field, beside the solutions are highly effective and on point on solving the problem or avoiding the problem. VORS can make a new revolution in the construction projects by reducing the variation order causes.

The company recommend:

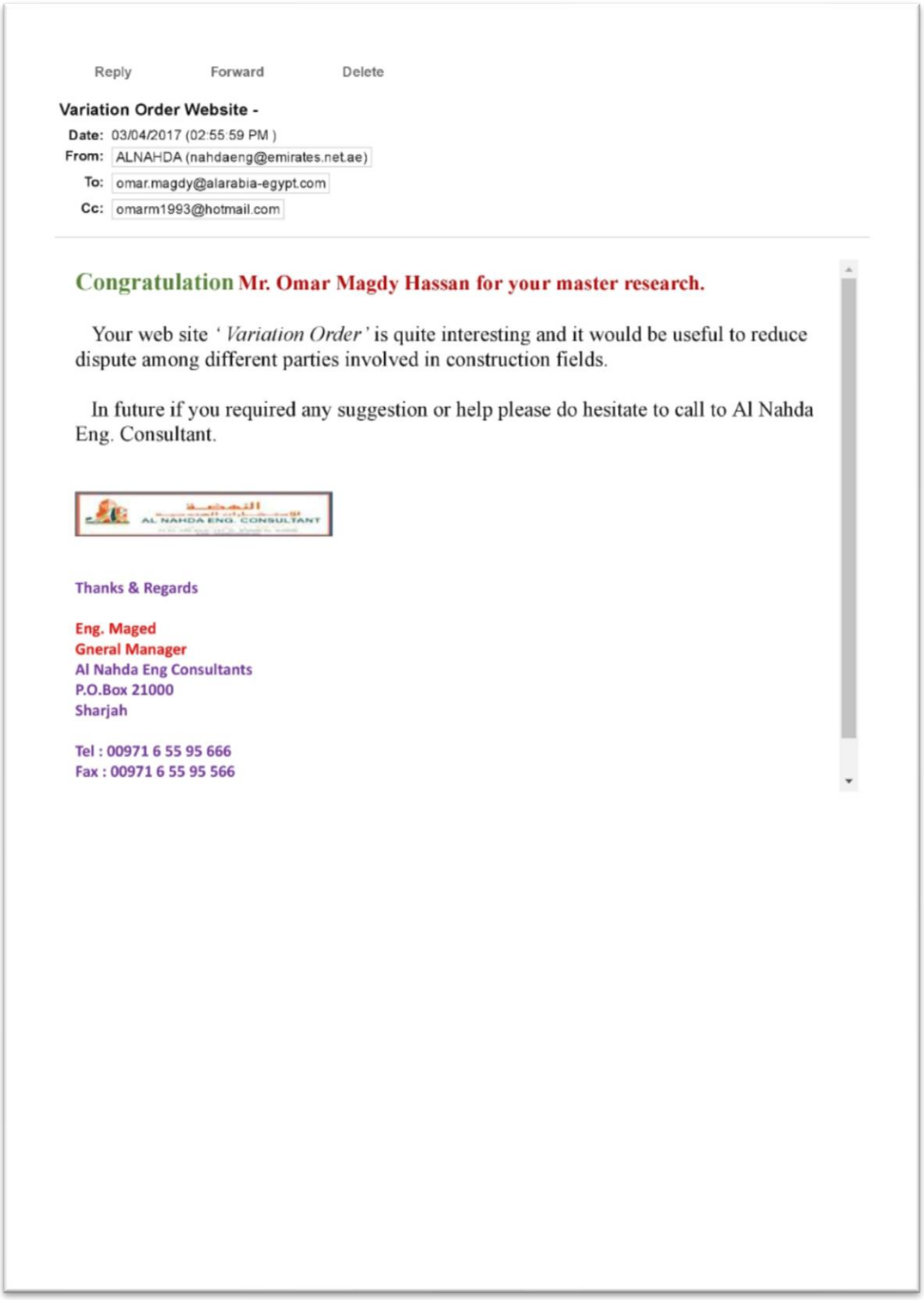
1. More research required to be able to develop VORS
2. Never stop researches and working on reducing variation order
3. Make a way to companies to sign in with their information to share knowledge and help in reducing variation order

The company wish you all the best and brighter future

Authorized Signature

BENAA CONSULTING GROUP

Figure 18: BENAA Consulting Group Certificate the Egyptian consulting company



Reply Forward Delete

Variation Order Website -

Date: 03/04/2017 (02:55:59 PM)
From: ALNAHDA (nahdaeng@emirates.net.ae)
To: omar.magdy@alarabia-egypt.com
Cc: omarm1993@hotmail.com

Congratulation Mr. Omar Magdy Hassan for your master research.

Your web site *' Variation Order '* is quite interesting and it would be useful to reduce dispute among different parties involved in construction fields.

In future if you required any suggestion or help please do hesitate to call to Al Nahda Eng. Consultant.

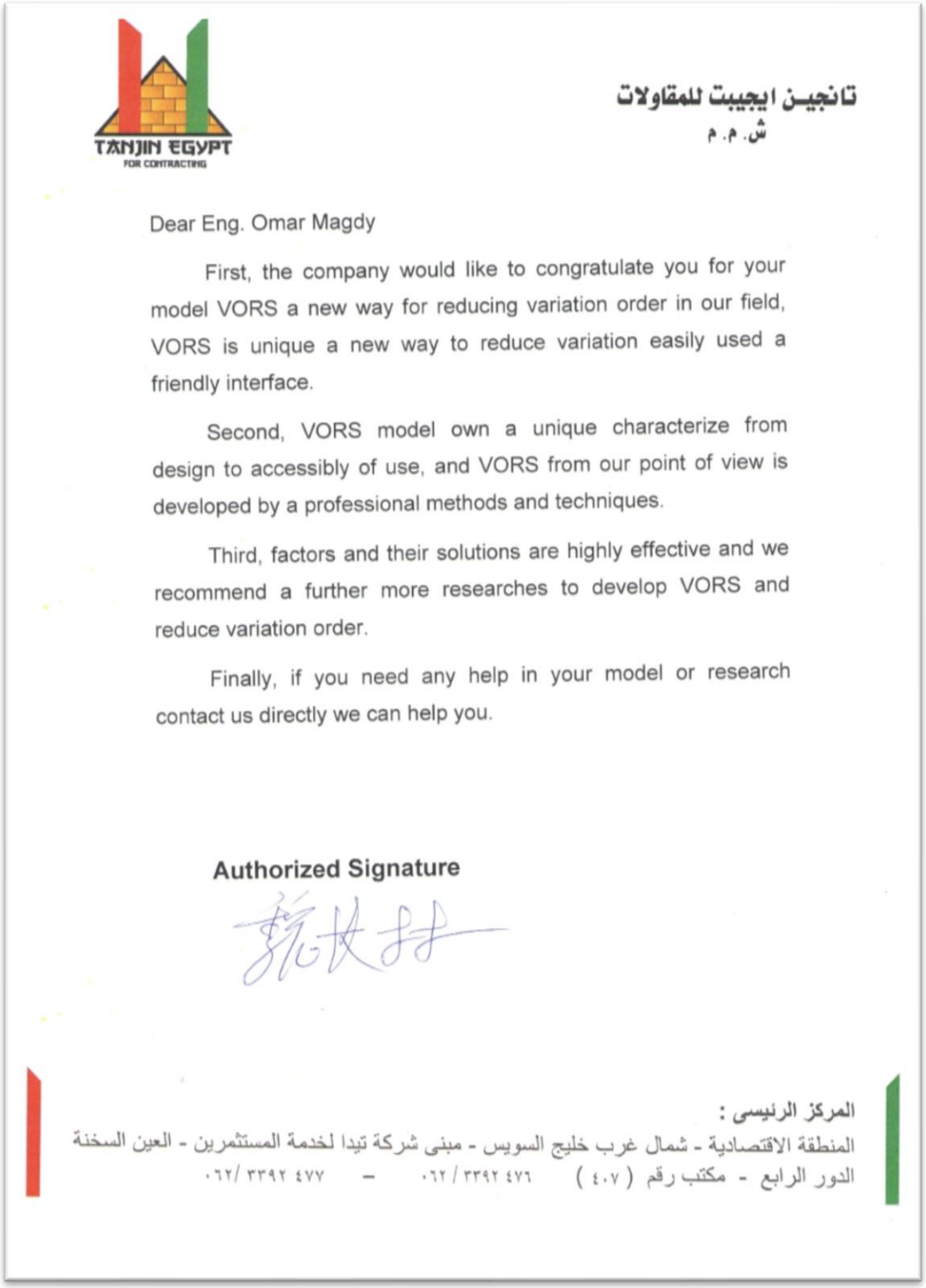
AL NAHDA ENG. CONSULTANT

Thanks & Regards

Eng. Maged
Gneral Manager
Al Nahda Eng Consultants
P.O.Box 21000
Sharjah

Tel : 00971 6 55 95 666
Fax : 00971 6 55 95 566

Figure 19: Al Nahda Eng Consultants Certificate the Emirates consulting company



تانجيـن ايجيبت للمقاولات
ش.م.م

TANJIN EGYPT
FOR CONTRACTING

Dear Eng. Omar Magdy

First, the company would like to congratulate you for your model VORS a new way for reducing variation order in our field, VORS is unique a new way to reduce variation easily used a friendly interface.

Second, VORS model own a unique characterize from design to accessibly of use, and VORS from our point of view is developed by a professional methods and techniques.

Third, factors and their solutions are highly effective and we recommend a further more researches to develop VORS and reduce variation order.

Finally, if you need any help in your model or research contact us directly we can help you.

Authorized Signature

المركز الرئيسى :
المنطقة الاقتصادية - شمال غرب خليج السويس - مبنى شركة تيدا لخدمة المستثمرين - العين السخنة
الدور الرابع - مكتب رقم (٤٠٧) ٠٦٢ / ٣٣٩٢ ٤٧٦ – ٠٦٢/ ٣٣٩٢ ٤٧٧

Figure 20: Tanjin For Contracting Certificate the Chinese contractor company

Al Arabia
Trading & Development Construction

Dear VORS

Al-Arabia Trading and Development Construction Company would like to thank Eng. Omar Magdy Hassan for the great job in VORS model, which help in reducing the variation order in the construction field.

VORS website is well design and is compatible and responsive with all devices plus it can be used from any place without searching for a source to install the model and this shows how the model is well developed.

In additional to the data analysis, which was analyzed by weighting every factor form the questionnaire and using SPSS software in analyzing the data.

Al-Arabia Trading and Development Construction Company wish Eng. Omar Magdy Hassan a brighter future and more success in his life.

Planning and Cost Control Director

Eng. Ahmed Taha

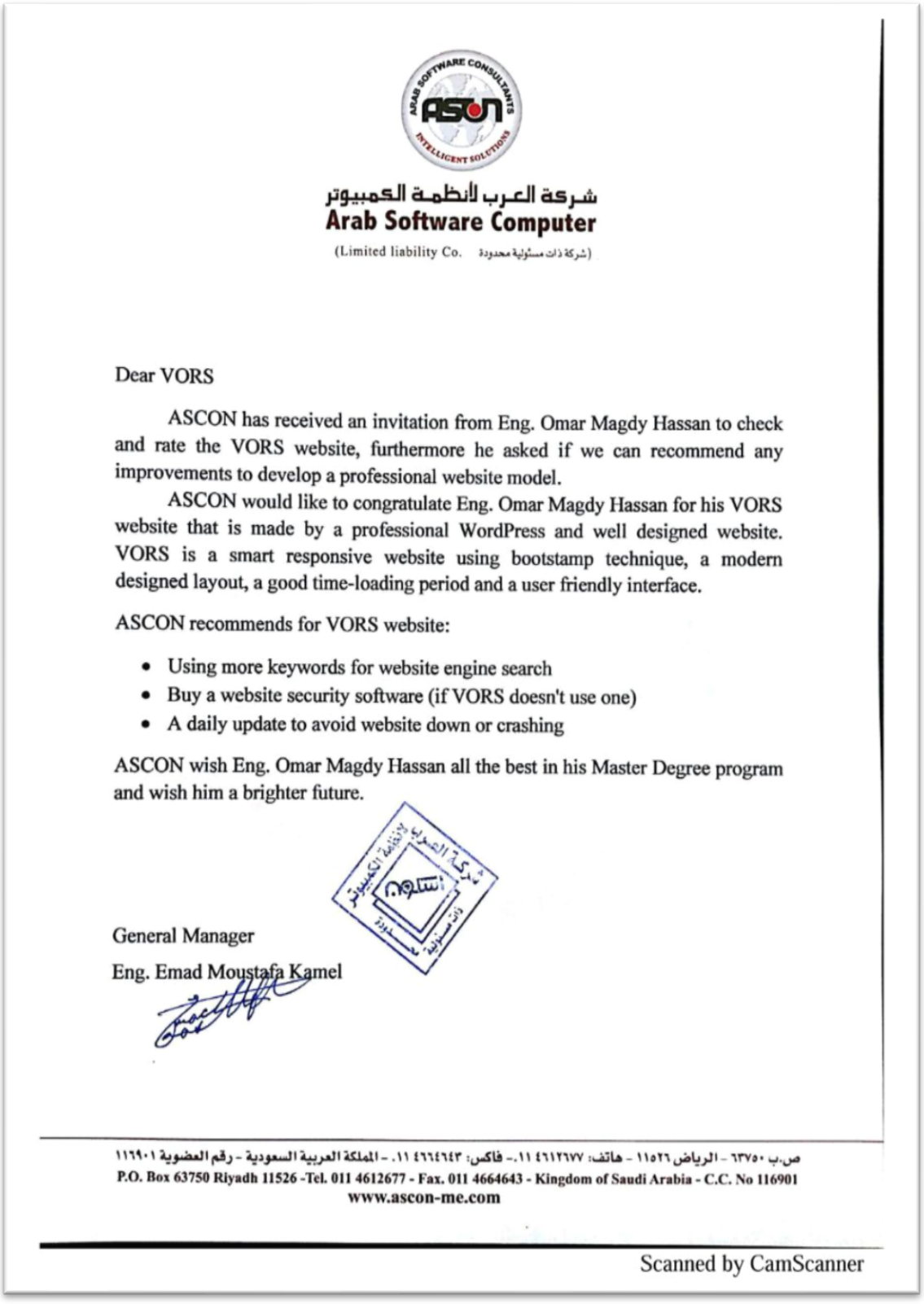
Al Arabia

0623710406 - 01097775637

Website: www.alarabia-egypt.com
E-mail: info@alarabia-egypt.com

9 عمارات المروة - أرض الجولف - مصر الجديدة - القاهرة
تليفون: 02 / 26909530 - 02 / 26909531
فاكس: 02 / 24184415

Figure 21: Al Arabia Trading and Development Construction Company Certificate the Egyptian contracting company



شركة العرب لأنظمة الكمبيوتر
Arab Software Computer
(Limited liability Co. شركة ذات مسئولية محدودة)

Dear VORS

ASCON has received an invitation from Eng. Omar Magdy Hassan to check and rate the VORS website, furthermore he asked if we can recommend any improvements to develop a professional website model.

ASCON would like to congratulate Eng. Omar Magdy Hassan for his VORS website that is made by a professional WordPress and well designed website. VORS is a smart responsive website using bootstamp technique, a modern designed layout, a good time-loading period and a user friendly interface.

ASCON recommends for VORS website:

- Using more keywords for website engine search
- Buy a website security software (if VORS doesn't use one)
- A daily update to avoid website down or crashing

ASCON wish Eng. Omar Magdy Hassan all the best in his Master Degree program and wish him a brighter future.

General Manager

Eng. Emad Moustafa Kamel

ص.ب ٦٣٧٥٠ - الرياض ١١٥٢٦ - هاتف: ٤٦١٢٦٧٧ ١١ - فاكس: ٤٦٦٤٦٤٣ ١١ - المملكة العربية السعودية - رقم العضوية ١١٦٩٠١
P.O. Box 63750 Riyadh 11526 -Tel. 011 4612677 - Fax. 011 4664643 - Kingdom of Saudi Arabia - C.C. No 116901
www.ascon-me.com

Scanned by CamScanner

Figure 22: ASCON Certificate the computer company from Saudi Arabia

Abstract

ترتيب الاختلاف هو الظواهر الشائعة في مجال البناء في جميع أنحاء العالم. هذه الظواهر تحدث عادة خلال أي مشروع بناء مما يؤدي إلى نزاع بين الأطراف التي تشارك في مشروع البناء. أيضا، مجال البناء هو واحد من الإبداعات الرئيسية لأي ثروة الأمة كما هو العمود الفقري لمعظم الصناعات لتطوير الاقتصاد. ويسبب التباين في كثير من الحالات مشاكل ونزاعات بين الأطراف التي تشارك في مشاريع البناء. وبالتالي، فمن المهم جدا لدراسة الأسباب الرئيسية لترتيب التباين ومعرفة والتحكم في الاختلاف. كما لو لم يتم التوصل إلى اتفاق بين أطراف المشروع، فإنه يتحول إلى مطالبة والنزاع التي قد تؤثر سلبا على التقدم المحرز في المشروع وتقليل قدرته على الانتهاء بنجاح في الوقت المناسب ضمن ميزانية المشروع. ويرجع سبب اختلاف النظام أساسا إلى عدم توفر المعدات وسوء صنعة وتصميم التعقيد وتغيير نطاق المشروع الخ. ترتيب أساسا الآثار على زيادة تكلفة المشروع والتأخير في وقت الانتهاء.

والهدف من هذا البحث هو إنتاج نموذجة البرمجيات للمساعدة في الحد من اختلاف أسباب أوامر التغيير والآثار في مشاريع البناء. لذلك، النموذجة يخفف من وظيفة ويساعد على الحد من المشاكل التي تأتي جنبا إلى جنب وحل المشاكل. النموذجة في مجال الهندسة الإنشائية سوف تعمل مثل محاكاة التي سوف تساعد في حل هذا النوع من الاختلافات التي يمكن العثور عليها في مشاريع البناء. هذا النموذج سيكون بمثابة أداة، والتي يمكن أن تظهر كيفية تجنب الاختلاف أو كيفية حل الاختلاف لتقليل أسباب ترتيب الاختلاف في مجال البناء. وبما أن أمر تغيير الواقع غير مرغوب فيه كما لو كنا نحلم بأن يكون لدينا مجال البناء خالية من الاختلافات، ولكن من المستحيل أن يكون لها مجال البناء خالية من ترتيب الاختلاف في الواقع، ولكن يمكن أن يكون تطوير أدوات للمساعدة في تقليل وحل الاختلافات وكان هذا هو الهدف الرئيسي.