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Avoiding Variation Orders In Egyption Construction Projects

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الملخص: أوامر التغيير (VOs) متكرر حدوثها و شائعة في مشاريع البناء والهندسة في جميع أنحاء العالم. يمكن أن يكون لأوامر التغيير تأثيرات شديدة، مثل التأخير الزمني، تجاوز التكاليف، الصراعات، والمطالبات، والنزاعات. إن أوامر التغيير هي حقوق تعاقدية لأطراف العقد و لا تسبب نزاعات إذا تمت إدارتها وفقًا للعقد. يتطلب تجنب أوامر التغيير VOs فهم أسباب أوامر التغيير (VOCs) وتأثيرها علي مشاريع البناء. لذا، يهدف هذا البحث إلى تعريف وتحليل أسباب أوامر التغيير (VOCs) التي تسبب النزاعات. تم إجراء مراجعة الأدبيات و تحديد قائمة بأسباب أوامر التغيير (VOCs) الشائعة في مشاريع البناء لتحقيق هذا الهدف. تم تحديد قائمة بأسباب أوامر التغيير و تمت مراجعتها وتنقيحها مع خبراء البناء بما يتناسب مع صناعة البناء في مصر من خلال اللقاءات. تتضمنت القائمة الناتجة ستة أسباب حدوث لأوامر التغيير وبعد ذلك تم إعداد استبيان منظم وتوزيعه على أصحاب المصلحة في قطاع البناء قي مصر للحصول على أرائهم حول الأهمية النسبية لكل سبب. تم عمل تحليل احصائي للاسباب باستخدام.(Chi-Square test) أشارت النتائج بوجود ارتباط بين دور القائمين علي المشروع وإساءة التفسير او التأويل لمعلومات العقد و كذا وود ارتباط بين سنوات الخبرة و تغيير في مجال الاعمال نتيجة المتطلبات الجديدة للمالك. تم تحديد الأهمية النسبية لهذه الأسباب استخدام مؤشر التردد (FI) للحصول على أهم الأسباب. من نتائج الدراسة اتضح ان اهم الأسباب هي تغيير نطاق الأعمال نتيجة للتغييرات في المتطلبات التي طلبها العميل، وأخطاء التصميم، والأخطاء في المواصفات، واختلاف ظروف الموقع. تم تحليل نموذجين دراسيين للمشروعات من واقع الحياة العملية بشكل شامل ومقارنتهما بأهم أسباب حدوث أوامر التغيير للتحقق من نتائج الاستبيان. وأخيرًا تم كتابة توصيات لتجنب أوامر(VO) بشكل فعال باستخدام عقد مناسب ومتوازن، إعطاء اعتبار خاص لبنود العقد التي تتناول أوامر التغيير ، عمليات المراجعة ،الموافقات، المدفوعات والتأخير. بالإضافة الي تخصيص وقت مناسب لاستكمال التصميم. أيضا علاوة على ذلك، فإن التخطيط المسبق الموسع للمشروع، والتأكد من حالة الموقع وتصميمه، بالإضافة إلى تحليل قابلية البناء في مرحلة المناقصة من شأنه أن يمنع / يقلل من أوامر التغيير أثناء مرحلة البناء.

الكلمات المفتاحية: أسباب أوامر التغيير ؛ مشاريع البناء المصرية , تجنب أوامر التغيير

Abstract: Variation orders (VOs) are frequent in construction and engineering projects all over the world. VOs can have severe impacts, such as time delay, cost overruns, confilict, climes and disputes. VOs are contractual rights to contract parties, and they will not cause disputes if managed according to the contract. Avoiding VOs requires the understanding of the causes of variation orders (VOCs) and their effect. So, this paper aims to define and analyze VOCs that cause disputes. To reach this aim, a literature review was undertaken to identify the common VOCs in Egypt. A list of the VOCs was determined, then revised and purged with construction experts through interviews. The resulting list includes six VOCs. Subsequently, a structured questionnaire survey was prepared and distributed among Egyptian construction stakeholders to get their feedback on the relative importance of each cause. Statistical analysis was carried out using a chi-square test. The test results indicated that there was an association only between the project role and misinterpretation of contract information and there was an association only between the years of experience and change of scope of works as a result of changes in requirement ordered by the client.The Frequency Index (FI) of these causes were determined to gt the most important causes. The top causes are Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client, Design Errors, Errors in Specifications, and Differing Site Conditions. Two real-life cases study was thoroughly analyzed and compared to the most important VOC to verify the developed questionnaire results. Finally, recommendations to effectively avoid / reduce VOs using an appropriate and balanced contract; giving special consideration for contract clauses dealing with VOs; inspections, approvals, payments and delays; and allowance for reasonable time for completion of design.Furthermore Extensive project preplanning, confirming site condition and design as well as buildability analysis in th tender phase would prevent / reduce VOs during construction phase.

1. Introduction

The construction sector is one of the key economic sectors and the main force motivating the Egyptian national economy that contributes to the Gross Domestic Product (GDP) of Egypt by 13.77% [1]. VOs are considered key sources of delays and budget overrun in construction projects [2]. VOs seem to be a never ending story within the construction industry. VO is the change in any project from the original contract or the work scope that agreed at contracting time [3]. Although variation orders (VOs) are contractual rights to contract parties, and they will not cause disputes if managed according to the contract, the appear to cause climes and delays in Egyption construction projects because of the long

approval time for such VOs in most projects and the crashed project time schedules that force Contractors to implement VO works prior to finalizing the paper works and getting the necessary approvals ahead with coordinated contract documents. Project parties' changes are one-construction engineering-related delays from an Egyptian perspective[4]. Nowadays, delays in construction projects is considered one of the most challenging aspects that lead to an increase in the project's cost and time particularly in Egypt. So VOs can result in project cost overrun and delays, as well as many other negative impacts such as affecting project performance, quality, health and safety [5]. VOs can be positive or negative on the stakeholders, yet it is a crucial aspect that has to be managed thoroughly as it can enormously affect the success of a project. Furthermore, VOs have a substantial impact on project performance and stakeholder performance [6]. The maximum project performance would be achieved if the work invariably flows smoothly within time limits and anticipated budget [7]. Increased variations in a construction project generally reduce productivity and efficiency, and increase the chances of construction claims, especially delay claims. VOs are defined as any change in the scope of works of a project that can result in an omission, addition or even modification in the contract documents.

It observes that VOs exists without the need to issue a new contract [8]. This VOs are issued as an official documents stating the associated VOs and agreed upon between the owner and the contractor. Upon agreement, this document becomes part of the project's contract document. The construction contract contains several documents such as drawings, bills of quantities, specifications, general and particular conditions, and other documents that may include soil geotechnical report, etc. [9]. In addition, Construction contracts are different from other contracts in many aspects such as; the numerous tasks to be implemented, the relatively long period of execution, and a large number of involved parties [10]. Therefore, if the construction contract is not clear in all aspects, variation orders, claims and disputes may arise as shown in **Fig.1.** Consequently, if disputes are not resolved promptly, they may drag on and escalate causing delays [11]. Improper managed variation orders during construction is one of causes of delay of the construction projcts in Egypt [12].

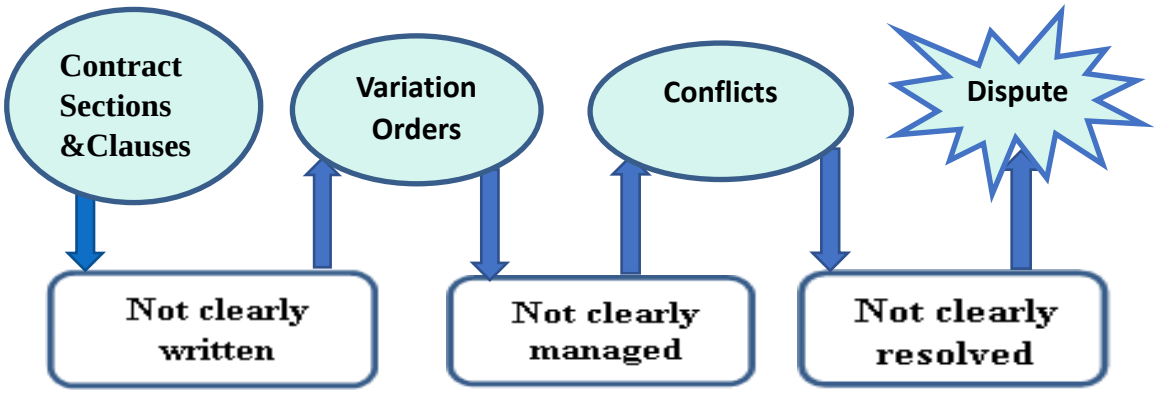

Fig.1. Relationship between Contract Sections, VOs, Conflicts, Disputes

Variation orders can occur due to many causes such as changes in the scope of work and contract documents. Factors such as the complexity of the project, procurement method and nature of the project affect the occurrence of variations. However, these factors differ from project to another [13]. Unforeseen soil condition is one of VOCs that causes delay in construction proects [14, 15] . Design changes is one of VOCs, [16,17,18,19]. Changing market conditions , Technological developments, Changes in environmental regulations, Changes in designs, material types and specifications by consultants, Changing needs of owner are VOCs that cause disputes[20]. Mistakes and discrepancies in design documents, inadequate details in drawings are VOCs that causes delay in Egypt [21]. Weather conditions; Safety considerations; Change in government regulations; Change in economic conditions; Socio-cultural factors; Unforeseen problems are VOCs [22,23,24,25]. Differing site conditions, errors in project

documents, design errors, and multiple meanings of terms in the project specifications VOCs that cause conflicts in construction projects[26]. The five most important VOCs were revealed to be:delay in land acquisition/compensation, differing site conditions, change of plans or scope by client, change of schedule by the client, and lack of coordination between overseas and local designers in Civil Engineering Construction Projects in Kenya[27]. In addition fluctuations in cost/currency, fluctuations in the rate of inflation are VOCs. Frequent change orders causes conflicts that lead to delay and disptes [28,29,30,31].

Although many researchers studied and explored different dispute resolution techniques, the Egyptian construction industry is still experiencing a tremendous increase in litigation and arbitration cases due to VOs . These VOCs occur frequently during the project's lifetime leading to climes, delays, disputes, and litigation. Therefore, the first important action to prevent them is to trace the root causes of such VOs. Therefore, the first important action to prevent them is to trace the root causes of such VOs [32]. VOCs may differ from other countries worldwide. Because of the different nature of the Egyptian construction industry in terms of the attitudes, culture, and business environment of construction contract parties. Therefore, the aim of the current study is to identify and analyze the VOCs and their effect on Egyptian construction

2. Materials and Methods

2.1Materials

The current study was carried out using a list of VOCs in Egypt and international researches as materials for this research that retrieved from extensive literature review and the authors' experience then revised and purged based on appropriateness to Egypt with ten experts (three owners, four consultants, and three contractors). The ability to prevent delay claims and disputes depend largely upon the recognition of the VOCs.

2.2. Methods

2.2.1 Study Design

The methodology of this research is comprised of the following steps:

- Create a list of VOCs in Egyptian construction projects from the literature review.
- Determine the different VOCs from conducting semi-structured interviews with experts.
- Create and distribute a questionnaire survey among the experts in the field of construction projects to get the importance of each VOC.
- Check the VOCs Reliability.
- Check the significance association between VOCs and the respondents' characteristics by analysis and statistical test (Chi-Square) for the questionnaire results
- Determine the Frequency Index (FI) of these VOCs to rank VOCs according to their importance.
- Verify the VOCs using two real case studies.
- Analyze the most important VOCs results according to their Frequency Index.
- Provide Conclusions, and recommendations for future researches.

A list of VOCs retrieved from extensive literature review was determined then revised and purged based on appropriateness to Egypt with ten experts (three owners, four consultants, and three contractors). Based on the identified VOCs as shown in Table 2. A questionnaire survey was conducted to get the most important of VOCs by getting the frequency index FI of each CVO. The Questionnaire consists of two sections: section 1- respondent information such as years of experience: (1-5 Years - 6-10 Years -11-15 Years- 16-20 Years - 21-25 Years - > 25 Years) and role in construction Projects (Owner/Owner' representative - Contractor/ Subcontractor - Engineering consultant) and section 2- list of VOCs in the Egyptian construction contracts. The respondents were asked to select the appropriate degree of

importance for VOCs using a scale of 1 to 5 (one represents not important, while two is little importance, three is neither, four is important and five represents the highest important cause).

a) Sample Design

The size of the sample required from the targeted population, i.e. 135 respondents was determined statistically (Kish 1995) [33]. The results suggested that the minimum sample size required was:

$$n_o = (P * q) / v^2 \quad \text{Eq. 1}$$

$$n = n_o / (1 + (n_o / N)) \quad \text{Eq. 2}$$

Where:

n= sample size

n_o= first estimate of sample size

p = population of the characteristic being measured in the target population

q = 1 – p

v = maximum standard error allowed

N = population size.

The numbers of contractors working and classified as general contractors according to the Egyptian Federation for Construction and Building Contractor (EFCBC) in 2020 are 36000 and the first class contractors are 817. Then N is 36000and P is 817/3600 = 0.0227. To account for the possible error in the qualitative answers from the questionnaire, the maximum stander error (V) was set as 10% substituting in equations (3.1) and (3.2) the number of samples required = 2.218 ~ 3 Subjects.

It is observable that this number of the essential sample is less than the number of respondents' feedback (i.e., 186 respondents). Since the number of construction companies in Egypt is more than the number of consultant companies and owner representatives, therefore, it is sufficient to utilize the same sample size for owner and consultant representatives as for construction companies, the respondents are sufficient sample to represent the target population.

b) Demography of Respondents

The questionnaire was distributed to a total of 186 experts were 136 responded completed the survey. Demographics included Respondent's role in their construction Firm Project, Respondent's years of experience, Respondents were divided into three groups: (1) Owners / Owners representative; (2) Contractors; and (3) Consultants. Most of the respondents were the Contractors 73, 64 consultants and 43 owner/ owner representatives. Most of the respondents hold senior positions with related working experience in the construction field for more than 25 years.

c) Causes Reliability

Analyzing data and checking if any of these causes is reliable or not is an important step in this phase before getting the importance of each cause and its relative importance. Table1. shows the frequency of respondents' answers reflecting the importance (from 1 to 5) of each cause, one represents the least important Not important, while two is little important, three is neither, four is Important and five represents the highest important cause. The filtering score to eliminate unreliable causes are considered. Cause is considered reliable if it satisfies the following equation (Marzouk et al. 2013) [34]:

$$[((1)+(2)+0.5*(3)) \leq (0.5*(3) + (4) + (5))] \quad \text{Eq.3.}$$

Based on the analysis, all the six causes should be considered in the next step without eliminating any of them as shown in **Table 1.** Data were analyzed using SPSS statistical package version 17 [35]. The association between respondents' characteristics by the group and their rating of CMCC is tested using Chi-Square test. A p-value < 0.05 (probability of error) was considered significant [36]. Chi-Square statistic test is used to compare the counts of participants' responses to the importance of the six causes and their demographic variables as shown in **Table 2&3**.

Table 1. Frequency of Responses for Each Cause

No.	causes	1	2	3	4	5	Total	Ave-rage	FILTER	
									<50%	>50%
C1	Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client	3	10	33	43	44	133	3.67	22.18	77.82
C2	Change of Scope of Works as a Result of Design Errors	3	15	24	57	34	133	3.36	22.56	77.44
C3	Change of Scope of Works as a Result of Errors in the Bill of Quantities	6	16	39	44	28	133	3.56	31.20	68.80
C4	Change of Scope of Works as a Result of Differing Site Conditions	6	16	39	44	28	133	3.55	31.20	68.80
C5	Change of Scope of Works as a Result of Errors in Specifications	6	14	23	52	38	133	3.85	23.68	76.32
C6	Misinterpretation of contract information	7	19	48	35	24	133	3.58	37.59	62.41

Table 2: Feedback of respondents according to their role in the Organization

Organization Role	Owner No (%)	Engineer No (%)	Contractor No (%)	Chi-Square- (P-Value)
1. CMCC 1				
Not Important	3 (8.1)	7(14.6)	3(5.9)	2.91
Some Important	8 (21.6)	13(27.1)	13(25.5)	(0.573)
Very Important	26 (70.3)	28(58.3)	35(68..6)	
2. CMCC 2				
Not Important	7 (18.9)	9(18.8)	3(5.9)	4.73
Some Important	7 (18.9)	7(14.6)	10(19.6)	(0.316)
Very Important	23 (62.2)	32(66.7)	38(74.5)	
3. CMCC 3				
Not Important	5 (13.5)	7(14.6)	10(19.6)	.842
Some Important	12 (32.4)	14(29.2)	14(27.5)	(0.933)
Very Important	20 (54.1)	27(56.2)	27(52.9)	
4. CMCC 4				
Not Important	6 (16.2)	9(18.8)	7(13.7)	2.81
Some Important	11 (29.7)	9(18.8)	9(17.6)	(0.590)
Very Important	20 (54.1)	30(62.5)	35(68..6)	
CMCC 5				
Not Important	5(13.5)	9(18.8)	5(9.8)	1.719
Some Important	7(18.9)	8(16.7)	9(17.6)	(0.787)
Very Important	25(67.6)	31(64.6)	37(72.5)	
CMCC 6	11(29.7)	8(16.7)	6(11.8)	8.86*
Not Important	7(18.9)	20(41.7)	23(45.1)	0.055
Some Important	19(51.4)	20(41.7)	22(43.1)	
Very Important				

Table 3: Feedback of respondents according to their years of experience

Organization Role	Less than 10 years No (%)	10 to 20 Years No (%)	More than 20 Yrs No (%)	Chi-Square- (P-Value)
4. CMCC 1				
Not Important	2 (5.6)	10(20.0)	1(2)	11.82* (0.019)
Some Important	12 (33.3)	9(18.0))	13(26)	
Very Important	22 (61.1)	31(62.0)	36(72)	
5. CMCC 2				
Not Important	5 (13.9)	98 (14)	6(12)	2.33 (0.675)
Some Important	5 (13.9)	7(14.6)	12(24)	
Very Important	26 (72.2)	35(70)	32(64)	
6. CMCC 3				
Not Important	6(13.5)	11(22)	5(10)	5.77 (0.217)
Some Important	9 (25)	18(36)	13(26)	
Very Important	21 (58.3)	21(58.3)	32(64)	
4. CMCC 4				
Not Important	4 (11.1)	11(22)	7(14)	2.343 (0.763)
Some Important	9 (25)	9(18.)	11(22)	
Very Important	23 (63.9)	30(60)	32(64)	
CMCC 5				
Not Important	5(13.9)	8(16)	6(12)	1.844 (0.764)
Some Important	4(11.1)	10(20)	10(20)	
Very Important	27(75)	32(64)	34(68)	
CMCC 6				
Not Important	4(11.1)	14(28)	7(14)	5.059 (0.281)
Some Important	14(38.9)	16(32)	20(40)	
Very Important	18(50)	20(40)	23(468)	

d) Causes Ranking According to Frequency Index

The Frequency Index (FI) is an index that measures how frequent the respondents replied to a certain factor. FI is calculated using the formula **(Eq.4.)** stated in (Assaf & Al-Hejji 2006) [37]

$$FI = \sum_{1}^{5} \frac{a \times n}{N} \times \frac{100}{5} \quad \text{..... Eq.4.}$$

Where: a = number of respondents who rate the causes in a given degree of importance,

n = degree of important (1-5).

N =total number of respondents.

The frequency index (FI) was obtained for owners, consultants and contractors replies in order to determine the most important VOCs ranking for each of the three categories representing the parties involved in the construction projects.

The analysis of FI of all respondents is shown in **Table 4** , the results show that the most important causes are: Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client (FI=77.2), Change of Scope of Works as a Result of Design Errors (FI=75.6) and Change of Scope of Works as a Result of Errors in Specifications (FI=75.4).

Table 4. Ranking VOCs According to Frequency Index (FI)

Causes		Frequency(F)					Ave-rage	FI
		1	**2**	**3**	**4**	**5**		
C1	Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client	3	10	33	43	44	3.67	77.2
C2	Change of Scope of Works as a Result of Design Errors	3	15	24	57	34	3.36	75.6
C3	Change of Scope of Works as a Result of Errors in the Bill of Quantities	6	16	39	44	28	3.56	70.8
C4	Change of Scope of Works as a Result of Differing Site Conditions	6	16	39	44	28	3.55	73.6
C5	Change of Scope of Works as a Result of Errors in Specifications	6	14	23	52	38	3.85	75.4
C6	Misinterpretation of contract information	7	19	48	35	24	3.58	67.6

3. Results and Discussion

3.1. Respondents' Classification Analysis

The questionnaire responses have been analyzed and categorized based on two categories:

1- years of experience

2- Firm/project characteristics

Fig. 2 shows the categorization of the respondents according to their years of experiences of the respondents. The respondents are classified as per their years of experiences to six groups: 1-5 years; 6-10 years; 11-15 years; 16-20 years; 21-25 years and more than 25 years. The highest percentage of the respondents (31.35%) has more than 25 years of experience. In addition, more than 55% of the respondents are more than 15 years' experience. This indicates that most of the respondents are of high experience in the construction field.

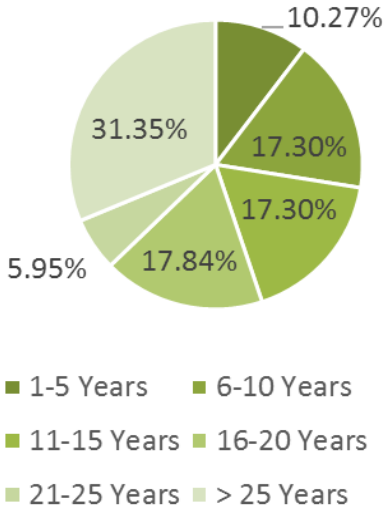

Fig.2. Respondents' Categorization According to Years of Experience

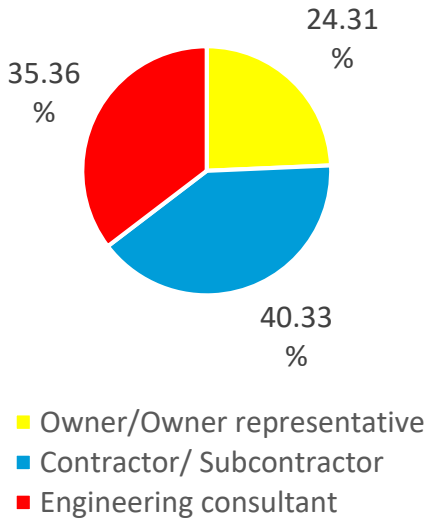

Fig.3. Respondents'Categorization According to Organization type

The second category is based on the place where the respondents are working, i.e., their role in the project whether the respondent represents one of the following: (1) Owner/ Owner representative; (2) Consultant; (3) Contractor. Figure 3 shows that the majority of the respondents were from Contractor/ Subcontractor, 40.33%. The VOCs in the Egyptian construction projects from the technical point of view is mainly effect on the contractor's progress then the owner; therefore, having most of the respondents representing the contractor gives more credibility and strength and enriches the collected data. Most of the respondents were contractors/subcontractors (40.33%), which gives more credibility and strength to the collected data as shown in **Fig.3**.

3.2. Analysis of Variation orders causes." VOCs "

Fig. 5 illustrate the most important six VOCs according to their FI that cause conflict, disputes and litigation in the Egyptian construction projects as follows:

The analysis of FI of all respondents is shown in Table (3.14), the results show that the most important causes are: Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client (C1) (FI=77.2), Change of Scope of Works as a Result of Design Errors(C2) (FI=75.6) and Change of Scope of Works as a Result of Errors in Specifications (FI=75.4).

3.2.1 Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client "C1"

Based on the results of the questionnaire survey, there was a common agreement among all respondents that C1 is the most important VOC because the Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client will send designers back to change the design drawings (architectal , structural, mechanical, electrical and plumbing changes) , the quantity surveyors will have to prepare the bills of quantities again, the time table will crached, then cause important change impacts on the project that leads to disputes.Theses changes occuer during the construction implementation by owner due to his lack of participation in the fesabilty study phase, pre-tendering phase and during the implementation of the project. Inaddition the owner is not much involved in the resources and design of the project. Therefore, the project cost and time will increase that lead to delay and disputes.

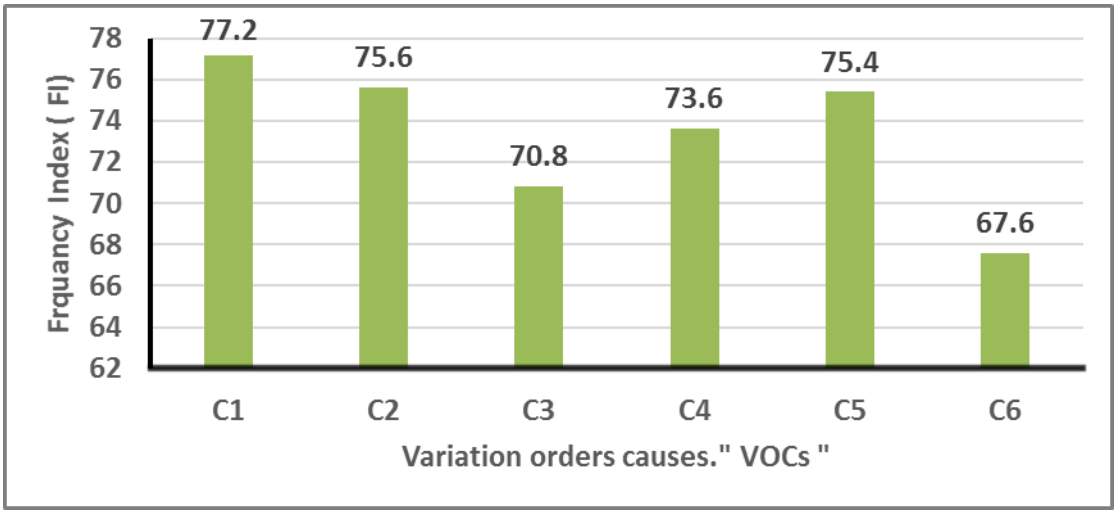

Fig. 5. Ranking of VOCs according to FI.

3.2.2 Change of Scope of Works as a Result of Design Errors "C2"

Based on the results of the questionnaire survey, there was a common agreement among all respondents that C2 is the scond important VOC which is relatd to the consultant. This cause occure due to many resons such as the incompetent consultant, Poor design fee that resultant in the consultant employ incompetent designrs , Inaddation, lack of proper understanding of clients' brief and clients' requirements , Lack of design coordination,and In-adequate time for design. Therefore, the VO will increase consquantly delay, cost and time overrun and disputes will occure.

3.2.3 Change of Scope of Works as a Result of Errors in Specifications "C5"

Fig.5 showes that Change of Scope of Works as a Result of Errors in Specifications "C5" is the third VOC. Contractual specifications are among the most important items based on which a proper cost study and duration of project implementation is made, as the contractor determines the period, the cost of raw materials and equipment's according to their specifications. So Errors in specifications may lead to differences in the interpretation of contractual material specifications which leads to change of the scope of works. These erros are significantly affect the work progress and the project time schedule that leads to great losses for the stakeholders.

3.2.4 Change of Scope of Works as a Result of Differing Site Conditions"C4"

Change of Scope of Works as a Result of Differing Site Conditions"C4" is ranked in the fourth position as showen in Fig.5. The nature of the project site is one of the most important elements on which designs are made, starting from feasibility studies, passing through the designs phase, bill of quantities, determining project cost, as well as its implementation time.This VOC may be occurred due to many sub causes such as; Investigation Lack of Knowledge of Site Conditions, Ignorance of client and consultant on importance of site Investigation, Wrong Interpretation of Site Investigation, lack of money, time and experts in Site, and/or Carelessness of site conditions. So differing site conditions from the expected conditions leads to restudy the soil properties consequently the structural design of the project foundationswill be changed that result in VO that result in conflicts, delay and disputes.

3.2.5 Change of Scope of Works as a Result of Errors in the Bill of Quantities"C3"

Change of Scope of Works as a Result of Errors in the Bill of Quantities"C3" is ranked in the fifth position as showen in Fig.5. Bill of quantities is an important item in the construction contract because the project cost is determined according to it consugantly the owner approve to start the implementation of the project therefore any error in the bill of quantity may leads to the owner change the scope of works which result in occurance of VO that leads to delay and disputes.

3.2.6 Misinterpretation of contract information"C6"

Misinterpretation of contract information"C6" is ranked in the sixth position as showen in Fig.5. A Construction Contract agreement is a document that sets a date and specifies which parties are going to participate in the construction process. Usually, the contract agreement is executed between the Owner of

the project and the Contractor or supplier that is providing the requested services and contains several sections of clauses defining the scope, terms, risks, duration, drawings, specifications, bill of quantities, communications tree, general conditions and special conditions, and construction schedule.These information should be clearified to avoid VO. Therfore if there was Misinterpretation of contract information VO will occure and cause conflict,delay and disputes.

4. Verification of Variation Order Causes (VOCs)

To validate the survey results, an actual case study is summarized in the following section:

4.1 First Case Study

This case study refers to the construction of El-Borolo's fishing harbor in Kaur El-Sheikh Governorate in Egypt. A contract was signed between the defendant (The Central Authority for development of the Ministry of Housing, Utilities and Urban Communities) and the claimant (The Egyptian Dredging Company) for executing fishing port and the necessary construction works (Docks, roads, breakwaters, buildings, services and facilities…. etc.). The contract price is 25,000,000 EGP and time for completion is 30 months. In addition, an appendix of his contract, to implement the protection works of the breakwaters with amount 6,800,000 EGP and duration 6 months. The contractor began the work once mobilized to the site and received the modified design to finish the required works in 36 months then, the project was delayed because of the following reasons and their equivalent VOCs from the questioner results;

- Suspension of the Work because of the increasement of the stones' quantities that executed in the marine barriers over the measured quantities from the drawings due to penetration of stones to the soil at foundation' barrier level, increase of the side inclinations, Marine cores, Sea Waves, Slaughtering and Silting operations that occur during implementation. (C3, C4, C5).
- The owner asked the contractor for executing a Mockup for the marine barrier with a quantity of 1000 m3 of stones to build 8.3 m length according to the design under consultant supervision, but after finishing the actual length was only 2.6 m. (C4 and C5).
- Suspension of works because the owner insisted on calculating the quantities geometrically from the drawings. (C6)
- The owner asked the contractor for executing additional works and rebuilt the collapsed part of the marine due to Suspension of the Work and Marine cores. (C1,C2)

The contractor (Claimant) presented a claim to measurement and payment for actual stone quantities, Increase prices in respect of varied items, compensation for the suspension of work, and compensation for rebuild the collapsed part of the breakwater. Finally, the arbitral award was:

- Calculating the actual stone quantities, which supplied to the site.
- Higher price for the entire contract unites due to extension of time that resulted in change orders.
- No Compensation for the suspension of work and rebuild the Collapsed part of the breakwater.

4.2 Second Case Study

Owner signed contract with contractor for build and finish a malty story building in 24 months, and total cost 9 million pounds. As soon as the contractor began the executing process of the building, he found many obstacles, so the project has not finished in time for many causes:

- Heavy ground water table at level 2.00 meters from soil surface which is different than the primary soil borings and different types and thickness of soil layers as result of Differing Site Conditions (C4)
- Redesign the structure design of the foundations and columns as a result of poorly written contracts clauses (C6).
- Owners'request of constructing an addition service building and adding central air condition for the building after finishing the construction due to lack of proper understanding of clients' brief (C1) and Misinterpretation of contract information (C6)

Because of these delays causes, owner agreed to give the contractor extra time 12 months without any compensation. The contract included an arbitration clause, so the claimant resorted to a mediation to solve this problem. Finally, the contractor got his rights and the project has finalized by 24 million pounds.

By comparing the above VOCs with VOCs listed in questionnaire, these causes are equivalent. This verifies that most of the causes of conflict in the Egyptian construction projects are the same VOCs that were agreed upon by construction experts and the questionnaire survey results.

5. Conclusion and Recommendations

Variation orders (VOs) can have severe impacts, such as time overruns, cost overruns, bad quality, and relationship failure between stakeholders, and can lead to total abandonment of the construction contracts in Egypt. There are endless stories in practice that have resulted in dire financial and project delays consequences due to VOs and there is no guarantee to prevent them. However, reducing VOs and disputes requires an understanding of the causes of Variations. Therefore, the main objective of this research was to identify and analyze the VOCs to avoiding variation orders in Egyptian Construction Projects. Six causes of VOs were determined from a cross-section of the literature and a pilot study with Egyptian construction experts. Freqancy Index procedure (FI) was carried out on the collected questionnaire feedback to get the relative importance of each cause. There was a common agreement among all respondents that Change of Scope of Works as a Result of Changes in Requirement Ordered by the Client "C1" is the most important cause of Variation orders in Egypt. Other important main causes in their rank order are ; " Change of Scope of Works as a Result of Design Errors "C2", Change of Scope of Works as a Result of Errors in Specifications "C5", Change of Scope of Works as a Result of Differing Site Conditions"C4", Change of Scope of Works as a Result of Errors in the Bill of Quantities"C3", and the least important cause of Variation orders was found to be the misinterpretation of contract information"C6" respectively as shown in Fig4. Statistical analyses were carried out using the Chi-Square statistic method to test the causes of Variation orders in Egypt which obtained from the survey. The results indicated that there was only an association between their role in the organization and Misinterpretation of contract information (C6) and there was only an association between their years of experience and change of scope of works as a Result of changes in requirement ordered by the Client in the organization (C1) as shown in Table 2&3. Although variation orders (VOs) are contractual rights to contract parties, and they will not cause disputes if managed according to the contract, the appear to cause contract conflicts in Egypt because of the long approval time for such VOs in most projects and the crashed project time schedules that force Contractors to implement VO works prior to finalizing the paper works and getting the necessary approvals ahead with coordinated contract documents. According to the analysis of the results of the questionnaire, the case studies and experience of the authors, it is recommended for all stakeholders of the project (Owners, consultants, contractors and others) to VOCs to avoiding variation orders in Egyptian Construction Projects or at least reduce VOCs and try to mitigate potential effects by following number of precautions: The owners should consider:

1) Specify a realistic duration for Document Preparation and avoid acceleration of the consultant to finish the set of tender documents.

2) selecting a consultant with sufficient experience and paying a reasonable fee.

3) Hiring an experienced geological consultant who has a good reputation to study the soil condition and give an accurate soil report to avoid any amendments or variation orders after signing the contract.

4) Present a clear scope and his requirements before starting design stage of the project.

5) Clarify the necessary steps for approving the change orders required by the consultant or owner representative, and the time for review and approval.

6) The awareness towards using well-balanced construction contracts, in terms of the contractor / consultant / and owner rights and responsibilities, such as FIDIC contracts.

7) Formal relationships among project parties should be clearly identified, as well as roles and responsibilities of Variation order request and/ or approvals.

8) Having sufficient time to prepare feasibility study for the project, as well as the preparation of a comprehensive financial plan and cash flow.

9) Focus well in the pre-contracting stage in understanding and reviewing the required scope of work and contract clauses.

On the other hand, the consultants should consider:

1) hiring experienced engineers.

2) Provide complete and clear detailed design plans, updated specifications, an accurate bill of quantity according to the design drawings and site requirements.

3) avoiding generic specifications and customizing specifications to be particular to each project.

4) establishing clear system to handle, control, and evaluate the variation orders to be handled in a timely manner as it results in project delays or conflicts later.

5) Preview the site and execution of necessary borings with coordination with geological consultant before the structural design of the foundation to avoid any amendments or variation orders after signing the contract.

6) Establishment of a control system to handle, control, and evaluate variation orders, initiated by the owner.

Finally, the contractors should consider:

1) reviewing the contract clauses and documents before signing the contract.

2) reviewing the availability of materials and equipment of the project. Early participation of professionals may be beneficial in reducing the occurrence of variations. Also, improved design and avoiding frequent design changes will be very effective in controlling the problem of variations.

This paper attempted to provide a local angle to identify causes of variation ordrs and to provide measures for the reduction of common variation orders causes in future construction projects.

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