Preliminary Investigation on the Causes of Variation Orders in Building Projects - Studied Cases in the State of Khartoum, Sudan

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ABSTRACT

Variation orders (V.O) are considered one of the main challenges that face all stakeholders in construction projects. (V.O) in building construction projects could result from increasing contract value by more than 25%, adding new item that did not exist in the original contract, changing specifications of original contracted items due to unforeseen conditions or the need to change the scope of work. (V.O) in Building projects usually create negative impact on project sustainability and progress.

This study aimed to investigate the causes of (V.O) in Building projects in Khartoum State, Sudan. Study comprised two stages: critical review of the relevant Literature to outline the most commonly witnessed causes of (V.O) and the second stage included a case study exercise where specific cause were highlighted and their effect on project cost and time was calculated. The results showed that the majority of the recorded causes for (V.O) in building projects were related to client’s changing needs, client’s changing scope of work, design changes, instability of prices of material in local Market, Changing government regulations and legislation and Change the use of the project. The results also confirmed the negative impact of (V.O) in the project time and cost. It was found that the projects time increasing with a range of (22-344) % and likewise the projects cost increased within the range of (4-25) %. It could generally be concluded that (V.Os) in building projects in Khartoum, Sudan are caused by similar cause elsewhere. It was found that the
main top management requirements / changes (client needs) after starting the work, is driver for the presence of (V.O).

The impact of (V.Os) on the project cost and time is enormous and in some cases exceeding triple the original time, something that sets an alarm in projects control initializes. The study recommends to do detailed studies to identify causes more broadly, the professionals to exert more efforts and pay more attention in defining the scope of projects, allocating sufficient time for design development and improving design by adding more risk factors during the itemization process.

**Keywords**: Cost, Khartoum, Sudan, Construction, Industry, Time

1. **Introduction**

Construction industry It can be defined as: Service industry for the rest of the economic sectors and industries and usually offer their products as certain and specific objectives of the request. These products vary from very simple projects to complex projects using the highest degree of technology and knowledge.(1)

Complex industry, it includes a large number of shareholders and various scientific and practical backgrounds (managers, engineers from various fields, trade, consulting firms, geologists, urban planners, lawyers, accountants, financiers, technologists, government sectors, materials providers, mechanics providers, etc.), different experiences working or participating in the construction industry of the highest degrees of skills and experience to the workers without any experience or skills.(2)

Industry adopts the principle of the project, which have a long life and a heavy weight where it is not possible to transfer and re-use it because it is usually built for a specific purpose. Construction project and passes through several stages from the idea to the feasibility study and preliminary and detailed design and
construction contract and then and then the operation and maintenance and eventually replacement or removal. Where participants differs in each stage according to their role and their goals.(4)

Complex industry because the final product in the construction industry has a large number of different properties of materials and shapes, as well as various mechanical and electrical equipment. And used to produce this product a large number of temporary and permanent resources it may be possible to store or must be used within a certain time.(3)

Construction industry is one of the largest industries in the world. Developing countries, such as Sudan, dedicate a significant share of their annual budgets for the construction sector. During the execution of projects, some alterations in the scope, duration, or cost may be experienced. The impact of these changes may necessitate some actions to be considered to adjust the final product cost or time. These actions are normally conducted through what is known as change or variation orders.

2. Literature Review and Previous Studies

2.1 Literature Review
Webster's dictionary defines variation in the construction industry as a transformation or modification, or deviation, the substitution of one thing for another, and a replacement or substitution (5). In construction, a variation order is defined as "an action that specifies and justifies a change to the scope of a construction contract that alters the original time of completion or the project total cost, or both" (5).
Another definition for variation describe it as any modification to the contractual guidance provided to the contractor by the owner, owner’s agent, or design engineer (6). Lee, (2002)(7) defined variation as any event, which results in a modification of the original scope, execution time or cost of work while (8) put it as a movement, and movement means friction and he mentioned that only in the frictionless vacuum of a nonexistent abstract world can movement or change occur without that abrasive friction of conflict.

Al-Najar, (2008)(9), has defined a variation order as a written instrument prepared by the Engineer and signed by the Owner, Contractor and Architect while the impact of multiple variations is defined as large, untimely, and numerous change orders have a bad effect on productivity (5). According to (6), the problems exacerbated when multiple Variations are introduced into the project.

Variation orders have four main types. Those types are actual, constructive, cardinal, and conditional. According to CSU (2007)(10), the types of change orders are:
1- Normal change orders, and emergency change orders.
2- Actual change: An actual change arises in those circumstances where the owner directs a change to the scope of work (11).
3- Constructive change: A constructive change occurs when the owner, by his action and/or inaction, changes the scope of work, but does not recognize it as a change (11).
4- Cardinal change: A cardinal change has long been recognized in the federal sector of contracting (11). Also, it is a change or series
of changes that are beyond the scope of the contract (12). Variations order arises for a variety of reasons. Some are foreseeable, others are not. Some result from a genuine change of circumstances and others from the design team’s

Table 1: Summary Causes V.O (13)

<table>
<thead>
<tr>
<th>Category</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client related changes</td>
<td>1. Owner's financial problems</td>
</tr>
<tr>
<td></td>
<td>2. Change of scope</td>
</tr>
<tr>
<td></td>
<td>3. Change of project schedule</td>
</tr>
<tr>
<td></td>
<td>4. Replacement of materials</td>
</tr>
<tr>
<td></td>
<td>5. Inadequate project objectives</td>
</tr>
<tr>
<td></td>
<td>6. Change in specifications</td>
</tr>
<tr>
<td>Consultant related changes</td>
<td>1. Inadequate shop drawing details</td>
</tr>
<tr>
<td></td>
<td>2. Change in design</td>
</tr>
<tr>
<td></td>
<td>3. Lack of consultant's knowledge of available materials and equipment</td>
</tr>
<tr>
<td></td>
<td>4. Errors and omissions in design</td>
</tr>
<tr>
<td></td>
<td>5. Conflicts between contract documents</td>
</tr>
<tr>
<td></td>
<td>6. Inadequate scope of work for contractor</td>
</tr>
<tr>
<td></td>
<td>7. Design complexity</td>
</tr>
<tr>
<td>Contractor related changes</td>
<td>1. Lack of contractor's involvement in design.</td>
</tr>
<tr>
<td></td>
<td>2. Contractor financial problems</td>
</tr>
<tr>
<td></td>
<td>3. Unavailability of equipment</td>
</tr>
<tr>
<td></td>
<td>4. Unavailability of skills manpower</td>
</tr>
<tr>
<td></td>
<td>5. Defective workmanship</td>
</tr>
<tr>
<td>Other changes</td>
<td>1. Weather changes</td>
</tr>
<tr>
<td></td>
<td>2. Change in government regulations</td>
</tr>
<tr>
<td></td>
<td>3. Change in economic conditions</td>
</tr>
<tr>
<td></td>
<td>4. Unforeseen problems</td>
</tr>
</tbody>
</table>
2.2 Previous Studies

A critical change may cause consecutive delays in project schedule, re-estimation of work statement, and extra demands of equipment, materials, labor, and overtime. Changes, if not resolved through a formalized change management process, can become the major source of contract disputes, which is a severe risk contributing to project failure (14). Kaming et al. (15) studied influencing factors on thirty one high-rise projects in Indonesia and found that design changes is one of the most important factors causing time overrun. They stated that design changes inevitably lead to variation in original cost/time programmes. Yogeswaran et al. (16) scrutinised 67 civil engineering projects in Hong Kong and suggested that at least a 15–20% time overrun was due to inclement weather. Based on analysis of 46 completed building projects in the UK During the construction phase, value engineering can be a costly exercise, as variation in any design element would initiate
downstream variations to other relevant design components (17). Wu et al. (18) divided the cause of variation orders in construction highway projects into two parts: external and internal factors. The external factors include the political and economic factor, the natural environmental factor, and the third party factor. He classified the internal factor into four categories depending on whether they are initiated by the owner, construction design consultant, contractor, or other parties. Arun and Rao (20) reported that changes in design as well as defects and correction in design as factors that resulted in cost and time overruns in India construction project.

Arain and Pheng (21) studied 53 factors that causes variation orders in institutional buildings in Singapore, the result found that there are a strong correlation between lack of consultant's knowledge of available material and consultant's lack of required data, unavailability of equipment unavailability of skills, differing site condition and honest wrong beliefs of contractor, defective workmanship and contractor's lack of judgment and experience, unfamiliarity with local conditions and complex design and technology, and lack of specialized construction manager and lack of strategic planning.

Perkins (22) examined the causes for construction phase changes in 23 private design/build and 20 government design/build construction projects in the United States. He found that changes might arise from: owner-requested additions/deletions to the work; the action of third parties beyond the control of the owner or contractor; delays in owner-supplied access or equipment; differing site conditions; and discrepancies in the original design specifications. He reported that the number of changes...
due to design error in design/build construction is statistically significantly lower than that of the design-bid-build construction. Lee (23) studied the data of 161 completed transport projects. The results indicated that 95% and 100% of road and rail projects, respectively, had a maximum cost overrun of 50%. The key causes of cost overruns were found to be: changes in scope; delays during construction; unreasonable estimation and adjustment of project costs; and no practical use of earned value management.

Enshassi et al. (24) studied 64 factors that caused variation orders in construction project in The Gaza Strip. The study results identified the most important factors cause variation order are lack of materials and equipment spare parts due to closure, change in design by consultant, lack of consultant's knowledge of available materials, errors and omission in design, conflicts between contract documents, owner's financial problems, lack of coordination among project parties, using inadequate specification for local markets by international consultant, internal politics, and change is specification by owners, Al Momani (25) found that user changes are one of the main causes of delay in 130 public projects in Jordan. Hegazy et al. (26) identified causes of change order in the contract documents as change in the regulatory legislations or code after the contract was awarded, changes of scope during construction due to owner, owner’s agent or design engineer new or modified requirements, correction of design errors and omissions, availability of materials and equipment’s, value Engineering proposals.

Alnuaimi, et al. (27) conducted a survey of variations in public construction projects in Oman, they identified the most causes of change
order includes owner instructs additional works, owner instructs modification to design, non-availability of construction manuals and procedures for project construction in Oman, Non-availability of engineering licensing for engineers in Oman to maintain the quality of consultancy services, poor communication between relevant governmental units and the owner, non-availability of overall project planning, unrealistic design periods, unrealistic construction schedule, owner fails to make decisions or review documents at the right time low consultancy fee or less experienced designers.

3. Problem Statement and Study Objective

In general, changes present problems to all parties involved in the construction process. Changes are the major cause of project failure. From some interviews which was done with some construction managers in Sudan Construction Field, Variation orders were the main cause of increasing in contract value and/or the extension of time. This study aims to do Preliminary Investigation of variation orders in Building construction projects in Khartoum – Sudan.

4. Area of study

Khartoum state is the capital of the Republic of Sudan triangular located in central Sudan. It consists of Khartoum, which is located at the confluence of the White Nile and Blue Nile, and the Bahri, which lies east of the Nile and Omdurman, which represents the western part of the state. The three cities linked together a number of bridges and an estimated population of Khartoum triple by more than five million people.
5. Methodology
The researcher adopted a two stager plan to achieve the stated objectives. Initially, a Critical review for documented research results on the topic of (V.O). Secondly case study and analysis for 5 projects where detailed information was collected (contract documents, monthly reports and weekly reports). This followed by face-to-face interviews with projects participants with the aim of determining the effect of (V.O) in the overall performance of the studied cases.

6. Results
Case Study No (1)
Project Location: ElMogran – Khartoum State.
Project Description: Administrative Building- Area (3500m²) - Basement and Two floors and Roof.
Contract Price: 8,000,000 SDG.
Time Period: 18 Months, Starting: April 2010
Table 2: Data of Variation Orders for Case (1)

<table>
<thead>
<tr>
<th>Variation Order No</th>
<th>Date of Variation Order</th>
<th>Net Amount of this Variation Order (SDG)</th>
<th>Justification</th>
<th>% of executed Variation Order</th>
<th>Reasons for the Variation Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>December 2010</td>
<td>240,000</td>
<td>Change the Interface building to cladding works</td>
<td>100</td>
<td>1. Client’s changing needs 2. Design Changes.</td>
</tr>
<tr>
<td>2</td>
<td>January 2011</td>
<td>70,000</td>
<td>Increase building lighting</td>
<td>100</td>
<td>Error in design</td>
</tr>
<tr>
<td>3</td>
<td>March 2011</td>
<td>110,000</td>
<td>Change the External Surface of Building from Tiles to Land Scap</td>
<td>100</td>
<td>2. Client’s changing needs 2. Design Changes.</td>
</tr>
</tbody>
</table>

Case Study No (2)

- Project Location: Bahri – Khartoum State.
- Project Description: Administrative Building - Area (25500m²) – Ground and Three floors - Parking Area (2400 m²), Landscape Area (800m²)
- Contract Price: 22,000,000 SDG.
- Time Period: 20 Months, Starting: June 2012
Table 3: Data of Variation Orders for Case (2)

<table>
<thead>
<tr>
<th>Variation Order No</th>
<th>Date of Variation Order</th>
<th>Net Amount of this (Variation Order) SDG</th>
<th>Justification</th>
<th>% of executed Variation Order</th>
<th>Reasons for the Variation Order</th>
</tr>
</thead>
</table>
| 1                  | August 2012             | 400,000                                  | Convert the usability of the building | 100                            | 1. Client’s changing needs  
2. Change use of building |
| 2                  | June 2013               | 450,000                                  | Increase the Capacity of electricity of building | 100                            | 1. Client’s changing needs  
2. Design Changes |
| 3                  | April 2014              | 60,000                                   | 1. Addition the entrance of interface building.  
2. Addition the drainage system | 100                            | 1. Client’s changing needs  
2. Design Changes |

Case Study No (3)

- Project Location: Soba – Khartoum State.
- Project Description: compound - Area (2100m²) – Six building and 4 Villas.
- Contract Price: 6,000,000 SDG.
-Time Period: 12 Months, Starting:

September 2007

Table 4: Data of Variation Orders for Case (3)

<table>
<thead>
<tr>
<th>Variation Order No</th>
<th>Date of Variation Order</th>
<th>Net Amount of this (Variation Order) SDG</th>
<th>Justification</th>
<th>% of executed Variation Order</th>
<th>Reasons for the Variation Order</th>
</tr>
</thead>
</table>
| 1                   | May 2008                | 500,000                                  | Addition Asphalt street in the compound by length 3 kilometer | 100                            | 1. client’s changing needs
                                                                      |                                                          |                           |                              | 2. Design Changes.              |
                                                                      |                                                          |                           |                              | 3. Instability of prices        |

Case Study No (4)

-Project Location: Arkwet – Khartoum State.
-Project Description: Administrative building in power station - Area

(2000m2)

-Contract Price: 4,000,000 SDG.
-Time Period: 9 Months, Starting: June 2010
Table 5: Data of Variation Orders for Case (4)

<table>
<thead>
<tr>
<th>Variation Order No</th>
<th>Date of Variation Order</th>
<th>Net Amount of this (Variation Order) SDG</th>
<th>Justification</th>
<th>% of executed Variation Order</th>
<th>Reasons for the Variation Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>October 2010</td>
<td>1,000,000</td>
<td>Change the location of project by Ministry of Physical Planning after working start by 9 months</td>
<td>100</td>
<td>Changing government regulations and legislation</td>
</tr>
</tbody>
</table>

Case Study No (5)

-Project Location: Elmogran – Khartoum State.
-Contract Price: 2,500,000 SDG.
-Project Description: administrative building - Area (1300m2) – Basement and three floors.
-Time Period: 12 Months, Starting: May 2010

Table 6: Data of Variation Orders for Case (5)

<table>
<thead>
<tr>
<th>Variation Order No</th>
<th>Date of Variation Order</th>
<th>Net Amount of this (Variation Order) SDG</th>
<th>Justification</th>
<th>% of executed Variation Order</th>
<th>Reasons for the Variation Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>June 2010</td>
<td>350,000</td>
<td>Change the foundation of building</td>
<td>100</td>
<td>1. client’s changing needs 2. Design Changes.</td>
</tr>
</tbody>
</table>
7. Analysis & Discussion

(1) From the critical review of the Literature the results revealed that (22) causes, most recorded influential cause refer to table (1).

(2) From the studied cases it was evident that (client’s changing needs, client’s changing scope of work, design changes, instability of prices of material in local Market, Changing government regulations and legislation and Change the use of the project) were the most influential. This result goes in line with international experience however due to the limitation with the cases studied. The results were only confined to these six factors.

(3) The results shown in table (7) also confirmed a direct relationship between the presence of (V.O) and Project time overrun.

Table (7) Impact of Variation Orders on Cost & Time

<table>
<thead>
<tr>
<th>Case Study No</th>
<th>Cost</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Contract Price SDG</td>
<td>Final Contract price SDG</td>
</tr>
<tr>
<td>1</td>
<td>8,000,000</td>
<td>8,420,000</td>
</tr>
<tr>
<td>2</td>
<td>22,000,000</td>
<td>23,901,000</td>
</tr>
<tr>
<td>3</td>
<td>6,000,000</td>
<td>7,500,000</td>
</tr>
<tr>
<td>4</td>
<td>4,000,000</td>
<td>5,000,000</td>
</tr>
<tr>
<td>5</td>
<td>2,500,000</td>
<td>2,850,000</td>
</tr>
</tbody>
</table>
It was recorded that project’s durations were increase by (22-344) % due to (V.O) which is an consider alarming rate. Cost analysis also showed an increase by (8-25)% due to (V.O)

8. Conclusion & Recommendations

could generally be concluded that (V.Os) in building projects in Khartoum, Sudan are caused by similar cause elsewhere. It was found that the main top management requirements / changes (client needs) after starting the work, is driver for the presence of (V.O).

The impact of (V.Os) on the project cost and time is enormous and in some cases exceeding triple the original time, something that sets an alarm in projects control initializes

The study recommends to do detailed studies to identify causes more broadly, the professionals to exert more efforts and pay more attention in defining the scope of projects, allocating sufficient time for design development and improving design by adding more risk factors during the itemization process.

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