INTRODUCTION

Variation orders have long been an inherent part of the construction industry. It is seldom to spot a construction project being executed without a change which normally arises as a result of some causes attributed to the different parties involved in the project execution. Upon acknowledging its existence, the change – or variation is formally regularized by the issuance of a change order which is a document describing the scope of the change and its impact on both cost and / or time. If no agreement is reached between the parties of the project on the change, it turns into a claim or dispute that may negatively affect the execution of the project and curtail its chances of successful completion. A number of researchers gave several definitions to be change order. If no agreement is reached between the parties of the project on the change, it turns into a claim or dispute that may negatively affect the execution of the project and curtail its chances of successful completion. A number of researchers gave several definitions to be change order. A number of researchers gave several definitions to be change order. I

KEYWORDS: Contractors, Variation Orders, Khartoum, Building projects, Consultants, Owners.
Variation Orders strain the relationships of the owners, engineers, contractors, subcontractors, and others involved in the construction process as well as add cost and schedule delay. Changes on one project can also affect other unrelated projects by tying up resources that are committed elsewhere. Negative relationships between the parties are another byproduct of changes on a project. Not only is workflow disrupted, but also trying to get quick responses quotes, shop drawings, and many other things required to get back schedule causes a strain on working relationships (Rashid, et al. 2012.) [3]. Homaid et al. (2009) [4] investigated 21 causes and 11 potential impacts of change orders. Also, nine practices reported to management and control of change orders. The study identified eleven important causes and seven important impacts. It is further concluded that the consultant is the most responsible party for the change orders. The overall average increase in total cost of construction projects due to change orders was found to be 11.3%. The research concluded that change of project scope due to owner requirements is the most important cause and cost overruns are the most important impacts of change orders in those projects. According to Aljeshi and Almarzouq (2008) [5], Aldubaisi (2000) [6] and Zawawi (2010) [1], changing the plans by the owners is the main source of change orders, change in mind, substituting materials and/or procedures is the second source of change orders and errors and omissions in design is another source. Increase in project cost and duration were found as the main two effects of change orders. In another study it was concluded that the best way to manage change orders is to reach a negotiated.

In general, Variations orders present problems to all parties involved in the construction process. Variations 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 determine factors causing Variation orders in Building construction projects in Khartoum – Sudan.

II. MATERIALS AND METHODS

DATA COLLECTION

1. From studied cases

Initially, a study and analysis for 10 projects was conducted where detailed information was collected (contract documents, monthly reports and weekly reports). This was followed by face-to-face interviews with projects participants with the aim of determining the factors causing (Variation Orders) in the studied cases.

2. From questionnaire

Data were gathered through a questionnaire administered to owners, consultants, contractors and project managers. They were requested to answer questions pertaining to their experience with building Project and their opinions about variation orders. The participants were (23) engineers working in government entities represented owner, (53) engineers in contractors companies, (47) were engineers working in consultant firms and 7 were engineers working as project managers. The questionnaire was divided into two sections. Section one included the information about respondents. Section two included a list comprising twenty eight factors causing variation orders. In table 1 for factors were selected from the previous studies and highlighted as the most important factors were presented.

<table>
<thead>
<tr>
<th>Factor No</th>
<th>Factor Description</th>
<th>Factor No</th>
<th>Factor Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>Owner’s financial problems</td>
<td>Factor 15</td>
<td>The required labor skill are not available</td>
</tr>
<tr>
<td>Factor 2</td>
<td>Change of plan by Owner</td>
<td>Factor 16</td>
<td>The required equipment and tools are not available</td>
</tr>
<tr>
<td>Factor 3</td>
<td>Change of Scope by Owner</td>
<td>Factor 17</td>
<td>Material not meeting the specifications</td>
</tr>
<tr>
<td>Factor 4</td>
<td>Owner fails to maintain hold on the project schedule.</td>
<td>Factor 18</td>
<td>Contractor desire to improve his financial conditions</td>
</tr>
<tr>
<td>Factor 5</td>
<td>Owner fails to make decisions or review document at the right time.</td>
<td>Factor 19</td>
<td>construction delay by other contractors working on different contracts</td>
</tr>
<tr>
<td>Factor 6</td>
<td>Owner’s needs during the design stage are not well-defined or variably.</td>
<td>Factor 20</td>
<td>Acceleration of work Safety consideration / emergency field conditions</td>
</tr>
<tr>
<td>Factor 7</td>
<td>Change in design by engineer or consultant</td>
<td>Factor 21</td>
<td>Weather conditions</td>
</tr>
</tbody>
</table>
Statistical analysis of questionnaire

The data was presented in ordinal scale. This scale was transformed into an interval scale by assigning a weight to each interval. Considering intervals from (never) to (very often) as an interval scale from (one to five): (Very often = 5, Often = 4, Sometimes =3, Seldom = 2 and Never equals =1). Then weighted average for each factors was calculated according to the equations (1) & (2) Zaneldin (2006) [7]

\[
\text{Weighted Average} = (\frac{\text{Weight of each factor} \times \text{Number of respondents selecting it}}{\text{Total number of respondents}})
\]

\[
\text{Weight average, } \text{Weight average} = \frac{(5 \times x5) + (4 \times x4) + (3 \times x3) + (2 \times x2) + (1 \times x1)}{\text{(N)}}
\]

III. RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th>Case study no</th>
<th>Variation order no</th>
<th>Justification</th>
<th>% of executed variation order</th>
<th>Factors causing variation orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case no (1)</td>
<td>1</td>
<td>Change the design of electrical Wiring</td>
<td>100</td>
<td>Change in the use of the building</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>concrete of additional elevators</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Case no (2)</td>
<td>1</td>
<td>Addition Asphalt street in the compound by length 3 kilometer</td>
<td>100</td>
<td>Client’s changing needs, Design Changes, Instability of prices</td>
</tr>
<tr>
<td>Case no (3)</td>
<td>1</td>
<td>Change the Interface building to cladding works</td>
<td>100</td>
<td>Client’s changing needs, Design Changes, Error in design</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Increase building lighting</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Change the External Surface of Building from Tiles to Landscape</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Case no (4)</td>
<td>1</td>
<td>Change the foundation of building</td>
<td>100</td>
<td>Client’s changing needs, Design Changes</td>
</tr>
<tr>
<td>Case no (5)</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>
<td></td>
</tr>
<tr>
<td>Case no (6)</td>
<td>Convert the usability of the building</td>
<td>100</td>
<td>Client’s changing needs, Change use of building, Design Changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase the Capacity of electricity of building</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Addition the entrance of interface building. 2. Addition the drainage system</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case no (7)</td>
<td>Convert the usability of the building from Laboratories</td>
<td>100</td>
<td>Client’s changing needs, Change use of building, Design Changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase the Capacity of air condition of building</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Addition another small Building as Laboratory</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case no (8)</td>
<td>Add Additional Floors</td>
<td>100</td>
<td>Client’s changing needs, Design Changes</td>
<td></td>
</tr>
<tr>
<td>Case no (9)</td>
<td>Increase the height of suspended slab</td>
<td>100</td>
<td>Client’s changing needs, Design Changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change the type of intervals</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change the monitoring system</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case no (10)</td>
<td>Change the type of electrical connections</td>
<td>100</td>
<td>Change the Scope of Work, Design Changes</td>
<td></td>
</tr>
</tbody>
</table>

The results from table (2) showed that for projects executed during the years (2007-2017) at least a substantial (70%) 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) were the most influential. This result goes in line with the international experience.

**Questionnaire Results**

**General Information**

The configuration of the participant was as presented in fig (1) 5.4% of the respondents were working as project managers, 40.8% were working as contractors, 17.7% were owners and 36.2% were working as consultants.
Regarding to the work area that were involved in, 27.7% classify themselves as public sector org(s) while 72.3% were private sector (refer to fig 2).

When asked respondents to specify their specialization, 79.2% were civil engineering while 20.8% were architect engineering as shown in fig 3.

To evaluate the respondents experience, 12.3% admitted to be working in the field less than 5 years, 20.8% were working for (5 – 10) years, 32.3% for (10-15) years and 34.6% for more than 15 years. This confirms that the participants have been working for more than 15 years which implies a good experience to give reasonable consent. (refer to fig 4)
Fig 4. Number of experience years
To gauge the frequency of occurrence of VOs in building projects. VOs are witnessed in all executed projects, 20% said that happened less than 5 projects, while 14.6% said (5 – 10) projects, 36.9% said (10-15) projects and 28.5% said for more than 15 projects. This confirms the fact that about (2/3) of the respondents (65.4%) confirmed having at least 10 projects having VOs.(refer to fig 5)

Fig 5. Number of projects executed with witness VOs

Occurrence of factors causing variation orders
Owing to the fact that VOs could be caused by several factors with a variable impact level, respondents were asked to give their opinion ranking the occurrence of each of the highlighted 28 factors. The results presented in fig 6 showed that at least 46.15% of the respondents confirming that all 28 factors occur very often during project execution.

Fig 6. Occurrence of factors causing VOs
Figure 7. Occurrence of factors causing VOs (Consultants)

Upon checking the same result from the perspective of the different participants, about third (31.9%) of consultants confirmed that all 28 factors occur very often, as shown in fig 7.

Figure 8. Occurrence of factors causing VOs (Contracts)

Upon checking the same result from the perspective of the different participants, about (43.4%) of contractors confirmed that all 28 factors occur very often, as shown in fig 8.

Figure 9. Occurrence of factors causing VOs (Owners)
Upon checking the same result from the perspective of the different participants, about third (20.09\%) of owners confirmed that all 28 factors occur very often. as shown in fig 9

**Fig 10. Occurrence of factors causing VOs (Project Managers)**

Upon checking the same result from the perspective of the different participants, about third (28.57\%) of project managers confirmed that all 28 factors occur very often. as shown in fig 7

*Weighted average of factors causing VOS*

The results from figure(11) showed that weight average of factors causing VOs up 4.75 of Lack of stability of prices and the exchange rate change to 3.54 of Obstinate nature of owner and consultant.

**Fig 11. Weight average of factors causing VOs**

*Fig 12. Weight average of factors causing VOs (Consultants)*
The results from figure (12) showed that weight average of factors causing VOs up 4.89 of Lack of stability of prices and the exchange rate change to 3.11 of Obstinate nature of owner and consultant.

Fig13. Weight average of factors causing VOs (Contractors)
The results from figure (13) showed that weight average of factors causing VOs up 4.68 of Errors and omissions in design to 3.40 of Demolition and re-work.

Fig14. Weight average of factors causing VOs (Owners)
The results from figure (14) showed that weight average of factors causing VOs up 4.7 of Contractors financial difficulties, Contractor desire to improve his financial conditions and Lack of stability of prices and the exchange rate changed to 3.22 of Obstinate nature of owner and consultant.

Fig15. Weight average of factors causing VOs (Project Managers)
The results from figure (15) showed that weight average of factors causing VOs up 4.86 of Contractors financial difficulties to 3.29 of Owner fails to maintain hold on the project schedule.

**Ranking of factors causing VOs**

![Graph showing ranking of factors causing VOs](image)

**Fig 16. Ranking of factors causing VOs**

The results from figure (16) showed that the top ten factors causing VOs are: (1) Lack of stability of prices and the exchange rate change, (2) New government regulations, (3) Non availability of construction manual and procedure for construction project in Sudan, (4) Errors and omissions in design, two factors in the same ranking (5) Owner fails to make decisions or review document at the right time and Owner’s needs during the design stage are not well-defined or variably, (7) Owner’s financial problems, two factors in the same ranking (8) Contractors financial difficulties and The lack of coordination between consultant and contractors and subcontractors and (10) Non-use value engineering in design stage to find the best alternatives and providing cost.

![Graph showing ranking of factors causing VOs (Consultants)](image)

**Fig 17. Ranking of factors causing VOs (Consultants)**

According to the consultants views, the results from figure (17) showed that the top ten factors causing VOs are: (1) Lack of stability of prices and the exchange rate change, (2) New government regulations, (3) Non availability of construction manual and procedure for construction project in Sudan, (4) Owner’s needs during the design stage are not well-defined or variably, two factors in the same ranking (5) Change of Scope by Owner and The required labor skill are not available, (7) Owner’s financial problems, two factors in the same ranking (8) Owner fails to make decisions or review document at the right time and Non-use value engineering in design stage to find the best alternatives and providing cost and (10) Errors and omissions in design.
The results from figure(18) showed the contractors views which admit that the top ten factors causing VOs are:

1. Errors and omissions in design
2. Owner fails to make decisions or review document at the right time
3. Owner’s needs during the design stage are not well-defined or variably
4. New government regulations and Lack of stability of prices and the exchange rate change
5. Change of plan by Owner
6. Owner’s financial problems
7. Non availability of construction manual and procedure for construction project in Sudan
8. Change of Scope by Owner
9. Conflict between contract documents

According to the owners views, the results from figure(19) showed that the top ten factors causing VOs are:

1. Contractors financial difficulties
2. Contractor desire to improve his financial conditions
3. Lack of stability of prices and the exchange rate change
4. The lack of coordination between consultant and contractors and subcontractors
5. Construction delay by other contractors working on different contracts
6. Non availability of construction manual and procedure for construction project in Sudan
7. The required labor skill are not available
8. Material not meeting the specifications
9. New government regulations
10. The scope of work for the contractor is not well defined
The project managers also confirmed similar result from figure(20) showed that the top ten factors causing VOs are:

1. Contractors financial difficulties and New government regulations.
2. Owner’s financial problems and Lack of stability of prices and the exchange rate change.
3. Technology changes and Difference between the design and the actual construction on site.
4. Change of plan by Owner, Owner fails to make decisions or review document at the right time.
5. Owners needs during the design stage are not well-defined or variably.
6. Errors and omissions in design.
7. The lack of coordination between consultant and contractors and subcontractors.
8. Demolition and re-work.
9. Non-use value engineering in design stage.

IV. CONCLUSION

The results obtained from literature review and previous studies, the preliminary study (cases analysis) and the detailed survey were consistent confirming the fact that the selected 28 factors causing VOs are of great importance as they impact the project execution.

With the consent of all the parties involved in the project execution process of building projects in Khartoum state- Sudan, The most influential factors causing VOs were to be:
1. Lack of stability of prices and the exchange rate change.
2. New government regulations.
3. Non availability of construction manual and procedure for construction project in Sudan.
4. Errors and omissions in design.
5. Change of plan by Owner, Owner fails to make decisions or review document at the right time.
6. Owners needs during the design stage are not well-defined or variably.
7. Owner’s financial problems.
8. Contractors financial difficulties.
9. The lack of coordination between consultant and contractors and subcontractors.
10. Non-use value engineering in design stage.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES


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