IMPACT OF VARIATION ORDERS ON TIME & COST IN MEGA HYDROPOWER PROJECTS OF PAKISTAN

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ABSTRACT
The occurrence of Variation Orders (VOs) in construction industry is a regular trend all over the world. The Hydropower projects are no exception to such VOs. It is difficult to find a Hydropower project in Pakistan not experiencing VOs. The current research investigates the causes and impacts of VOs in Mega Hydropower projects. The present research has been carried out from the case studies of three (03) Mega Hydropower projects in Pakistan. Results from the case studies illustrate that the Error & Omissions in Design, Change in Scope and Change in Design were among the three leading contributing factors to VOs in Hydropower projects in Pakistan which resulted in time & cost overrun. Due to VOs time overrun is 20% and cost overrun is 31% with respect to original time and cost of the project. Based on this research, this study recommends measures to curb the causes and impacts of VOs in order to optimize the construction process in mega hydropower projects.

Keywords: Mega Hydropower projects, Variation Order (VO), Time overrun, Cost overrun, Pakistan.

INTRODUCTION
A VO is any change or modifications to the design, quality or scope of work which is subject to an agreement with respect to volume or nature of works carried out (O’Brien 1988). Construction Industry involves complex processes which are prone to changes, these changes are inevitable and it occurs during the construction. As a result of these changes, change orders are issued to modify the original scope or design (CII 1990).

VOs ultimately lead to delay in completion of projects (Arain et al. 2004). Delay in the projects would increase the cost of construction because of the price adjustment and fluctuations in prices of various components i.e labor, fuel, cement and miscellaneous materials. Cost overrun would further lead to serious problems in future upcoming project of Pakistan due to limited funds available in Pakistan and mostly in Pakistan hydropower projects are funded by World Bank and Asian Development Bank (ADB) on loan basis.

Whenever the project is delayed, it is difficult to agree upon the additional time and its cost associated with delay. Dispute and claim arises when both the parties (employer and contractor) do not agree on the extra time and cost. The results of this study would be beneficial for employer, contractor and even the
general public who can foresee the root cause of VOs in construction of hydropower projects of Pakistan as well as its effect.

To understand VOs, especially their causes and effects, the Chartered Building Institute of UK back in 1970s investigated that time delays and cost overrun increase as a result of variations to construction contracts explained by Goodacre and PE, Hunter. In 1990, the Construction Industry Institute (CII) of USA established two tasks teams on time and cost, the teams carried out a research study focused on root causes, the impact and magnitude of changes, and how these changes can be managed effectively (CII, 1990). In addition to the efforts by the above mentioned institutes, numerous research studies have been carried out on various construction projects as discussed below.

LITERATURE REVIEW

Changes and Variations are no matter the source undesirable but yet very common in all types of construction projects (O’Brien, 1998 & Frisk 1997). They are undesirable because of their negative effect on either the production flow or the product resulting in decreased cost, time and quality performance (González et al. 2010 & Lindhard 2014)

VOs are one of the main causes to changes and variation in construction (Al-Mamani et al. 2000). Therefore, VOs have a substantial effect on a projects cost and time performance (Ibbs 1998).

The many different parties involved in a construction project entail lots of possibility for VOs to arise. Thus, VOs can be caused by either the consultant, the employer, or the contractor (Hanna et al. 2002). Therefore, VOs are common and regarded as a normal part of a construction projects (Arian & Low Pheng 2005).

A degree of change should be expected as it is difficult for clients to visualize the end product they procure (Love, 2002). Variations should especially when renovating or upgrading a construction, Arian and Low (2005) found the average number of variations in upgrading projects was almost 21% more than in new projects.

Summed up, "the success of a construction project to a large extent is determined by the ability of the project team to manage the inevitable changes during the project" (Sun and Meng 2009). The project team need to make the necessary precautions to minimize both the number of VOs and their induced negative effect.

Previous research studies have been focusing on the causes of VOs. For instance, Alnuami et al., (2010) explored the causes of VOs in construction projects in Oman; they found the top three reasons of VOs to be related to: 1) additional work instructed by owner, 2) modifications by owners and 3) non-availability of manuals and specifications. N. Muhammad (2010) looked into the causes of VOs in construction projects in Malaysia and found that the top three reasons of VOs were: 1) change of plans by owner, 2) substitution of materials and 3) change in design by consultant. Additionally Ismail (2012) did, in a study in Iran, identify the top three reasons of VOs to be: 1) Change of plans, 2) Errors and omissions in design, 3) Differing site conditions. Finally Hanif et al. (2014), analyzed VOs in hydropower projects of Pakistan and found the top three reasons to be: 1) change in scope, 2) omissions in design and, 3) change in design.

Project performance depends upon a well-structured schedule of the work, if the work is carried out smoothly within the time limits and approved budget, then maximum project performance would be achieved. VOs induce project changes which have a negative effect on the project performance (A. Ismail et al. 2012). Variations adversely impact the performance of project in terms of cost, time delays, poor quality, productivity degradation, health and safety issues, and professional relations between the parties to the contract (Al-Morzoug, 2008 and Enshassi et al. 2011).

Many construction projects incur increased cost because of variation; however, all variations do not increase costs. Deletion does in most cases reduce the overall cost of the project, while additions always increase costs (Thomas et al. 2002).

Following direct costs are associated with VOs (Ssegawa et al. 2002):

- Price adjustment / escalation;
- Head office overheads;
- Consumable materials;
- Standby time of equipment;
- Time related costs associated with equipment & manpower; and
- Material charges associated with affected tasks.
The employer always requires that their project is completed within the prescribed time, otherwise the costs associated with time are huge and the employer cannot bear the time-related costs. The contractor desires to complete the project within time or before time. If the project is completed before time, the contractor is, as a standard practice, awarded with bonus and if project is delayed due to contractor’s risk event, then the contractor is, as a standard practice, penalized with a contract specific but often unbearable amount of liquidated damages. VOs are one of the key reasons to project time and cost overruns (Bower 2000).

A number of studies have also been exploring the effects of VOs in construction. Alnuami et al. (2010) found in a study in Oman that the top three effects of VOs were: 1) delays, 2) claims and disputes and 3) cost overruns. Moreover, Ijaloa and Iyagba (2012) studied VOs in Nigeria and found the top three effects of VOs to be: 1) claims and disputes, 2) delays and, 3) cost overruns. Huge effect of VOs on delay is supported by Haseeb et al. (2011) who in a research study, carried out in Pakistan, found VOs as the most frequent reason of delays. Lindhard and Wandahl (2014) who in a study in Denmark, identified changes in work plans as the second most important reason of delay.

The scientific contribution

The causes of variations and their effects/impacts have been explained by numerous authors and papers have been published in all the recognized journals from 1990 to date. Research work on VOs have been carried out in many countries such as USA, UK, South Africa, Iran, Malaysia, Oman, Jordan, Nigeria and Taiwan particularly on multi story buildings, institutional buildings and highway projects. However, the earlier researchers have not emphasized the VOs particularly in the construction of hydropower projects. To the best of our knowledge, no research work has been carried out in Pakistan to identify causes of variations in hydropower projects. The present research thus fills this gap in existing body of knowledge by reviewing the existing literature on construction projects and investigates causes and impacts of VOs especially in hydropower projects in Pakistan. Further, recommendations are proffered in order to minimize the effect of VOs in such projects.

Scope of study

The study is limited to construction of hydropower projects of Pakistan (projects costing over 5000 million rupees) executed by Federal Government of Pakistan in the last 10 years. These projects are constructed by construction contractors of category C-A as classified by Pakistan Engineering Council. Grade C-A contractors have no limit vis-à-vis construction cost of projects.

Pakistani environment

It is imperative to understand the climatic conditions of the Pakistani environment before carrying out a research to identify factors causing VOs in hydropower projects. Majority of the hydropower projects of Pakistan are located in northern areas of Pakistan. Northern areas of Pakistan have long cold weather and snowfall occurs for almost three months during the winter season. The temperature in the winter season falls below -10°C in certain areas, hence it is hard to work on site in these extreme conditions. As a result, most contractors prefer to work in the summer season.

These extreme climatic conditions pose various problems to the contractors such as delivery of equipment in high altitudes and unavailability of skilled manpower, etc. The extreme weather disrupts the progress of work resulting in delaying projects, cost and time overruns. To cater for the problems posed by extreme weather and limited time available for work, a number of variations orders are issued which adversely impact the progress of work. We can therefore argue that it is essential to know about the causes of variations and their impacts in order to control these variations effectively.

Hanif et al. (2014) identified an overall ranking of causes to VO in Pakistan, the ranking are shown in Table 1 by the relative importance index.

Placement of Table 1

RESEARCH METHOD

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The presented research is based on the findings of Hanif, H., et al. (2014). Hanif et al. (2014) made a literature review where the various causes to VOs are identified. In total 38 VOs were identified. By applying a questionnaire, employers, consultants, and contractors from the different Hydropower Projects in Pakistan ranked the VOs in relation to importance. To verify the results Hanif, H., et al. (2014) tested the findings in a reliability test (Cronbach alpha). All scales were found to be in acceptable range, with alpha value of above 0.70 as defined by Nunnally, J., (1978).

With outset in Hanif et al. (2014), this research is carried out to make an in-depth analysis of causes and impacts of VOs on time and cost of selected hydropower projects in Pakistan. To increase the depth of analysis a case study approach is selected. By comparing the findings to the findings of Hanif et al. (2014), a number of recommendations are reached. The research process is shown in Figure 0.

CASE STUDY FINDINGS

This section presents a summary of VOs analysis based case studies of three selected mega hydropower projects in Pakistan, with different capacities, which were executed by the Government of Pakistan. Unit/Item rate or traditional method was used as delivery system for all of the projects. In this method, the client hires a consultant for the design and then a contractor is selected by bidding. Table 2 shows salient features of the mega hydropower projects of all the case studies.

Case Study No 1: Hydropower Project, 1450 MW

The case study no 1 was related to Ghazi Barotha Hydropower Project. It is located on the Indus River, 7 km downstream of Tarbela Dam, in the Khyber Pakhtoonkhowa province. The project was completed during the fiscal year 2003-2004. This is a major run of the river and environmentally sustainable project designed to meet the acute shortage of peak power demand in the country. The project is based on utilization of the hydraulic head available between the tailrace at Tarbela Dam and the confluence of the Indus and Haro Rivers for power generation. In this reach, Indus River drops by 76 m in a distance of 63 km and generates 1450 MW electricity and 6.6 billion unit annually. The start
and end date of the projects were Dec, 1995 and Aug, 2003 respectively. The four VOs of this case study were selected on basis of time and cost. 46 VOs of the project delayed the project by 200 days and the below mentioned 4 VOs had a time impact of 90 days, which means there was an impact of 45% delay due to these 4 VOs. This time impact was the main reason to select this 4 important VOs from the study. The pictorial view of project is shown in Figure 1:

**Placement of Figure 1**

During the construction phase of this project, a number of VOs were issued by the consultants. The description of the four out of 46 major VOs are as follows:

**VO No 1, Change in Design:** It was issued due to flattening of cut slopes above service road level. In tender, drawings slopes were very steep, it was changed to mild slope during design review to safeguard service road against falling material. As a result of this VO, additional cost to the project was 0.77 Million USD and project was delayed by 20 days.

**VO No 2, Discrepancies between Contract Documents:** This was assigned owing to increase in cost of bill of quantities (BOQ) item i.e. admixture. At the time of tender, the cost of admixture was low. However, during the construction, cost of admixture increased abnormally due to high price inflation, this resulted in an additional cost of 0.49 Million USD and project was delayed by 15 work days.

**VO No 3, Change of Scope:** It was initiated as a result of an additional layer of reinforcing steel in lining concrete at different locations of structures. Power channel of Ghazi Barotha hydropower project was 52 km long. In order to strengthen the lining of power channel concrete, additional layer of reinforcing steel was placed. This variation resulted in additional cost of 2.18 Million USD and project was delayed by 30 work days.

**VO No 4, Error & Omission in Design:** Due to this variation, design of railway bridge was changed. Height of the railway bridge over the power channel, was increased by 2 feet compared to its original height. This resulted in an additional cost of 3.64 Million USD and the project was delayed by 35 work days. Due to this variation, dispute also raised between the employer and contractor.

**Case Study No 2: Hydropower Project, 1000 MW**

The case study No 2 was related to dam raising of Mangla hydropower project. Which is located in the vicinity of Mangla district Mirpur Azad Kashmir. The important feature of this project was raising the height of dam 30 feet from its existing height. Its storage capacity was enhanced by 2.88 MAF and would generate additional power of 120 MW (644 Gwh/Annum). The start and end date of the projects were Apr, 2004 and Dec, 2009 respectively. The four VOs of this case study were selected on basis of time and cost. 43 VOs of the project delayed the project by 282 days and the below mentioned 4 VOs had a time impact of 180 days, which means there was an impact of 60% delay due to these 4 VOs. This time impact was the main reason to select this 4 important VOs from the study. The pictorial view of the project is shown in Figure 2:

**Placement of Figure 2**

The description of four out of 43 major VOs are as follows:

**VO No 1, Change of Scope:** It was issued due to construction of additional stairs to instrument locations and instrument houses at main dam. To ensure safe access to the extended and new instruments the additional staircases had to be placed at locations other than the six staircases already shown on the tender drawings. This variation resulted in an additional cost of 0.35 Million USD and project was delayed by 40 work days.

**VO No 2, Change of Scope:** This VO was issued due to installation of new guard rail at crest of dam. Guard rail at raised crest was required for the security of traffic to avoid any mishap. It was provided in construction drawing at tender stage, however relevant pay item was not provided in the respective BOQ. The preparation of VO was necessitated to allow payment for the work item in

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accordance with one of the clauses of the contract. This variation resulted in an additional cost of 0.34 Million USD and there was time impact of 20 work days owing to this VO.

**VO No 3, Change in Design:** This VO is related to construction of concrete toe drains at main dam and intake embankment. Concrete drains consisting of varying sizes were constructed at main dam and intake embankment. At tender stage, cross section of a typical drain was given in the drawings. Thus the engineer had to decide about the provision of toe drains during the course of construction of the main dam and intake embankment. At different locations along the extended toe of the dam, different toe drains were constructed, which constituted a variation and resulted in an additional cost of 0.23 Million USD and project was delayed by 1 working month due to this VO.

**VO No 4, Error & Omission in Design:** It was issued due to underwater placing of three feet thick protective layer of riprap on toe weight upstream of intake embankment. Intake toe weight was constructed from sandy gravel. This material was borrowed from the Jhelum river bed and composed of rounded to sub-rounded particles of gravel and cobbles. Intake toe weight has a slope facing the tunnels intake. In order to protect this slope, it was required to place a three feet thick protective layer of riprap acting as stud against rolling of the rounded riprap particles. In view of the foregoing, a three feet thick layer of riprap (4 inch to 12 inch sizes) was incorporated in the works. Placing of three feet thick protective layer of riprap on toe weight constituted additional work which was carried out through VO. This VO resulted in an additional cost of 0.72 Million USD and the project was delayed by 70 work days.

**Case Study No 3: Hydropower Project, 969 MW**

The third case study is related to Neelum Jhelum Hydropower Project (NJHEP) located in the vicinity of Muzaffarabad (AJ&K). It envisages the diversion of Neelum river water through a tunnel out falling into Jhelum River. The intake of Neelum Jhelum is at Nauseri 41 km East of Muzaffarabad. The power house is being constructed at Chatter Kalas, 22 Km South of Muzaffarabad. After passing through the turbines the water will be released into Jhelum River about 4 Km South of Chatter Kalas. Neelum Jhelum Hydropower Project has installed capacity of 969 MW. The start and end date of the projects are Jan, 2008 and Dec, 2016 respectively. The four VOs of this case study were selected on basis of time and cost. 38 VOs of the project delayed the project by 730 days and the below mentioned 4 VOs had a time impact of 570 days, which means there was an impact of 75% delay due to these 4 VOs. This time impact was the main reason to select these 4 important VOs from the study. The project will produce 5.15 Billion units of electricity annually (Figure 3).

**Placement of Figure 3**

During the construction phase of the Neelum Jhelum project, number of VOs have been issued by the consultants. 38 VOs were issued up to Oct, 2013. The description of 4 major VOs are as follows:

**VO No 1, Change in Design:** This VO was based on redesign of diversion dam, intake and sedimentation basin. Due to high seismic risks, environmental demands and problems related to land acquisition, it became necessary to make several changes in the existing design leading to this VO. This VO incurred an additional cost of 124 Million USD and project was delayed by 150 work days.

**VO No 2, Change of Scope:** This VO was issued due to increase in hydraulic capacity of the transfer tunnels as per the requirements for the turbines. Concrete lining was introduced instead of shotcrete lining. The diameter of the tunnel was required to be enlarged to overcome the higher friction of shotcrete lining. As a result of this VO, additional cost to the project was 315 Million USD and project was delayed by 180 work days.

**VO No 3, Error and Omission in Design:** It was initiated as a result of concrete lining of headrace tunnel. Full face tunnel lining was selected in order to reduce hydraulic losses and reduce maintenance
and repair costs associated with an unlined tunnel. As a consequence of this variation, it resulted in an additional cost of 328 Million USD and project fell behind the schedule by 190 work days.

**VO No 4, Unavailability of Equipment:** This VO was assigned due to unavailability of equipment i.e. tunnel boring machine. For saving the time on tunnel excavation, it was decided by government to purchase this machine. It resulted in additional cost of 480 Million USD to client and almost 365 working days were saved due to the employment of this machine.

**RESULTS AND DISCUSSION**

In all the aforementioned case studies, VO had an impact on time and cost of the project. Table 3 shows the accumulated impact of time and cost overrun of all VOs of each project.

**Placement of table 3**

In all three case studies only a few key VOs were found to cause the majority of the total impact. In the first case study four out of 46 VOs were considered as critical, since these four VOs (change in design, discrepancies between documents, change of scope and error & omissions in design) caused the time overrun of 100 days and the cost overrun was found to be 7 Million USD which correspond to respectively 50% and 56% of the total time and cost overrun of this project. In Case Study No 2, four out of 43 VOs were identified as critical, because these four VOs (change of scope, change in design and error & omissions in design), lead to the time overrun of 180 days and the cost overrun of 1.6 Million USD. Moreover, the four VOs comprise respectively 63% and 40% of the total cost and time overrun of this project. In the third case study, four out of 38 VOs were considered as critical. These four VOs (change in design, change of scope, error & omissions in design & unavailability of equipment), caused a time overrun of 520 days and cost overrun of 1247 Million USD corresponding to 71% and 94% of the total impact on cost and time, respectively.

Evaluating the causes of the VOs considered in the case studies of the three hydropower projects and comparing their impacts, the most significant causes of VOs were identified. Table 4 presents the impact on time due to critical VOs, while their cost impact is presented in Table 5.

**Placement of table 4**

**Placement of table 5**

Both Table 4 and 5 contain most significant five causes with the largest impact on either time or cost of the project in each case study. In all the case studies following three significant causes of VOs were found common: error & omission in design, change of scope, and change in design.

**COMPARISON OF RESULTS:**

The presented case study research was conducted with the outset in Hanif et al. (2014). A quick comparison of top three VOs between the case study and the findings of Hanif et al. 2014) is showed in Table 6. In both studies emission in desing, change of scope and change in design are found in the top three, thus the findings of the study match.

**Placement of table 6**

Moreover, the identified top causes to VO are similar to the findings from previous VO studies. In Table 7 is the top five causes of VOs from research studies conducted in Oman, Malaysia, Iran, and Pakistan shown. Change of scope, omissions in design, and changes in design are found as top causes in all studies (with varying wording). Thus, the findings supports and strengthen the findings of previous research.
Other important causes are unavailability of equipment, change of project schedule, substitution of materials, Non-availability of manuals and procedures, Nonavailability of license to maintain quality of consultancy service, and weather conditions.

Placement of table 7

CONCLUSIONS AND RECOMMENDATIONS

This paper presented a detailed case study based analysis of impacts of VOs on the time and cost of hydropower projects in Pakistan. Following important conclusions/findings can be drawn from this research:

VOs occurred in all the three mega hydropower projects followed, the frequency varied between 38 and 46 with an average frequency at 42 registered occurrences.

1. The most significant factors with respect to time and cost impacts caused by VOs in construction of hydropower projects of Pakistan were found to be (1) error and omissions in design, (2) change of scope, (3) change in design, (4) unavailability of equipment; and (5) discrepancies between contract documents.

2. Case studies, capturing the actual time and cost impacts, revealed that only a few VOs comprise the majority of the total impact on cost and time of the project.

3. In all the the three case studies VOs impact on time varied between 12.8 and 25.7% corresponding to an average time overrun of 20% w.r.t all the VOs occurred on the project.

4. In relation to the cost impact, the VOs had an impact between 4.94 and 89.13% corresponding to an average cost overrun on 31% w.r.t all the VOs occurred on the project.

5. The average impact of the three critical causes were calculated: error & omissions in design, time overrun: 4.9%, and cost overrun: 7.7%; change of scope by employer, time overrun: 4.4%, and cost overrun: 7.0%; change in design, time overrun: 3.0%, and cost overrun: 2.0%.

Based on the findings of this research study the key recommendations to reduce the frequency and impact of VOs in future construction projects are as follows:

1. The most critical cause i.e errors and omissions in design can be reduced by engaging proper design consultants who have participated in the completion of similar construction projects. Employment of a permanent and well settled team member can definitely lead towards a successful project completion and create an environment of mutual understanding among the key project stakeholders.

2. With regard to the second most critical cause of VOs, i.e., change of scope, it is recommended that proper feasibility, detailed design of the project and modeling techniques be carried out before finalization of the scope of work. The working personal should be engaged who have previously worked on similar hydropower projects and lessons learnt should be adopted in order to reduce scope creep.

3. Keeping the remaining three critical causes of VOs in mind, it is recommended that the consultants should not transfer their well-settled design team members from their respective design offices in order to avoid hampering project design activities and client must ensure, at the stage of bidding, that the contractor has all the equipment available that is needed for the construction of the project. Proper review of method statement, resource loaded schedule which clearly defines the role and responsibilities of labor and machinery, equipment and anticipated progress curves of project can prevent from the highlighted causes of VOs.

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Moreover, a proper constructability analysis by a panel of experts before the start of the project would ensure reduction in discrepancies in the contract documents.

REFERENCES


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Figure 0: Research Methodology Flow chart
Figure 1: Ghazi Barotha Hydropower Project (1450MW)
Figure 2: Mangla Raising Hydropower Project (1000MW)
Figure 3: Neelum Jehlum Hydropower Project (969 MW)

Table 1. Factors causing Variation orders (Hanif, et al., 2014)

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<td>Scope Changes by Employer</td>
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<td>Inadequate shop drawing details</td>
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<td>Change in Specification by owner</td>
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<td>Insufficient scope of work for contractor</td>
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<td>Lack of consultant’s knowledge of available materials</td>
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<td>Lack of contractor’s involvement in design</td>
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## Table 2. Salient Features of three Case Studies

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<th>Case III</th>
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<td><strong>Contract Cost (Million USD)</strong></td>
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Table 3. Time & Cost overrun due to VOs for all Case Studies

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<th>Case II</th>
<th>Case III</th>
<th>Avg of III Case Studies</th>
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<td>Total No of VOs</td>
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<td>Cost Impact (%)</td>
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Table 4. Time Overrun (%) due to Critical VOs for all Case Studies

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<th>Case II</th>
<th>Case III</th>
<th>Avg of III Case Studies</th>
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<td>5.94</td>
<td>6.71</td>
<td>4.9</td>
</tr>
<tr>
<td>Change of Scope</td>
<td>1.94</td>
<td>5.09</td>
<td>6.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Change in Design</td>
<td>1.29</td>
<td>2.54</td>
<td>5.30</td>
<td>3.0</td>
</tr>
<tr>
<td>Unavailability of Equipment</td>
<td>--</td>
<td>--</td>
<td>(12.8)**</td>
<td>--</td>
</tr>
<tr>
<td>Discrepancies between Contract Documents</td>
<td>0.96</td>
<td>--</td>
<td>--</td>
<td>*</td>
</tr>
</tbody>
</table>

* VOs related to unavailability of equipment or to discrepancies between contract documents did only appear once, thus no average values are calculated.

** The VO causing the unavailability of equipment was introduced to reduce time, thus it had a negative impact on time overrun.
Table 5. Cost Overrun (%) due to Critical VOs for all Case Studies

<table>
<thead>
<tr>
<th>VOs</th>
<th>Case I</th>
<th>Case II</th>
<th>Case III</th>
<th>Avg of III Case Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error &amp; Omission in Design</td>
<td>1.45</td>
<td>0.20</td>
<td>21.65</td>
<td>7.7</td>
</tr>
<tr>
<td>Change of Scope</td>
<td>0.31</td>
<td>0.10</td>
<td>20.85</td>
<td>7.0</td>
</tr>
<tr>
<td>Change in Design</td>
<td>0.87</td>
<td>0.06</td>
<td>5.26</td>
<td>2.0</td>
</tr>
<tr>
<td>Unavailability of Equipment</td>
<td>--</td>
<td>--</td>
<td>31.5</td>
<td>*</td>
</tr>
<tr>
<td>Discrepancies between Contract Documents</td>
<td>0.18</td>
<td>--</td>
<td>--</td>
<td>*</td>
</tr>
</tbody>
</table>

* VOs related to unavailability of equipment or to discrepancies between contract documents did only appear once, thus no average values are calculated.
Table 6: Comparison of Causes of Variation Orders Revealed by Survey based approach and Case Study approach

<table>
<thead>
<tr>
<th>Rank</th>
<th>Causes (Pakistan) (Hanif.H. et al. 2014) Survey based Approach</th>
<th>Present Study Case Study Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Change of scope</td>
<td>Emission in Design</td>
</tr>
<tr>
<td>2</td>
<td>Omissions in design</td>
<td>Change of scope</td>
</tr>
<tr>
<td>3</td>
<td>Change in design</td>
<td>Change in design</td>
</tr>
</tbody>
</table>
Table 7: Comparison of Causes of Variation Orders Revealed by Different Studies

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Change of scope</td>
<td>Change of Plan by owner</td>
<td>Change of Plan</td>
<td>Owners instruct additional work</td>
</tr>
<tr>
<td>2</td>
<td>Omissions in design</td>
<td>Substitution of materials</td>
<td>Errors and omissions in design</td>
<td>Owners instruct changes in design</td>
</tr>
<tr>
<td>3</td>
<td>Change in design</td>
<td>Change in design by consultant</td>
<td>Differing Site Conditions</td>
<td>Non-availability of manuals and procedures</td>
</tr>
<tr>
<td>4</td>
<td>Change of Project Schedule</td>
<td>Errors and omissions in design</td>
<td>Weather Conditions</td>
<td>Non-availability of license to maintain quality of consultancy service</td>
</tr>
<tr>
<td>5</td>
<td>Conflicts between Contract Documents</td>
<td>The scope of work for the contractor</td>
<td>Employer’s Financial Problems</td>
<td>Poor communication between government and owner.</td>
</tr>
</tbody>
</table>