# Assessing the Occurrence and Significance of VO Factors in affecting Quality of Construction Projects

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**Abstract:** Construction projects are often facing a severe problem of variations. The variations are caused by numerous factors. These variations have significant effect on the project performance especially the quality of the works. This paper has investigated the probability of occurrence of various factors of variations and the relative responsible party causing this occurrence of factors. Also, level of significance for each factor in affecting the quality of the projects is assessed. Data collection for this study involved survey using questionnaire with client, consultant and contractors. Statistical analysis of all 101 completed questionnaire received against 200 distributed forms was carried out with SPSS software package and average index method. Finding of the study highlighted that the top 5 factors which are most commonly occurred in construction projects are unavailability of equipments, poor workmanship, design complexity, change of schedule and impediment to prompt decision making process. Consultants are found as responsible for most of the factors i.e. 12 factors out of 18 investigated factors. Poor workmanship, changes in specification, financial difficulties, inadequate working drawing details and change in design are rated as the top 5 significant factors in affecting quality of the projects. It is recommended that changes in specification and design be minimized; effective financial management be adopted to reduce variations and improve the quality of the projects.

[Memon AH, Rahman IA, Memon AH. **Assessing the Occurrence and Significance of VO Factors in affecting Quality of Construction Projects**. *Life Sci J* 2014; 11(7):247-253]. (ISSN:1097-8135). http://www.lifesciencesite.com. 30

**Keywords:** Variation order, factors of variations, Quality performance

## 1. Introduction

Variations in construction industry have become a common practice where almost every project is suffering (Ssegawa et al. 2002). A Variation is a deviation from original work scope (Ibb et. al. 2001). In the contract documents, the term variation is used to refer the required changes carried out with agreement of the designer, contract administrator or the client. In standard forms of contract, mostly a clause of variation is provided which allows client or his representative to issue an instruction for variation in the works mentioned in the original contract. This clause may comprise of a method to estimate the financial effect of the variation and also revised the completion date of the project (Nachatar et al. 2010). All the variations occurred in a project are regularized through issuance of variation order. A variation order is a written instruction by consultant/client to the contractor highlighting the modification required in the project (Oladapo 2007). It is a formal document issued for amending the original contractual agreement and is considered as the part of the contract (Halwatura and Ranasinghe, 2013). Variations in any project occur due to various reasons such as extra work caused by subsurface conditions, errors in contract documents, additional quantities of works or materials, reduction of work, or lack of proper communication between the parties (Keane et al. 2010). These variations exert various negative effects to the project such as reducing labour productivity (Thomas and Napolitan 1995, Hanna and Gunduz 2004), overrun of time and cost (Tse and Love, 2003), material waste (Motele 2003) and poor project quality (Smallwood 2000). Variations can affect project completion time and may cause accelerated construction process affecting the quality (Keane et. al., 2010). Fisk 1997 and CII 1995 also reported that variations have severe effect on project quality. Hence, this study is focusing on studying various factors of variations occurring during the execution of the project together with the significance level of each factor in affecting project quality. Studies show that all the parties involved in any project are the responsible for variations (Ssegawa et al. 2002) and hence this study has also identified the responsible party for each of the factor. This will be very helpful in formulating an efficient strategy to control variation order and improving project quality.

## 2. Related Works

### 2.1. Project Quality

Achieving the quality is one of the basic requirements of the project owners. Quality is intangible parameter which cannot be measured directly. Various researchers have defined quality in different way. For example: Burati et. al (1992)

defined quality as the conformance to established requirements of the client. From the perspective of construction industry, quality is referred as the meeting of legal, aesthetic and functional requirements of a project. If the requirements are satisfactory and accepted by the owner/user, the product is considered as quality product. Quality of a project is very important component which adds "value for money" (Arditi and Gunaydin, 1997) where quality of a project can be categorized as:

- Meeting the requirements of owner as to functional adequacy; completion on time and within budget; lifecycle costs; operation and maintenance.
- Meeting the requirements of the design professional as to provision of well-defined scope of work; budget to assemble and use a qualified, trained and experienced staff; budget to obtain adequate field information prior to design; provisions for timely decisions by owner and design professional; and contract to perform necessary work at a fair fee with adequate time allowance.
- Meeting the requirements of the constructor as to provision of contract plans, specifications, and other documents prepared in sufficient detail to permit the constructor to prepare priced proposal or competitive bid; timely decisions by the owner and design professional on authorization and processing of change orders; fair and timely interpretation of contract requirements from field design and inspection staff; and contract for performance of work on a reasonable schedule which permits a reasonable profit.
- Meeting the requirements of regulatory agencies (the public) as to public safety and health; environmental considerations; protection of public property including utilities; and conformance with applicable laws, regulations, codes and policies.

**2.2. Variation and VO Factors**

Variation is an unwanted act which is unavoidable in construction project. Almost every construction project experiences variations; however, the nature and frequency of variations vary from one project to another depending on various factors. (Arain and Pheng 2006). These variations have several negative effects on construction projects. Major effects of variations in a construction are:

**Delay:** Progress of activities is obstructed if the variations are occurred. These affect the planned completion time of activities. Consequently, the completion of whole project is delayed (CII, 1995, Ibbs, 1997). As an example, in Hong Kong 50% of the projects investigated by Kumaraswamy et. al. (1998) were delayed due to variations.

**Cost Overrun**: Overrun of cost in construction projects is a common issue (Rahman et. al. 2013, Memon and Rahman 2014) and one of major reasons for this is occurrence of variations (CII, 1990). If the variations are occurred in any project, they cause modification in design and execution with a significant amount of demolition or rework of any several project components which results in cost overrun (Clough and Sears, 1994).

**Rework:** If the variations are occurred in any project during the execution phase, they can result in significant amount of demolition of constructed components resulting rework (Clough and Sears, 1994, CII, 1994).

**Logistics delays:** Logistic delay is a common effect of variations (Hester et. al. 1991). It happens because, often due to variation, for project completion the manager requires extra quantity of several materials (Fisk, 1997).

Beside these, variations have very significant effect on the project quality (Fisk, 1997). CII (1995) reported that the quality of work is frequently affected by variations because contractors have to compensate for the losses by cutting corners. Hence, it is very important to identify and control variations in a project. For this, the first step is to identify the factors which cause the variations and affect the quality. Through reviewing the literature, a total of 18 common factors were identified and used for investigation in this study as shown in table 1

Table 1. Factors of Variation Orders

| Factors | Source |
|---|---|
| Change in scope of the project | CII (1990), Arain et al (2004) |
| Change in Schedule | Fisk (1997), O'Brien (1998) |
| Owner's financial problems | Sanvido et al (1992), O'Brien (1998) |
| Impediment to prompt decision-making process | Sanvido et al (1992), Gray and Hughes (2001) |
| Obstinate nature of owner | Wang (2000), Arain et al (2004) |
| Change in specifications by the owner | O'Brien (1998), Arain et al (2004) |
| Changes in Design | Fisk (1997), Arain et al (2004) |
| Design complexity | Fisk (1997), Arain et al (2004) |
| Inadequate working drawing details | O'Brien (1998), Arain et al (2004) |
| Inadequate design | CII (1990), Fisk (1997) |
| Conflicts among contract documents | CII (1990) |
| Change in specifications by the consultant | O'Brien (1998) |

Table 1 (Continue). Factors of Variation Orders

| Factors | Source |
|---|---|
| Unavailability of equipments | O'Brien (1998) |
| Poor workmanship | Fisk (1997), O'Brien (1998) |
| Lack of strategic planning | Clough and Sears (1994), O'Brien (1998), Arain et al (2004) |
| Contractor's financial difficulties | Thomas and Napolitan ( 1995) |
| Poor procurement process | Fisk (1997), Arain et al (2004) |
| Shortage of Skilled Manpower | Arain et al (2004) |

## 3. Data Collection and Analysis

Data collection involved survey with a questionnaire. Form of questionnaire consisted of 18 common factors of variation orders identified from previous similar research works. It aimed to investigate the probability of occurrence for each VO factor in construction industry using 5 point liker scale as 1 for never, 2 for rarely, 3 for some times, 4 for often and 5 for very often. Further, responsible party of each factor was determined with 3 point scale as 1 for client, 2 for consultant and 3 for contractor. Besides these, the significance level of each factor in affecting project quality was investigated with 5 point likert scale as 1 for not significant, 2 for slightly significant, 3 for moderately significant, 4 for very significant and 5 for extremely significant. It involved client, consultant and contractor organizations for participation to get relevant feedback. Data analysis was carried out with statistical approach of mean and frequency analysis using software package SPPS; and Average Index (AI) method with following equation:

$$AI = \frac{\sum X_1 + X_2 + X_3 + X_4 + X_5}{N}$$

For probability of occurrence, the used scale of measurement was:

$X_1$= Number of respondents for very often
$X_2$= Number of respondents for often
$X_3$= Number of respondents for some times
$X_4$= Number of respondents for rarely
$X_5$= Number of respondents for never
N= Number of respondents

While, assessing the significance level of the factors, scale was modified as;

$X_1$= Number of respondents for Not Significant
$X_2$= Number of respondents for Slightly Significant
$X_3$= Number of respondents for Moderately Significant
$X_4$= Number of respondents for Very Significant
$X_5$= Number of respondents for Extremely Significant
N= Number of respondents

## 4. Results and Discussion

This section explains the results obtained by analyzing the survey data. For the purpose of survey, 200 forms of questionnaire were distributed and only 101 completed forms were received back. Among the respondents, 51 participants are representing private firms, 47 participants are related with government sector and only 3 participants are from joint venture organizations. Most of the respondents have experience of handling large construction projects i.e. project with contract amount of more than 5 Malaysia Ringgits (Memon and Rahman, 2013b). Majority of respondents have attained bachelor degree in civil engineering with an average of experience of 8 years, which showed that the participants are capable for giving reliable feedback on survey. The analysis of the questionnaire is presented and discussed in following sections.

### 4.1. Variation and VO Factors

Occurrence level of the factors was ranked according to AI value. The results of AI and rank based on overall, client, consultant and contractor group of respondents is presented in table 2. From table 2, it be seen that, the unavailability of equipment is the most common factor which is often occurred in construction projects and is placed at 1st rank by the respondents. This might happen in construction projects because of inability of contractors for handling construction work load. Often, the contractors have limited number of equipments which they swipe from one project to other. It causes hindrance in work especially if any particular equipment is required in more than one project simultaneously. Poor workmanship is 2nd common factor occurring in construction projects resulting in variations. Fisk (1997) and O'Brien (1998) highlighted that poor workmanship can cause reworking of activities. This may waste material and time. Design complexity is placed art 3rd rank by the respondents. Design plays very important role in smooth execution of activities in any project. If design is simple and clear, it is very helpful for labour to understand and execute the work. Complex design can cause misunderstanding and misinterpretation which lead to deviations and need special skill to perform the work (Arain et al. 2004). Change of schedule is 4th major factor which is often occurred in construction projects. Its occurrence affects whole plan of work and resource allocation which can result in time and material loss.

Consequently, variations in contract conditions take place. Impediment to prompt decision making process is ranked as 5th common factor of variation occurring in construction projects.

Table 2. Ranking of Occurrence of VO factors

| No | The causes of variation order | Overall | |
|---|---|---|---|
| | | AI | Rank |
| 1 | Unavailability of equipments | 3.24 | 1 |
| 2 | Poor workmanship | 3.14 | 2 |
| 3 | Design complexity | 3.08 | 3 |
| 4 | Change in Schedule | 3.01 | 4 |
| 5 | Impediment to prompt decision-making process | 3.01 | 5 |
| 6 | Changes in Design | 2.99 | 6 |
| 7 | Obstinate nature of owner | 2.98 | 7 |
| 8 | Inadequate design | 2.98 | 8 |
| 9 | Lack of strategic planning | 2.95 | 9 |
| 10 | Inadequate working drawing details | 2.94 | 10 |
| 11 | Poor procurement process | 2.94 | 11 |
| 12 | Contractor's financial difficulties | 2.89 | 12 |
| 13 | Shortage of Skilled Manpower | 2.87 | 13 |
| 14 | Conflicts among contract documents | 2.86 | 14 |
| 15 | Change in specifications by the owner | 2.85 | 15 |
| 16 | Change in scope of the project | 2.82 | 16 |
| 17 | Owner's financial problems | 2.77 | 17 |
| 18 | Change in specifications by the consultant | 2.4 | 18 |

**4.2. Responsible Party for causing VO factors**

Beside, identifying the causes and effects of VO, this study also attempted to identify the responsible party that causes VO factors. Three main parties that had been identified to hold these responsibilities are client, consultant and contractor. The result from the questionnaire survey indicated through the frequency responses to identify the responsible party is as in table 3.

Table 3. Responsible Party of Occurrence for VO Factors

| No | The responsibility party for causes | Overall | | Client (client) | | Consultant (cos) | | Contractor (con) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Party | Mean | Party | Mean | Party | Mean | Party |
| 1 | Change in scope of the project | 2 | cos | 2 | cos | 1 | client | 2 | cos |
| 2 | Change in Schedule | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 3 | Owner's financial problems | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 4 | Impediment to prompt decision-making process | 2 | cos | 2 | cos | 1 | client | 2 | cos |
| 5 | Obstinate nature of owner | 1 | client | 1 | client | 1 | client | 1 | client |
| 6 | Change in specifications by the owner | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 7 | Changes in Design | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 8 | Design complexity | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 9 | Inadequate working drawing details | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 10 | Inadequate design | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 11 | Conflicts among contract documents | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 12 | Change in specifications by the consultant | 2 | cos | 2 | cos | 2 | cos | 2 | cos |
| 13 | Unavailability of equipments | 3 | con | 3 | con | 3 | con | 3 | con |
| 14 | Poor workmanship | 3 | con | 3 | con | 3 | con | 3 | con |
| 15 | Lack of strategic planning | 3 | con | 2 | cos | 3 | con | 3 | con |
| 16 | Contractor's financial difficulties | 3 | con | 2 | cos | 3 | con | 2 | cos |
| 17 | Poor procurement process | 3 | con | 2 | cos | 3 | con | 3 | con |
| 18 | Shortage of Skilled Manpower | 3 | con | 3 | con | 3 | con | 3 | con |

Table 3 shows that for the factor "change of scope", consultants are responsible and is agreed by client and contractor while consultant respondents mentioned change of scope is initiated by client. For

the factor, "change of schedule and financial problems", it is found that consultant is responsible party and is agreed by all groups of respondents including client, consultant, and contractors. The factor "impediment to prompt decision making process" is contributed by the consultants and is agreed by client and contractor but consultant respondents mentioned that impediment to prompt decision making process is initiated by client. Obstinate nature of owner is caused by clients as agreed by all groups of respondents. All the groups of respondents are agreed that for the factors "changes in specification, change in design, design complexity, inadequate working drawing details, inadequate design, conflicts among contract document and change in specification by consultant", the responsible party is consultant. On other hand, for two factors i.e. "unavailability of equipment and poor workmanship" all the respondents agreed that those are occurred due to contractors. For the factor, lack of strategic planning, the contractor is the responsible and is agreed by contractor itself and consultant while client respondents mentioned this factor is caused by consultant. For the factor, financial difficulties, contractors are found as responsible which is agreed by consultant. However, contractors and client respondents mentioned that this factor is caused due to consultants as they take long time in verifying the work done by contractors and also monthly bills are verified late which cause delay in releasing monthly payments of contractor. Hence, contractor faces financial difficulties. For the factor, poor procurement process, contractor is responsible party as agreed by consultant and contractor but the client stated that consultant is the contributor for this factor. It is found that contributor for the factor, "lacking of skills" is contractor and it is agreed by all groups of respondents including client, consultant and contractors.

### 4.2. Significance of VO Factors in affecting Project Quality

Significance of VO factors in affecting project quality was assessed based on AI value and rank. Table 4 shows AI value rank of each factors based on overall respondents, client, consultant and contractors accordingly.

Table 4. Significance Level of Factors in Affecting Project Quality

| Factors | Overall | | Client | | Consultant | | Contractor | |
|---|---|---|---|---|---|---|---|---|
| | AI | Rank | AI | Rank | AI | Rank | AI | Rank |
| Poor workmanship | 2.92 | 1 | 2.97 | 1 | 3.11 | 2 | 2.78 | 5 |
| Change in specifications by the owner | 2.89 | 2 | 2.69 | 15 | 3.00 | 5 | 3.05 | 1 |
| Contractor's financial difficulties | 2.85 | 3 | 2.87 | 4 | 2.89 | 10 | 2.78 | 6 |
| Inadequate working drawing details | 2.84 | 4 | 2.74 | 10 | 2.95 | 6 | 2.84 | 3 |
| Changes in Design | 2.80 | 5 | 2.87 | 3 | 3.00 | 3 | 2.68 | 9 |
| Lack of strategic planning | 2.79 | 6 | 2.90 | 2 | 2.84 | 11 | 2.62 | 10 |
| Owner's financial problems | 2.79 | 6 | 2.69 | 14 | 2.95 | 8 | 2.86 | 2 |
| Change in scope of the project | 2.75 | 7 | 2.74 | 8 | 2.68 | 16 | 2.78 | 7 |
| Obstinate nature of owner | 2.75 | 7 | 2.74 | 9 | 2.68 | 17 | 2.78 | 8 |
| Poor procurement process | 2.74 | 8 | 2.82 | 5 | 2.84 | 12 | 2.62 | 11 |
| Conflicts among contract documents | 2.74 | 8 | 2.77 | 7 | 3.16 | 1 | 2.46 | 14 |
| Shortage of Skilled Manpower | 2.73 | 9 | 2.82 | 6 | 3.00 | 4 | 2.43 | 17 |
| Inadequate design | 2.72 | 10 | 2.74 | 11 | 2.95 | 7 | 2.57 | 12 |
| Change in Schedule | 2.71 | 11 | 2.69 | 13 | 2.63 | 18 | 2.84 | 4 |
| Unavailability of equipments | 2.63 | 12 | 2.74 | 12 | 2.74 | 14 | 2.46 | 15 |
| Design complexity | 2.62 | 13 | 2.67 | 16 | 2.79 | 13 | 2.49 | 13 |
| Change in specifications by the consultant | 2.60 | 14 | 2.62 | 18 | 2.95 | 9 | 2.38 | 18 |
| Impediment to prompt decision-making process | 2.56 | 15 | 2.62 | 17 | 2.74 | 15 | 2.46 | 16 |

Table 4 shows that poor workmanship is the most significant factor affecting project quality and ranked at 1st place. However, there is disagreement between the respondents regarding ranking. Client respondents ranked this factor at 1st place while consultants placed this factor at 2nd rank and contractors placed it at 5th rank. Changes in specifications is the 2nd ranked significant factor while contractor respondents believed that this factor is the most significant factor in affecting project quality, consultant respondents ranked this factor at 5th place and client respondents assumed this factors at low significant and ranked it as 15th place. "Financial difficulties" is 3rd ranked factors based on overall respondents while there is disagreement between respondents on the ranking. Client respondents have placed this factor at 4th rank; contractors placed this factor at 3rd rank, contractors have placed it at 6th rank and consultants placed it at 10th rank. 4th major VO factor in affecting project

quality is "inadequate working drawing details" based on overall respondent's feedback while contractors placed this factor at 3rd rank; consultants have placed this factor at 6th rank and clients considered this factor as less significant by placing at 10th rank. Based on overall respondent's feedback, changes in design is found as 5th ranked factors while client and consultants consider this factor more significant and placed at 3rd rank. On the other hand contractors have placed this factor at 9th rank who consider that changes is design is moderately significant VO factor in affecting the quality of project.

## 5. Conclusion

This study investigated 18 factors of variation orders for assessing their probability of occurrences; responsible party and significance level of each factor in affecting project quality. For this, data collection involved survey through structured questionnaire. Among 101 respondents participating in survey, 39 represented clients, 37 were contractors and 25 were representatives from consultant firms. Analysis of survey through average index method showed that unavailability of equipments, poor workmanship, design complexity, change of schedule and impediment to prompt decision making process are the top 5 factors which are most commonly occurred in construction projects. Among the 18 factors, 12 factors are caused due to consultants performance where as poor workmanship, changes in specification, financial difficulties, inadequate working drawing details and change in design are the top 5 significant factors in affecting quality of the projects. It is recommended that the performance of contractors be improved for achieving the required quality of the projects. Minimizing the changes in specification and design; ensuring the financial capabilities can be very effective in improving the quality of the projects.

**Acknowledgements:**

The authors would like to thank Universiti Tun Hussein Onn Malaysia, for encouragement and support in carrying out this research work. The authors also pay thanks to respondents participating in the survey, without their cooperation and precious time the completion of this work was not possible. Aftab Hameed Memon is also thankful to the Quaid-e-Awam University of Engineering, Science and Technology also for granting permission to carryout research work at Universiti Tun Hussein Onn Malaysia.

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4/15/2014