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Research Article

Significant Causes and Effects of Variation Orders in Construction Projects

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Abstract: Variation Order (VO) is a common phenomenon in construction projects. It involves an amendment of the original scope of work as in the contract. VO is caused from various factors. Variations often cause disputes and dissatisfactions among the parties involved in construction projects. Thus, it is very important to control VOs in a construction project. For this, the first step is to uncover and understand the causes and effects of VO. Hence, the aim of this study is to determine the significant causes and effects of VO in construction projects. Data collection involved the survey with a structured questionnaire consisting of 18 causes and 9 effects of variation orders identified through comprehensive literature review. Survey was carried out among client representatives, consultants and contractors involved in handling projects of Malaysian Public Works Department (PWD) known as Jabatan Kerja Raya Malaysia (JKR). A total of 101 completed questionnaire sets were collected against 200 questionnaires distributed among the practitioners. Collected questionnaires were analyzed with statistical software package SPSS and Average Index formula. The results of the study showed that in Malaysia's JKR projects often variation orders are occurred; these VO's are majorly caused because of unavailability of equipment, poor workmanship and design complexity. While most significant effects of VO on the projects are increased project cost, delay in completion and logistic delays. Early participation of professionals may be beneficial in reducing the occurrence of variations. Also, improved design and avoiding frequent design changes will be very effective in controlling the problem of variations.

Keywords: Causes of VO, effects of VO, JKR projects, variation orders

INTRODUCTION

Malaysian economy recorded a higher growth of 5.4% in the second quarter of 2012 (CIMP, 2012), driven by a stronger expansion in domestic demand and further moderation in external demand. There are many sectors that contribute to the improvement of Malaysia economy. One of these is the construction sector. The GDP growth of the construction sector has recorded a growth of 22.2% in the second quarter of 2012 (BNM Quarterly Bulletin, 2012) driven mainly by the civil engineering sub-sector. This pick-up in the civil engineering works was due to significant progress in infrastructure, utility and oil and gas projects such as the Second Penang Bridge, Seremban Gemas Double Track, Janamanjung Power Plant, Sabah Oil and Gas Terminal and Melaka Regasification Terminal. Thus, construction industry is one of the key industries in Malaysia. Unfortunately, the industry is facing many problems in its projects. One of the major problems faced by the construction project is the issue of the variation order occurring during the construction phase (Ibb *et al*., 2001) which results in delaying projects, overruns the cost and causes other negative effects. Hence it is very important to control variation orders.

Variations were common in all types of construction projects (CII, 1994; Fisk, 1997; O'Brien, 1998; Ibbs *et al*., 2001). The study, of the Joint Legislative Audit and Review Commission (JLARC, 2001) on 300 road construction project in Virginia revealed that average project change was more than 11%. In United State, Hanna and Gunduz (2004) estimated that the United States construction industry spent 13-26 billion dollar in 1 year for construction variation orders. Variation orders have become a common problem in construction projects in Malaysia also which are incurred because of various causes and result with a negative impact on projects. A study conducted by Sambasivan and Soon (2007) showed that in 2005 about 17.3% (of 417 government contract projects in Malaysia) were considered sick i.e., more than 3 months of delay or abandoned. For this, it is very important to understand the problems of variation orders in achieving successful projects. Hence, this study focused on identifying significant causes and effects of variation orders. However, the scope of this study is limited to projects administrated by JKR only in southern region of Malaysia through structured questionnaire survey. Understanding the root of problem will be helpful to JKR in minimizing the undesirable situation.

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CAUSES OF VARIATION ORDERS

Variation order is the deviation experienced in any project from base contract or work scope mutually agreed at contracting time (Keane *et al*., 2010). It is written agreement between the contracting parties that represent an addition, deletion, or revision to the contract documents, identifies the change in price and time and describes the nature of the work involved (CMAA, 1993). Variation orders arise for a variety of causes, of which some causes are foreseeable and others are not. Many researchers have identified various causes of variation orders (CII, 1990a; Thomas and Napolitan, 1995; Clough and Sears, 1994; Fisk, 1997; Ibbs *et al*., 1998; O'Brien, 1998; Mokhtar *et al*., 2000; Gray and Hughes, 2001; Arain *et al*., 2004). As a results of literature review, a total of 18 causes were identified as discussed below.

Change of schedule: A change of schedule during the project construction phase may result in major reallocation of resources. A change in schedule means that the contractor will either be required to provide additional resources or keep some resources idle. In both cases, additional cost is incurred (Fisk, 1997; O'Brien, 1998).

Change in scope: Change of plan or scope of the project is one of the most significant causes of variation in construction projects (CII, 1990b). It is usually the result of inadequate planning at the project definition stage or because of lack of involvement of the owner in the design phase (Arain *et al*., 2004).

Owner's financial problems: The owner's financial problems can affect project progress (Clough and Sears, 1994; O'Brien, 1998). This problem often leads to change in work schedules and specifications, affecting the quality of the construction.

Impediment to prompt decision-making process: Prompt decision making is an important factor for project success (Sanvido *et al*., 1992; Gray and Hughes, 2001). Failure to make the decision efficiently may result in the delay, causing the need for the change order due to cost increments.

Obstinate nature of the owner: A building project is the result of the combined efforts of the professionals involved, which have to work at the various interfaces of a project (Wang, 2000; Arain *et al*., 2004). If the owner is obstinate then this could cause major variations at the later stages of a project.

Change in specifications by the owner: Changes in specification is a common phenomenon in construction projects with inadequate project objectives (O'Brien, 1998). If these changes in the specification of the design or requirement are carried out, this leads to variations in the construction phase.

Change in design by the consultant: A change in design improvement by the consultant is a norm in contemporary professional practice (Arain *et al*., 2004). Changes in design were frequent in projects where construction starts before the design is finalized (Fisk, 1997). Such changes affect the project in various ways depending on the timing of the change.

Conflicts among contract documents: Conflict between contract documents can result in misinterpretation of the actual requirement of a project (CII, 1986). It is essential that the contract documents are clear and precise. Insufficient details in the contract documents may result in delays to the project completion or cause variations in cost.

Design complexity: Complex designs require unique skills and construction methods (Arain *et al*., 2004). Complexity affects the flow of construction activities, whereas simpler and linear construction works are relatively easy to handle (Fisk, 1997).

Inadequate working drawing details: To convey a complete concept of the project design, the working drawings must be clear and concise (Geok, 2002). Inadequate working drawing details can result in misinterpretation of the actual requirements for the project (Arain *et al*., 2004), causing variations in the project.

Change in specification by the consultant: Changes in specification are observed frequently in construction projects (O'Brien, 1998). Changes in specification results in variations to the project, leading to delay and increased overall cost.

Unavailability of equipment: Unavailability of equipment is a procurement problem that can affect the project completion (O'Brien, 1998).

Shortage of skilled manpower: Skilled manpower is one of the major resources required for technological projects (Arain *et al*., 2004). Variations and delays may occur due to shortages of skilled labor.

Contractor's financial difficulties: Construction is a labor intensive industry. Whether the contractor has been paid or not, the wages of the worker must still be paid (Thomas and Napolitan, 1995). If a contractor experiences financial difficulties during the course of a project, it may result in lacking of resource availability. Consequently, the progress of the project is affected which may require variation and extension of time.

Poor workmanship: Defective workmanship may lead to demolition and rework in construction projects

Table 1: Causes of variation order

Causes	Author: CII (1990a)	Arain *et al*. (2004)	Clough and Sears (1994)	O'Brien (1998)	Sanvido *et al*. (1992)	Gray and Hughes (2001)	Wang (2000)	Fisk (1997)	Geok (2002)	Thomas and Napolitan (1995)
Conflicts among contract documents	√									
Change in specifications by the consultant				√						
Owner's financial problems	√	√								
Shortage of skilled manpower		√								
Contractor's financial difficulties										√
Change in schedule	√			√				√		
Unavailability of equipments				√						
Poor procurement process								√		
Change in scope of the project	√	√								
Impediment to prompt decision-making process					√	√				
Obstinate nature of owner		√					√			
Change in specifications by the owner		√		√						
Changes in design		√						√		
Inadequate design	√							√		
Lack of strategic planning			√	√						
Poor workmanship				√				√		
Design complexity	√	√						√		
Inadequate working drawing details		√		√					√	

(Fisk, 1997; O'Brien, 1998). This results in delay and increased cost.

Poor procurement process: Procurement delays have various adverse effects on other processes in the construction cycle (Fisk, 1997). Other processes in the construction cycle are affected by poor procurement processes. Consequently, variations are required.

Lack of strategic planning: Proper strategic planning is an important factor for successful completion of a building project (Clough and Sears, 1994). The lack of strategic planning is a common cause of variations in projects where construction starts before the design is finalized (e.g., in concurrent design and construction contracts) (O'Brien, 1998).

Inadequate design: Inadequate design can be a frequent cause of variations in construction projects (CII, 1990a; Fisk, 1997).

The summary of cause variation orders is presented in Table 1.

EFFECTS OF VARIATION ORDERS

Variation orders exert various effects on the projects. Numerous researchers (CII, 1986; CII, 1990a; Clough and Sears, 1994; CII, 1994; Thomas and Napolitan, 1995; Fisk, 1997; Ibbs *et al*., 1998) have highlighted the effects of VO. The review of these studies resulted in identifying 9 effects as discussed below.

Delay in completion: Variations often hinder the project progress, leading to delay in achieving the targeted milestones during construction (CII, 1995; Ibbs, 1997). Zeitoun and Oberlender (1993) reported that a variation may delay the projects by 9% of the original scheduled time duration for projects. Kumaraswamy *et al*. (1998) studying delay problems in construction projects of Hong Kong summarized that 50% of the projects surveyed were delayed because of variations. In reducing the delay of a project, the contractor would try to accommodate the variations by utilizing the free floats in the construction schedules.

Increase in project cost: Increase in project cost is regarded as the most common effect of variations (CII, 1990a). Any alteration or addition is the design during execution of the project may results in demolition or rework of any project component and eventually increase the project cost (Clough and Sears, 1994). Hence, in order to keep overall project cost unchanged; normally in every construction project a contingency sum is allocated which caters possible variations in the project. Further, variations require processing procedures, paper work and reviews before they can even be implemented (O'Brien, 1998). The process and implementation of variations in construction projects would increase the overhead expenses for all the participants concerned. Normally these overhead charges are provided for from the contingency fund allocated for the construction project.

Quality of projects: Variations affect the quality of work adversely (Fisk, 1997). CII (1995) reported that the quality of work is frequently affected by frequent variations because contractors have to compensate for the losses by cutting corners.

Causes rework: Variations in construction often results in rework and demolition (Clough and Sears, 1994) if the variations are occurred during the construction is underway or even completed (CII, 1994). This effect is to be expected due to variations during the construction phase while variations during the design phase do not require any rework or demolition on construction sites.

Logistics delays: Variation may cause requirement of new or additional amount of material and equipments which results in logistics delays (Fisk, 1997). Hester *et al*. (1991) mentioned that logistics delays are among the significant effects of variations in construction projects.

Altogether with above part of the literature review, total 9 major effects of variations were identified by reviewing nine previous published research works as summarized in Table 2.

Table 2: Effect of variation order

Effect of variations	CII (1990a)	Arain *et al*. (2004)	Clough and Sears (1994)	O'Brien (1998)	Ibbs and Allen (1995)	Fisk (1997)	Thomas and Napolitan (1995)	Assaf *et al*. (1995)	Hester *et al*. (1991)
Delay in completion	√								
Slower project progress	√							√	
Increase in project cost	√		√						
The quality of projects	√					√			
Causes rework	√		√						
Unnecessary procurement				√					√
Logistics delays						√			√
Causes non value adding activities		√		√					
Loss of productivity					√		√		√

Table 3: Causes of variation order

	Overall		Client		Consultant		Contractor	
The causes of variation order	AI	Rank	AI	Rank	AI	Rank	AI	Rank
Unavailability of equipments	3.24	1	3.15	3	3.56	1	3.05	3
Poor workmanship	3.14	2	3.00	11	3.20	3	3.22	1
Design complexity	3.08	3	3.05	5	3.24	2	3.03	5
Change in schedule	3.01	4	3.05	6	2.76	13	2.59	18
Impediment to prompt decision making process	3.01	5	2.95	16	2.96	8	3.11	2
Changes in design	2.99	6	2.95	17	2.92	9	3.03	6
Obstinate nature of owner	2.98	7	2.97	12	2.80	12	3.05	4
Inadequate design	2.98	8	3.10	4	3.00	6	2.84	13
Lack of strategic planning	2.95	9	3.03	10	3.04	5	3.00	8
Inadequate working drawing details	2.94	10	3.05	7	3.04	4	2.89	11
Poor procurement process	2.94	11	2.97	13	2.84	11	3.00	9
Contractor's financial difficulties	2.89	12	2.79	18	2.64	16	3.00	10
Shortage of skilled manpower	2.87	13	3.36	1	2.64	15	3.03	7
Conflicts among contract documents	2.86	14	3.05	8	2.88	10	2.70	15
Change in specifications by the owner	2.85	15	3.21	2	2.60	17	2.86	12
Change in scope of the project	2.82	16	3.05	9	2.76	14	2.68	16
Owner's financial problems	2.77	17	2.97	14	2.56	18	2.78	14
Change in specifications by the consultant	2.40	18	2.97	15	3.00	7	2.65	17

RESEARCH METHOD AND ANALYSIS TECHNIQUES

A questionnaire designed in accordance with the objectives based on comprehensive literature review was used as data collection tool in this study. It aimed to retrieve perception of the client, consultant and contractor employees on causes and effects of variation orders. Causes of variation orders were measured based on Likert-Scale of 1 to 5 where 1 represent 'not significant', 2 'slightly significant', 3 'moderately significant', 4 'very significant' and 5 'extremely significant'. For effects of variation also scale contained 5 points as 1 as 'not effective', 2 as 'slightly effective', 3 as 'moderately effective', 4 as 'very effective' and 5 as 'extremely effective'. Gathered questionnaire sets were analyzed by using Statistical Packages for Social Sciences (SPSS) and Microsoft Excel. Rank of causes and effects of variation order is assessed based on Average Index (AI) value calculated based on following formula below:

$$\text{Average Index} = \sum ((1x_1+2x_2+3x_3+4x_4+5x_5)/N)$$

where,

x_1 = Number of respondents for Not Significant/Effective
x_2 = Number of respondents for Slightly Significant/Effective
x_3 = Number of respondents for Moderately Significant/Effective
x_4 = Number of respondents for Very Significant/Effective
x_5 = Number of respondents for Extremely Significant/Effective
N = Number of respondents

RESULTS AND DISCUSSION

The respondents in this survey were personnel handling construction projects administrated by JKR in the southern part of Peninsular Malaysia. 101 respondents involved in construction projects returned back completed questionnaire sets from 200 respondents contacted in person, through postal mail and e-mail. The addresses of the companies were taken from Construction Industry Development Board (CIDB) website and contractor services centre (PKK) website.

Demographics of respondents: Demographics study presents the detailed features of the respondents including type and category of companies, size of a project, qualification, working position and experience in the industry. Received questionnaire sets showed that 39 respondents responding the survey are client's representatives followed by contractors with 37 respondents and 25 respondents from consultant firms. Among these, 51 respondents are engaged in private organizations while 47 are associated with government firms and only 3 respondents work with joint venture organizations. Majority with 78 respondent stated that they are involved in handling large size projects i.e., projects with a contract sum of more than RM 5 Million. Remaining 23 respondents are involved in medium and small size projects. A total of 50 respondents have completed their civil engineering education while 32 and 10 respondents have received diploma and professional certificate while other 9 respondents have got master degree in civil engineering and project management. All the respondents have several years of experience which have made them able to understand the field problems and give reliable feedback in the survey. Overall demographic characteristics of respondents are summarized in Table 3.

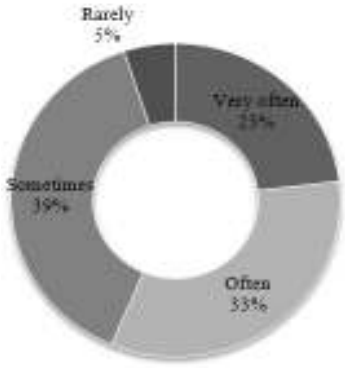

Fig. 1: Client's perception on occurrence of variations

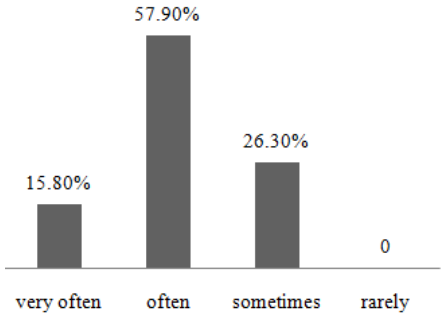

Fig. 2: Consultant's perception on occurrence of variations

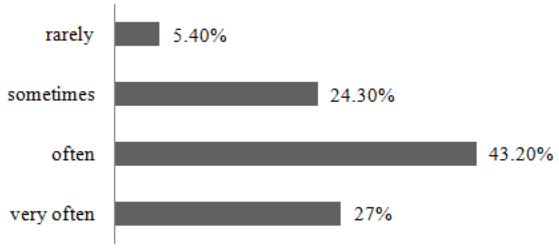

Fig. 3: Contractor's perception on occurrence of variations

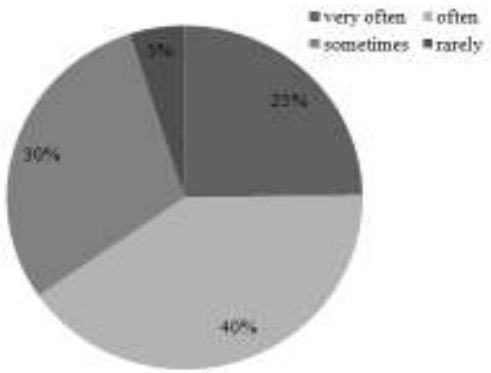

Fig. 4: Overall respondent's perception on occurrence of variations

How common are variations occurred in construction projects: The occurrence of variations was determined for understanding the problem of variation orders in the construction industry. It was done by assessing the frequency of rating about how often the respondents face variation orders in their projects. The understanding of the respondents for each party i.e., contractor, consultant and client was analyzed and is discussed in following sections where Fig. 1 shows the frequency of occurrence for variation orders in construction projects based client respondents.

As revealed from Fig. 1, all the respondents from client group agreed that the variation is a common problem in construction projects. Amongst 39% respondents stated that they sometimes face variation in their projects. On the other hand, 33% of respondents highlighted that they often faced variations in their projects. It is followed by 23% respondents highlighting that they faced variations very often. Only 5% respondents faced variations rarely in their projects. Similarly, the understanding of consultants for occurrences of variations in construction projects is illustrated in Fig. 2.

From Fig. 2, it is notably seen that a significant number of respondents with 57.9% highlighted the occurrence of variation in projects as often followed by 26.3% respondents mentioning that sometimes variations are occurred while other 15.8% mentioned that the problem of variations in construction projects occurs very often. The perception of contractors regarding occurrences of the variation order is summarized in Fig. 3.

Based on the contractor's perceptions as revealed from Fig. 3, problem of variations is often faced dilemma as highlighted by 43.2% respondents. While 27% of the respondents pointed out variations as very often occurring problem. Among other respondents, 24.3% said that variations are occurred sometimes in projects while 5.4% respondents stated that this problem is rarely occurred. Comparing the responses of all parties, the combined results on the perception for occurrence of variations highlighted that 41 (40%) of respondents stated that the variation orders often occur in construction projects, 30 (30%) respondent affirmed occurrences of variations as sometimes, 25 (25%) respondents referred problem of variations as very often and only 5 (5%) respondents said that rarely they experienced variations in their projects. These analysis results are summarized in Fig. 4.

Causes of variation: The ranking of the variation order was calculated using average index formula in order to find most common cause of the variation order. The result of ranking variation order causes is shown in Table 4.

As highlighted from Table 4, unavailability of equipment, poor workmanship, design complexity, change of schedule, impediment to quick decision making process, change in design, obstinate nature of the owner and inadequate design are most important causes of variation in construction projects. Among

Table 4: Causes of variation order

	Overall		Client		Consultant		Contractor	
The causes of variation order	AI	Rank	AI	Rank	AI	Rank	AI	Rank
Increase project cost	3.45	1	3.28	1	3.40	2	3.57	1
Delay in completion	3.20	2	3.00	2	3.52	1	3.27	2
Logistic delays	2.82	3	2.62	4	3.16	3	2.81	3
Slower activity progress	2.75	4	2.72	3	2.84	4	2.73	5
Causes rework	2.61	5	2.59	5	2.48	6	2.78	4
Increase unnecessary procurement	2.51	6	2.51	6	2.48	7	2.54	7
Causes non value adding activities such as demolition	2.42	7	2.36	7	2.60	5	2.35	8
Loss of productivity	2.41	8	2.23	8	2.40	8	2.54	6
Affects on project's quality	2.21	9	2.18	9	2.16	9	2.27	9

these causes, unavailability of equipment is the firstly ranked cause which means this cause is the most significant and occurs more commonly at construction as agreed by overall group and consultant group respondents. However, there is a conflict between client group and contractor group of respondents who placed this factor at 3rd ranking. Significance level for cause of 'poor workmanship' is second ranked in the overall group of respondents. Contractors considered this factor as most significant factor and placed this factor at 1st rank. But client group of respondents ranked this factor at 11th position and consultant group of respondents placed it at 3rd rank.

The design complexity is the third ranked cause of variations based on overall respondent's perceptions. However, there is disagreement between client group and contractor group of respondents placing this cause at 7th rank while consultant group respondents placed it at 2nd rank. Change schedule is 4th ranked cause variations while it is placed at 6th rank by clients, at 14th rank by consultant group and at 18th by contractors. Impediment to prompt decision making process is 5th ranked cause based on results for overall respondents. However, client group of respondents placed this factor at 16th rank, consultant group respondents ranked this factor at 8th place and contractor group of respondents placed it at 2nd rank. Change in design is 6th ranked cause; which is placed at 17th ranks by client, consultants ranked it at 9th place and contractor group of respondents placed it at 5th rank. Obstinate nature of the owner is at 7th rank in overall respondents. Client group respondents placed it at 14th rank; consultant group of respondents ranked this factor at 12th position and contractor group placed it at 4th rank. 'Significance of inadequate design' is recorded as 8th ranked cause. However, client group of respondents considered this factor as more significant in causing variations by and placed it at 4th rank. While consultant group of respondents has ranked this factor at 6th place and contractors placed it at 13th rank.

Effects of variation: AI value for all effects of the variation order was calculated to find most significant effect. Significance level of effects was assessed based on ranking as shown in Table 4.

From Table 4, it is apparent that Increase Project Cost, Delay in completion and Logistic Delays are significant effects of variations in construction projects. However, there is some conflict between the respondents on the ranking. Increase of project cost is found as firstly ranked effect which means this is the most significant effects occurred due to variations in construction projects. However, consultant group of respondents have placed this effect at 2nd rank. Similarly, 2nd most significant effect of variation on project cost is delay in completion of the project but consultant group of respondents have highlighted this effect as the most significant by placing it at 1st rank. Logistic delay in the construction project is 3rd significant effect. It often occurs due to new requirements of materials or equipments and is agreed by consultants and contractors. Client representative disagreeing this ranked has placed this effect at 4th rank.

Principal component analysis: Principal Component Analysis (PCA) test was carried out to sort the causes of variation based on similarity. PCA is the most popular multivariate statistical technique and it is used by almost all scientific disciplines to extract the important information from observed data based on inter- correlation (Abdi and William, 2010). To run PCA test, first step is to check the suitability of data. It was done with Barlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. PCA test showed that with KMO = 0.834 and significance = 0.000, the data gathered for this study is adequate. PCA test also showed that a total of 4 components are extracted with Eigen values of greater than 1 as shown in Table 5.

Table 5 demonstrates that with 66.45% of the variance is accounted for variations with four extracted components. PCA was conducted by using varimax orthogonal rotation criteria and the extracted components with loading value are illustrated in Table 6. These four components are named:

Table 5: Total variance accounted

	Initial eigen values			Rotation sums of squared loadings		
Component	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	7.808	43.375	43.375	3.429	19.052	19.052
2	1.562	8.680	52.055	3.306	18.368	37.421
3	1.491	8.284	60.339	3.089	17.159	54.580
4	1.101	6.115	66.454	2.137	11.875	66.454

Table 6: Principle Component Analysis (PCA) loading results

	Component			
	1	2	3	4
Owner's financial problems	0.726			
Impediment to prompt decision making process	0.665			
Poor procurement process	0.658			
Contractor's financial difficulties	0.651			
Change in schedule	0.632			
Lack of strategic planning	0.601			
Inadequate working drawing details		0.829		
Inadequate design		0.771		
Design complexity		0.703		
Changes in design		0.619		
Conflicts among contract documents		0.519		
Shortage of skilled manpower			0.802	
Poor workmanship			0.753	
Unavailability of equipment			0.609	
Change in specifications by the consultant				0.773
Change in scope of the project				0.668
Change in specifications by the owner				0.520
Obstinate nature of owner				0.501

Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser normalization; Rotation converged in 12 iterations

- Financial and Decision Management
- Design and Drawing Issues
- Human and Equipment Resource
- Client Related Issues

CONCLUSION

This study focused on highlighting major causes and effects of variation in construction projects of Malaysia. The scope of the study included the projects administrated by Public Work Department (PWD) called as JKR Malaysia. Average index analysis of the gathered data through survey revealed that:

- In Malaysian construction projects, variations are often experienced in JKR projects.
- Five most significant causes are unavailability of equipment, poor workmanship, design complexity, change of schedule and impediment to prompt decision making process.
- Logistic delays, delay in completion and increase project cost are significant effects of variations faced in construction projects.
- With Principle Component Analysis (PCA) technique, four components are extracted as Financial and Decision Management; Design and Drawing Issues; Human and Equipment Resource; Client Related Issues.

Based on above findings, for minimizing the occurrence of variations in JKR projects, it is recommended that professionals should participate from design phase to assist in clarifying the project objectives and in identifying the noncompliance with their requirements at early stages. Further, consultant must focus on controlling the recurrent change in design; avoid inadequate working drawing details through systematic detailing of the design.

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