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Variation Orders in Construction Projects

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Abstract: This study presents results of a study on causes, effects and controls of variation orders in large building construction. The researcher developed a survey questionnaire. The questionnaire was distributed to all building contractors, grade A and B as well as building consultants. The survey questionnaire included four areas of study. The first included questions on the general market characteristics and general trend. The second included questions on the possible causes of variation orders. The third included questions on the possible outcomes of variations. The fourth included questions on the management control tools utilized for minimizing the problems of variation orders. Responses from 34 consultants and contractors working in the field of large building construction were analyzed. Analysis of data indicated that cost overruns due to variation orders were in the magnitude of 5-10% of the original contract value. Schedule overrun was reported <10% of the original contract duration. The study also concluded that the owner is the major source of variations and that most variations are civil and structural. Change of plans and material substitution are first causes of variation orders in large buildings.

Key words: Variation, orders, causes, effects, controls, hypothesis

INTRODUCTION

There have been numerous articles written on variations, variation orders and variation management in construction. Most of the studies written discuss the legal aspects of variations such as claims and disputes. Many other articles were devoted to the discussion of the effects of variations on labor productivity. The studies written on the subject of variation orders deal with three aspects: legal, cost and management.

In this regard, we refer to legal aspects such as contract variation, clause interpretation, substantiation and management of claims. In this approach, variations are looked at as a major source of construction claims and disputes. The major legal aspects are:

- Selecting the best delivery system (contract format)
- Drafting and interpreting variation clauses
- Documenting variation orders to be ready in case of litigation

Of direct bearing on the legal subjects of variation orders in the subject of the contract format used. There are numerous contract types used in construction depending on owner and project requirement. The more common types will be reviewed here.

Construction contracts are typically drafted by the owner or his representative (consultant) and contain the subject matter and terms and conditions. The construction contract is typically compromised of Alaa and Gorold (1993):

- Bid form
- Agreement form
- General conditions or standard specifications
- Special provisions
- Plans
- Addenda

Construction contracts must also include a compensation system and generally are classified according to the compensation system as shown in Fig. 1.

The impacts of a variation are classified as follows:

- Direct cost impact
- Direct schedules impact
- Indirect or Consequential impact

To make a variation and process takes time. This usually results in placing a hold on research and waiting for new instructions to come. In addition, equipment,

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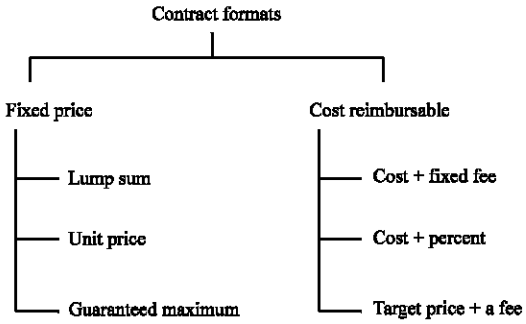

Fig. 1: Contract format

tools and materials may not be the same after a variation is introduces. To procure or rent new material, tools and equipment will cause delay and cost of resources may be substantial. Furthermore, if delays are prolonged demobilization/remobilization may become quite costly (Ibbs *et al*., 2003).

Variations, which are introduced when the construction is underway or even complete, involve several direct cost items, which can be summarized as follows (Charles, 1987):

- Labor cost to demolish existing facility
- Equipment cost to demolish existing facility
- Materials wasted by removal of existing work
- Associated cost of engineering/shipping and handling of waste materials

Nevertheless, managers of construction projects must develop the means to evaluate and estimate the consequential impacts of a change. An effective tool in consequential impact evaluation is the use of Work Breakdown Structure (WBS). A contractor should consider using the Work Breakdown Structure (WBS) as an evaluation tool especially on large projects. In this method, the whole project is broken into hierarchical fashion. Resources are allocated to each element in the WBS. The WBS is a vital tool in variation management. If a variation involves work not previously included on the WBS, it can be logically added to the WBS and its relationship to the WBS element seen. Ripple effects can be traced by the use of WBS. The discussion of the details and applications of the WBS is beyond the scope of this study (Hanna *et al*., 2002).

Costing of variations can become a real challenge on a fixed price or lump sum contract. On a cost plus, there is a direct transfer of cost to the owner and the problem does not exist.

The following procedures are used in costing variations:

- Price and schedule adjustments are negotiated prior to the start of implementation
- If unit prices are part of the contract, they will be used as the basis of change work pricing. Unit prices quoted in the contract should not be used to cost variations without consideration to change variation. A quantity limit of unit price validity may be used
- The contractor is directed to proceed with after the fact adjustment

Owners should expend more effort (such as site studies) in the early development of the design to minimize variations during detail design and construction. Perhaps, the most important steps in the development of a variation order are the scope definition step (Cooper and Emory, 1995). First, the original scope should be clear and well defined to distinguish between a variation of scope and a variation due to design development. A poorly defined scope does not provide a clear baseline against, which variations can be evaluated as being either variations within or outside of scope.

The ability to define both original scope and variation scope requires very strong technical skills. Many contractors expressed dissatisfaction with client representative asking the contractor to share risk for variation work outside the original scope. Hence, the owner, owner representative and contractor have to be familiar with the facility, standards and the contract when discussing a change scope.

A variation order as defined by Edward (1998) is the formal document that alerts some conditions of the contract documents. The word 'formal' implies legal binding and as such all variations should be in writing and verbal variations should be avoided. Although, there is no mandatory form, owners usually have their own forms and procedures that must be followed to process a variation.

The complexity of procedures is a problem in large organization. Too many control systems and technical department approvals become barriers to an efficient variation order procedure. The inefficiency cost could be quite enormous. In addition, the level of trust between the parties has a direct impact on the simplicity or complexity of the variation order procedures. The less the trust, the more cumbersome is the procedure.

MATERIALS AND METHODS

An investigation was undertaken on 34 companies (contractors and consultants). The results as shown in Table 1.

Table 1: Summery of (34 respondent) answers on questionnaire

Industry characteristics	Variables	Number of companies
Increase cost/percent	0-5	3
original contract value	6-10	18
	11-15	9
	16-20	3
	>20	1
Type of contract	Lump sum turnkey	19
	C+	2
	LS-LBR	6
	D and B	3
	BQ	4
Craft generate VO	Electric	8
	Mechanical	1
	C and S	21
	Others	4
Increase in schedule	<10%	19
	10-20%	12
	>20%	3

Over a period of four months after mailing the questionnaire and making contact with the contractors and consultants, the researcher collected 34 responses, from which 17 were contractors and 17 were consultants.

RESULTS AND DISCUSSION

Contractors: Figure 2 shows the results of responses of contractors on the causes of variation orders.

Now, if we list the five most common causes of variation orders from the contractor's point of view, we have the following list starting with the most important:

- Change of plans by owner
- Errors and omissions in design
- Change in design by consultant
- Substitution of materials or procedures
- Owner's financial problems and conflict between contract documents (both having the same index)

Consultants: Figure 3 shows the results of responses of consultants on the causes of variation orders.

If we carry out the same exercise we did for contractor data, we can list the five most important causes from the point view of consultants as follows:

- Change of plans by owner
- Substitution of materials or procedures
- Owner's financial problems
- Owner Change of schedule
- Lack of coordination between contractor and consultant

Overall: Figure 4 shows, the results of the survey for both contractors and consultants.

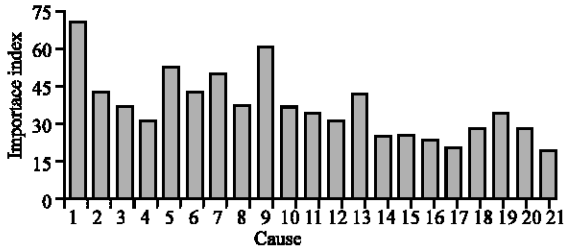

Fig. 2: Importance indexes for causes-contractor's view

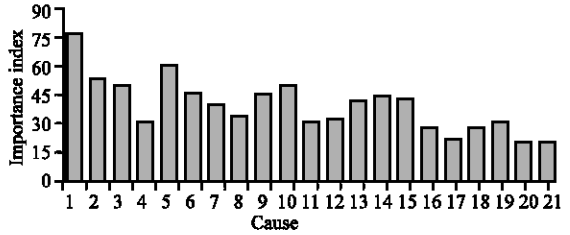

Fig. 3: Importance index of causes-consultant's view

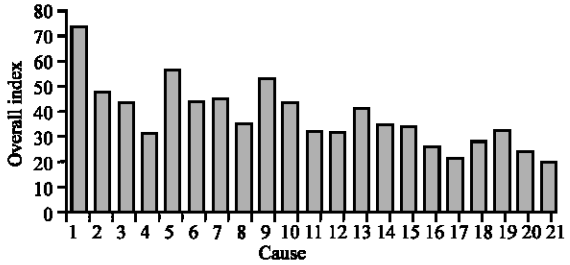

Fig. 4: Importance indexes of causes-overall

The overall ranking of the top five causes of variations among all contractors and consultants is as follows:

- Change of Plans by owner
- Substitution of materials and procedures
- Errors and omissions in design
- Owner's financial problems
- Change in design by consultant

Figure 4 is a histogram of the overall Importance Index of causes of variation.

Effects of variation orders:

Contractors: Figure 5 summarizes the results of responses of 17 contractors who participated in the survey on the effects of variation orders on their large building projects. The data is still widely dispersed reflecting the wide variation of opinion. However, the mean values or the Indexes are generally higher than those given to causes in the previous study.

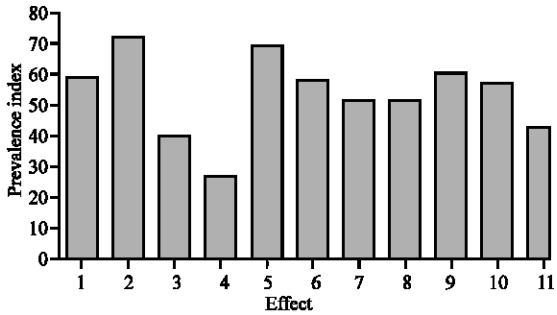

Fig. 5: Prevalence indexes of effects-contractors

From the contractor's point of view, the top 5 effects (prevalence) of variation orders in their large building projects listed in descending order are:

- Delay in completion schedule
- Increase in project cost
- Increase in contractor's overheads
- Decrease in productivity of workers
- Additional revenue for contractors

Consultants: Figure 6 shows the results of the responses of 17 consultants on the effects of variation orders on their large building construction projects.

From the consultant's point of view, the top five effects (prevalence) of variation orders on their large building projects listed in descending order are:

- Increase in project cost
- Delay in completion schedule
- Additional revenue for contractors
- Dispute between contractors and owners
- Delays in payment to contractor

We might also, note here that importance indexes reported by consultants are generally higher than those reported by contractors.

This means that consultants consider these effects more prevalent than the contractor. Figure 6 gives a clearer picture of the distribution of prevalence indexes of effects of variations in large building projects as seen by consultants:

Overall: Figure 7 shows the overall results of the survey of responses on effects of variation orders in large building construction considering both contractors and consultants.

Listing the five most prevalent effects from the above table, we find the following:

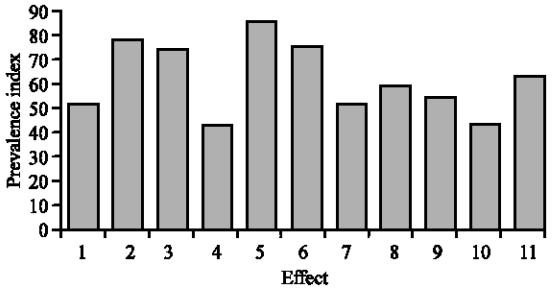

Fig. 6: Prevalence indexes of effects-consultants

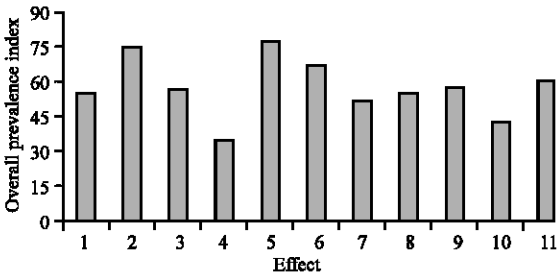

Fig. 7: Prevalence index of effects-overall

- Increase in project cost
- Delay in completion schedule
- Additional revenue for contractor
- Demolition and re-work
- Increase in contractor's overhead

Controls of variation orders: In this study, we will examine the responses from contractors, consultants and the overall responses on the controls of variation orders in large building construction projects.

Contractors: Figure 8 shows, the summery of the results of the survey's responses from the 17 contractors, who participated in the survey.

The five most utilized controls by contractors to safeguard against occurrence of variation orders to minimize their impacts if they occur are:

- Clarity of scope of work of the variation order
- Negotiation of variation orders by knowledgeable people
- Appropriate approval in writing
- Early setting of variation order procedure
- Review of design variations for feasibility before approval

Consultants: Figure 9 summarizes the responses of the 17 consultants who participated in the survey on the utilization of variation order control procedures.

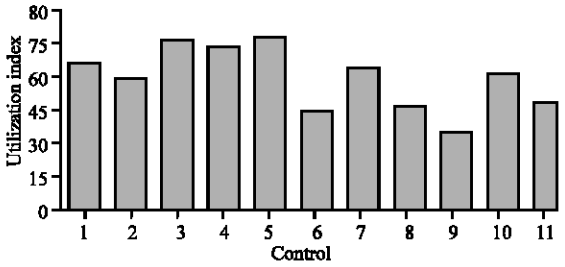

Fig. 8: Utilization indexes of controls-contractors

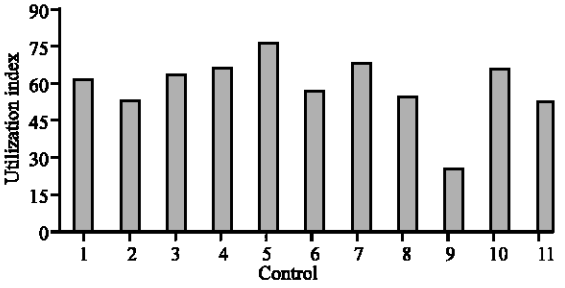

Fig. 9: Utilization indexes of controls-consultants

The five most utilized controls by consultants of large building construction projects are:

- Clarity of the scope of work of the variation order
- Review of design variations for feasibility before approval
- Appropriate approval in writing
- Team effort among construction parties
- Negotiation by knowledgeable people

Overall: Figure 10 summarizes the results from contractors and consultants.

The overall response shows the following descending order of the five most utilized by contractors and consultants:

- Clarity of scope of variation
- Appropriate approval in writing
- Negotiation by knowledgeable people
- Checking and review of design variations for feasibility
- Team effort between parties

The least used control among contractors and consultants is freezing of design. This means that the design continues to be modified until the last activity in construction. The data for overall utilization index is depicted on Fig. 10.

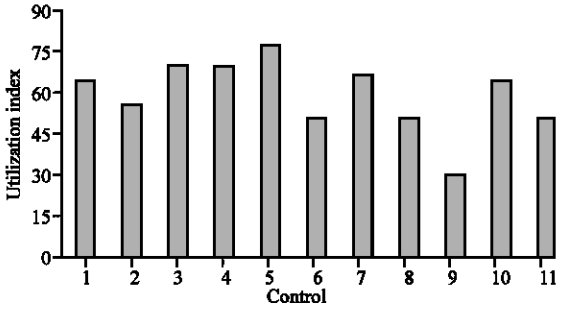

Fig. 10: Utilization index of controls-overall

Test of agreement: In this study, we want to test for the degree of agreement or disagreement between the consultants and contractors on the causes, effects and controls of variation orders. To do this, we will use t-test for independent samples. The analysis here was done on the mean value for causes, effects and controls. Numbers of causes, effects and controls indicated on Fig. 11-13 refer to their order as they appear in the questionnaire forms and also in previous tabulation.

The null hypothesis and the alternative hypothesis can be formulated as follows:

H_o: Contractors and consultants agree on the causes of variation orders.

H_A: Contractors and consultants disagree on the causes of variation orders.

The t-value calculated is -0.65 (parameters: $n_1 = 21$, $n_2 = 21$, $s_1 = 13.21$, $s_2 = 13.97$). The critical value of t is 2.02 ($df = 40$, $\alpha = 0.05$). The statistical decision therefore, is not to reject the null hypothesis. Contractors and consultants do agree on the causes of variation orders.

Figure 11 is a scatter plot of the mean values for contractors and consultants and shows the close agreement on the assigned importance index.

Likewise for the effects of variation orders, the null hypothesis and the alternative hypothesis can be formulated as follows:

H_o: Contractors and consultants agree on the effects of variation orders.

H_A: Contractors and consultants disagree on the effects of variation orders.

The t-value calculated is -1.366 (parameters: $n_1 = 11$, $n_2 = 11$, $s_1 = 13.20$, $s_2 = 14.61$). The critical value of t is 2.09 ($df = 20$, $\alpha = 0.05$). The statistical decision therefore is not to reject the null hypothesis. Contractors and consultants do agree on the effects of variation orders. Figure 12 is a

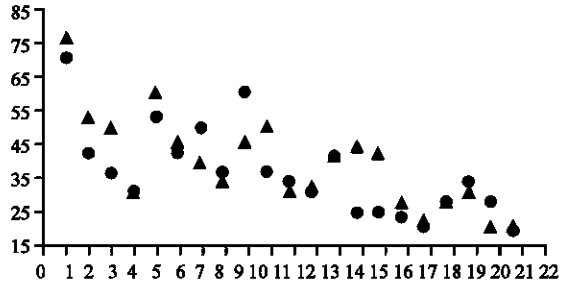

Fig. 11: Contractors and consultants agreement on causes

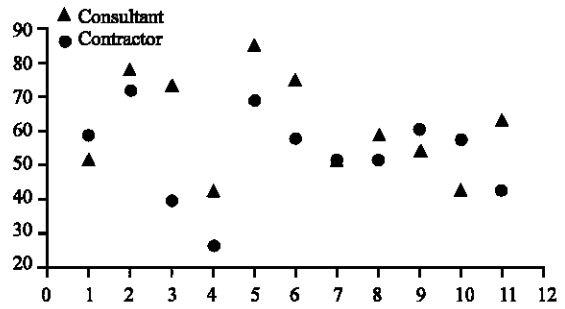

Fig. 12: Contractors and consultants agreement on effects

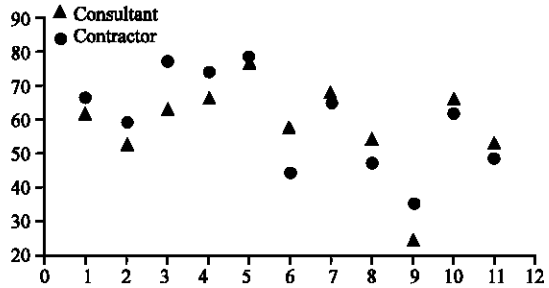

Fig. 13: Agreement of contractors and consultants on controls

scatter plot of the mean values of effects for contractors and consultants and shows the close agreement on the assigned importance index.

Finally, for the utilization of control procedures of variation orders, the null hypothesis and the alternative hypothesis can be formulated as follows:

H_0: Contractors and consultants agree on the controls of variation orders.

H_A: Contractors and consultants disagree on the controls of variation orders.

The t-value calculated is 0.160 (parameters: $n_1 = 11$, $n_2 = 11$, $s_1 = 14.14$, $s_2 = 13.26$). The critical value of t is 2.09 (df = 20, $\alpha = 0.05$). The statistical decision therefore is not to reject the null hypothesis. Contractors and consultants do agree on the controls of variation orders. Figure 13 is a scatter plot of the mean values of controls for contractors and consultants. Close agreement is very evident.

CONCLUSION

The causes of variation orders and their effects on project cost and schedule are complex and influenced by numerous interrelated factors. The risk and uncertainties associated with project variations make predictions and planning for variations a difficult task. The objective of this research was to carry out a literature review and field survey to identify major causes of variations, their effects on projects and control procedures adopted in large building projects.

Based on the field survey conducted and the results, the following can be concluded:

The general industry information collected indicates the following facts: contractors involved in large building construction are large in size and most of them reported over 15 years experience. The common contract format in large building construction is the Lump Sum Turnkey (LSTK). Most variations in large building projects are Civil and Structural in nature. The working relation between principal parties in the construction process is generally very good. Results indicated an active participation of owners during design and construction of large buildings. The cost overrun due to variation orders is shown to be between 6-10% of the original contract value in large building construction. This value agrees with values indicated by some studies as discussed in the study. Similarly, the schedule overrun is shown to be <10% of the original project duration. This extension of the schedule is close to values reported in other studies. Hence, the effects of variation orders on cost and schedule are comparable to other sectors or locations.

The owner is the main source of variations in large building projects. Change of plans by owner is the main cause of variations. There are three possible explanations to this. First, the owner was not involved in the design development. This is unlikely considering the positive or active participation of owner indicated in the first conclusion. Second, the owner did not understand or visualize the design. The designer may not have made the design clear or the owner just lack the ability to read the drawings. Third, it is merely a change of mind, while not appreciating the negative impacts of variations. The results showed that variations can be made by owner due to financial problems facing the owner.

Substituting materials and/or procedures is the second source of variation orders generated by the owner. This might be due to new materials becoming available in the market or due to change in mind on part of the owner directly or through his representative.

Consultant is the second major contributor to variations by generating conflicting design documents or through change in design after award. Another source is errors and omissions in design.

Noticeably the following causes rated low, which might be particular to the environment:

- Differing site conditions
- Value engineering
- Technology changes

Increase in project cost and duration are the two main effects being noted for variation orders. Degradation of labor productivity and disputes scored lower and are less prevalent. The degradation of productivity is considered a major concern here. This might be explained by the low labor wages. Quality of work is not affected by variations. Additional revenue for contractors is considered an outcome of variations.

Clarity of the scope of variation ranked the first among controls adopted. Freeze of design, use of WBS and review of contract, ranked last and are least utilized by contractors and consultants.

Finally, the research showed that contractors and consultants agree to a large extent on the cause of variation orders, effects of these variations and the controls adopted. This is contrary to the common perception that consultants and contractors would not agree. The normally adversarial relation did not affect their evaluation of the problem. This indicates a mature and well-developed contractual relationship in this field of construction. This may not be present in small-scale construction projects.

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