

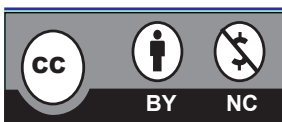
Causes and Impacts of Variation Order in Building Construction Projects: A Case Study of Three Projects at Bharatpur Metro

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ABSTRACT

Variation orders are common in civil engineering construction projects and serve as significant measurement tools for project efficiency and success. This study focuses on identifying the causes and impacts of variation orders in building projects. Three hotel buildings under construction in Bharatpur were considered for the study. The study population included the client, consultant, and contractor, as they are the major stakeholders in any construction project. Data were collected using a five-point Likert scale and analyzed using the Relative Importance Index (RII) to rank the causes and impacts of variation orders. The study also identified strategies to minimize variation orders. Based on the overall ranking using the RII index, the top three causes of variation orders in building projects at Bharatpur were found to be: Errors and omissions in design (RII = 0.953), Variations in the scope of work by additions, omissions, and alterations of the employer's requirements (RII = 0.937) and Change in design and drawings by the consultant (RII = 0.905)

Regarding the impacts of variation orders, the top three identified impacts were: Completion schedule delay, Increase in project cost, Affect on progress. All parties strongly agreed on the ranking of these impacts, as supported by a Kendall's coefficient of concordance value of 0.973. Strategies to minimize variation orders: Fourteen major strategies were identified and analyzed to minimize variation orders. The top three measures, ranked based on overall RII analysis (Kendall's coefficient of 0.812), were: Complete the drawings at the tendering stage (RII = 0.942), All involved parties should plan adequately before works start on-site (RII = 0.937) and Carry out detailed site investigation, including soil investigations, and consider them during the tendering stage (RII = 0.895)

Keywords: Variation order, cause of variation, impacts of variation, minimize variation

Introduction

Variation orders in construction projects involve changes or alterations to the design, quality, or scope of work as defined in the contract (O'Brien, 1998). These variations often result in unnecessary increases in construction costs without adding value to the project. The number of variation orders a project faces directly impacts the project's completion time and cost. Variation orders can occur due to changes in technology, legal provisions, site conditions, geological deviations, unavailability of specified materials, or ongoing design development after the contract is awarded (Assaf. & Al-Hejji, 2006; Akinsola, 1997).

It has been seen that the design made during project preparation in construction projects needs revision during implementation; hence, the variations take place. Design may require change owing to any of the stakeholders' i.e. due to change in needs of client, due to construction difficulty for contractors or due to faulty design by consultant at times. (Arian & Low. 2005)

Variation order may have positive or negative impact on the project about time and cost. The most observed impact of variation order is delay in project completion. Delays increase the cost of construction because of price adjustment and fluctuations in the prices of various components, i.e., labor, fuel, cement and miscellaneous materials. In Nepal, cost overrun also leads to serious problems in upcoming projects due to limited funds being available and construction projects are usually carried out on a loan basis. (El Karriri, 2012)

Variation orders may arise due to reasons that may be predictable and non-predictable. Some variations result from change of conditions that cannot be prevented whereas some originate from the incompetence of the project team. Natural disasters like earthquake, landslide, epidemics and political disturbances like strike etc could be indisputable. Arain and Pheng (2006) categorized causes of variations as

client, consultant, contractor and others related changes, this makes clear that variations are required because one or more of the parties fails to complete definite necessities for carrying out the project. This could include strike from the workers, unavailability of labor, equipment, material etc. (Ismail et. al, 2012).

Building projects also undergo variations frequently. The most common type of variation that any building project experiences are variations to the pre defined set of work or variations arising from unforeseeable circumstances in the field. Any two buildings of similar design may have difference in contract agreement based on the terrain, available facilities, or other factors such as geological conditions, material availability etc. Variation orders are taken as part of contract administration (Ndihokubway, 2008)

Globally, variation orders have a considerable effect on a project's cost and time performance. In a study conducted by Arain and Low (2005), it has been found that the average number of variations were almost 21% more in upgrading projects than that in new projects. The Nepalese construction industry is not different to the global scenario in terms of variation. Almost every construction project experience variation, may be little or significant. Chitwan district has undergone a rapid growth and transformation by experiencing significant number of constructions in the last ten years or so. Big hospitals, resorts, schools, and government buildings were constructed in the city. Large and complex buildings were being built, attracting domestic and foreign-based contractors. This situation is good for the national economy.

However, the construction industry is just blooming, it is obvious to have inexperienced contractors, consultants and even the client. Because having a little experience in construction leads to design and approve the document and plan with insufficient detail resulting in various alterations to plans, specifications, and contractual terms. This had resulted in

variation orders. Rapid development also needs a lot of renovating and upgrading works and as noted earlier, such projects undergo even more variation (Arain and Low, 2005).

But the causes and impact of variation in Nepalese context are least documented. Research done by Arain and Pheng, (2006) categorized the causes in relation into three stakeholders- client, consultant and contractor and an additional category for causes that are not related to any of the contracting parties such as political interference, community interference. Other causes of variation include design errors and omissions, design changes and unforeseen conditions like natural disasters, political strikes, epidemics etc (Ibbs, 1997).

Despite the prevalence of variation orders in the Nepalese construction industry, there is limited documentation on the causes and impacts of variations. Previous studies have categorized causes into three stakeholder groups: client, consultant, and contractor, with an additional category for causes not related to any contracting party, such as political interference or community interference. Causes of variation include design errors and omissions, design changes, and unforeseen conditions like natural disasters, political strikes, and epidemics. There is a lack of research specifically focusing on the causes and impacts of variation orders in building construction projects in Bharatpur Metro. Therefore, this study aims to fill this gap and document the causes and impacts of variation orders in building construction projects in Bharatpur Metro.

Research Objective

The objective of this study is to assess the causes and impacts of variation order in selected projects at Bharatpur Metro for suggestive strategies to minimize variation order.

Literature Review:

Variations are expected to occur in construction projects, even with the best efforts of stakeholders during planning, implementation,

and contract administration (Arain and Low, 2005). Variation orders play a crucial role in project performance and need to be collectively considered by all relevant stakeholders (Arain and Low, 2005). Simply put, a variation refers to a change, modification, alteration, revision, or amendment to the original scope of work, and a variation order is a legal document that modifies the contract and becomes an integral part of the project documentation (Fisk, 1997).

Numerous studies have been conducted by researchers to identify the causes of variation orders, which include the following:

1. Instruction by the owner to carry out additional works.
2. Alterations and changes in plans initiated by the owner.
3. Non-availability of manuals and specifications.
4. Owners' financial problems.
5. Changes in materials and technology.
6. Changes in design by the consultant.
7. Errors and omissions in design.
8. Lack of skilled human resources.
9. Differing site conditions.
10. Contractor's desired profitability (Alnuaimi et al., 2010; Ismail et al., 2012; Hanif et al., 2014).

Ssegawa et al. (2002) found that addition and omission accounted for 45.7% of all variation orders in building projects, making it the most likely cause of variations. The study also highlighted that limitations of space, site access, and personnel replacement had a relatively low impact on causing variations. Causes of omission-related variations were attributed to financial limitations, changes in design, and unfeasible construction techniques originating from the client and consultant.

Several studies have investigated the impacts of variation orders on project performance (Hester et al., 1991; Thomas and Napolitan, 1994; Ibbs, 1995; Ibbs, 1997; Haldun, 1998; Hanna et al., 2002; Arain and Pheng, 2005b; Osman et al., 2009). The top five impacts of variation orders

identified in these studies are:

1. Increase in project cost.
2. Delay in project completion.
3. Delay in payment to contractors and workers.
4. Quality degradation.
5. Increase in overhead expenses.

These impacts highlight the negative consequences of variation orders on project timelines, costs, and quality. In case of different construction projects of Nepal studies on price fluctuation were done by Mishra and Regmi(2017) followed by operations of price adjustments by Mishra et al, 2023 : Chaudhary et al,2023: Mishra and Aithal,2020: Pokharel and Mishra,2020, however, in private building constructions projects were not given much focus.

Methodology

This study will adopt mix design. Quantitative data regarding variations will be collected from the literature review and the project reports or related stakeholders. Data will also be collected from various construction sites. Likewise, Qualitative data acquired from the respondents will be analyzed. Research will be based on the database collected from primary as well as secondary sources, and will relate to the characteristics or relationships of respondents. Qualitative analysis will be carried out by converting the opinion of respondents to numerical data by the use of five point Likert scale. There were around 16 hotels under construction (Source: Municipal office). Out of these 16 hotel construction projects, 3 hotel buildings were selected for this study.

Study population

105 client, consultant and contractors representatives were selected for the questionnaire survey. The face to face questionnaire survey was conducted by the investigator.

Data Analysis

Relative importance Index suggested by Fagbenle et al., 2004 was used as shown in equation 1.

$$RII = \frac{\sum W}{A \times N} \dots\dots\dots(1)$$

W is the mentioned scale for rating a factor by the respondents that ranges from 1 to 5

A is the highest weight in the scale

N is the total number of respondents

Here $W = \frac{1N_1 + 2N_2 + 3N_3 + 4N_4 + 5N_5}{A(N_1 + N_2 + N_3 + N_4 + N_5)}$

Where $N_1 \dots\dots N_5$ are the frequencies of respondents in 5 point Likert scale

Kendall's coefficient of concordance was used to determine the correlations among the contractor, client and consultant representatives. As per Kendall, and Gibbons (1990) it can be expressed as shown in eq 2.

$$W = \frac{S}{\frac{(N^3 - N)K^2}{12}} \dots\dots\dots(2)$$

Where,

$$S = \sum (R_j - \bar{R}_j)^2$$

K = no. of sets of rankings i.e., the number of judges;

N = Number of objects ranked

Result and Discussion

The respondents' opinions were collected and analyzed using statistical tools and techniques. The analysis showed certain relations with various causes and impacts of variation in building construction projects.

Client Related Causes of Variation**Table 1: Client Related Causes of Variation Order**

Owner / Client related causes	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Variations in Scope of work by "Additions, Omissions and Alterations" of the Owner's Requirements	0.927	2	0.933	1	0.950	1	0.937	1
Changes in owners' interests/ requirements	0.964	1	0.840	2	0.850	3	0.879	2
The long waiting time to get approval drawings	0.473	5	0.547	5	0.583	5	0.537	5
Replacement of materials or procedures	0.782	3	0.813	3	0.867	2	0.821	3
Impediment in prompt decision making process	0.636	4	0.680	4	0.617	4	0.647	4

(Source: questionnaire survey, 2077)

Table 1 shows the rank of respondents to the client related causes of variation. The respondents from consultant and contractor believe that the Variations in Scope of work by "Additions, Omissions and Alterations" of the owners requirements was the most common cause of variation, with RII 0.950 and 0.937, respectively, with client ranking this cause as second with RII 0.927. Changes in owners' interests / requirements was assigned first rank by client with RII 0.964, second by consultant

with RII 0.840 and third by contractor with RII 0.850.

However, while considering the overall population, variations in Scope of work by "Additions, Omissions and Alterations" of the Owner's Requirements is the most common and Changes in owners' interests / requirements are two most common causes followed by replacement of materials or procedures with RII 0.937, 0.879 and 0.821, respectively.

Consultant Related Causes**Table 2: Consultant Related Causes of Variation Order**

Consultant related causes	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Change in design and drawings by consultant	0.927	2	0.893	2	0.900	2	0.905	2
Errors and omissions in design	0.982	1	0.920	1	0.967	1	0.953	1
Conflicts between contract documents	0.691	6	0.587	6	0.500	7	0.589	6
Inadequate design team experience	0.745	4	0.800	3	0.750	5	0.768	4
Lack of consultant's knowledge of available material and equipment	0.709	5	0.680	5	0.800	4	0.726	5
Insufficient time for preparation of contract documents	0.418	7	0.493	7	0.600	6	0.505	7
Inadequate working drawing details	0.836	3	0.787	4	0.833	3	0.816	3
Failure to observe all other parties' requirements (water, electricity, etc.)	0.364	8	0.387	8	0.417	8	0.389	8

(Source: questionnaire survey, 2077)

Table 2 shows the rank of responses to the causes related to consultant by the respondents. All three stakeholders agree that errors and omission in design is the main cause of variation order with the same result in overall analysis in the group with overall RII 0.953. Similarly, Change in design and drawings by consultant was ranked second by all groups and the result was same for overall analysis with overall RII 0.905. Failure to observe all parties requirements is being

ranked the least important. If the experience consultant be selected for carrying the DPR and design is followed after completing the DPR in consultation with client committing errors and omissions in design be minimized. However, to save small amount of expenses clients are not interested to prepare DPR, which ultimately causes the error in design and drawing hence variation order incurring delay and larger expenses.

Contractor Related Causes

Table 3: Contractor Related Causes of Variation Order

Contractor related causes	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Improper control over site resource allocation	0.582	4	0.640	4	0.617	3	0.616	4
Sub contract and petty allocation of works	0.764	3	0.773	1	0.667	2	0.737	2
Defective workmanship	0.782	2	0.760	2	0.717	1	0.753	1
Changes in construction method	0.564	5	0.600	5	0.533	5	0.568	5
Contractor's desired profitability	0.818	1	0.760	2	0.617	3	0.732	3

(Source: questionnaire survey, 2077)

The rank of responses to the causes related to contractor by the respondents is shown in Table 3. "Sub contract and petty allocation of works" is ranked first by consultant with RII 0.773, whereas "contractors, desired profitability" is ranked first by client with RII 0.818 and defective workmanship is ranked first by contractor with RII 0.717. Contractors, desired profitability is ranked second by consultant with RII 0.760 and

it was ranked third by contractor with RII 0.617. Overall, defective workmanship was ranked first by overall RII. It could be inferred from the above ranking that defective workmanship is one of the most important causes of variation in construction of buildings. This could be avoided if skilled and trained workers be used by the contractor or training be given to the workers before using them as workforce in construction.

External Causes

Table 4: External Environment Related Causes of Variation Order

External environment related causes	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Weather conditions	0.491	5	0.547	5	0.583	5	0.542	5
Acts of Gods (Floods, Landslides)	0.800	2	0.800	2	0.817	2	0.805	2
Land/Resettlement Problems and other unseen social issues	0.836	1	0.827	1	0.867	1	0.842	1
Time gap between Design and actual Start of Works after bidding and procurement	0.745	3	0.680	3	0.783	3	0.732	3
Interventions of beneficiaries	0.491	5	0.467	6	0.567	6	0.505	6
Intervention of others in the decision making process	0.564	4	0.560	4	0.667	4	0.595	4

(Source: questionnaire survey, 2077)

Under External causes of variation order , Land/ Resettlement Problems and other unseen social issues”, “Acts of Gods (Floods, Landslides)” and “Time gap between Design and actual Start of Works after bidding and procurement “ were

ranked first, second and third by all groups and in overall as well. There is a strong correlation among the groups. The detailed ranking is presented in Table 4.

Table 5: Overall Ranking of top 10 Causes of Variation Order

Causes of Variation Order	Overall	
	RII	Rank
Errors and omissions in design	0.953	1
Variations in Scope of work by "Additions, Omissions and Alterations" of the owner's or client's Requirements	0.937	2
Change in design and drawings by consultant	0.905	3
Changes in owners' interests / requirements	0.879	4
Land/Resettlement Problems and other unseen social issues	0.842	5
Replacement of materials or procedures	0.821	6
Inadequate working drawing details	0.816	7
Acts of Gods (Floods, Landslides)	0.805	8
Inadequate design team experience	0.768	9
Defective workmanship	0.753	10

(Source: questionnaire survey, 2077)

Top 10 causes of variation order are shown in Table 5, Errors and omissions in design was found to be the top causes of variation in the building construction at Bharatpur with RII = 0.953. Similarly, Additions, Omissions and Alterations of the owner's or client's Requirements in the

design was found second top causes of variation order, where as defective workmanship came under top tenth position with RII Value of 0.937 and 0.753, respectively. Whereas, change in design and drawing by consultant was ranked third cause of variation order.

Impacts of Variation Order

Table 6: Impacts of Variation Order

Impacts of variation order	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Completion schedule delay	0.945	1	0.920	1	0.883	2	0.916	2
Increase in project cost	0.927	2	0.907	2	0.933	1	0.921	1
Disputes among professionals	0.691	6	0.693	5	0.700	5	0.695	5
Progress is affected	0.745	4	0.787	3	0.817	3	0.784	3
Increase in overhead expenses	0.782	3	0.787	3	0.783	4	0.784	3
Procurement delay	0.727	5	0.653	6	0.617	6	0.663	6
Quality degradation	0.418	8	0.547	7	0.417	8	0.468	7
Blemish firm's reputation	0.527	7	0.373	8	0.433	7	0.437	8

(Source: questionnaire survey, 2077)

The impacts are ranked as shown in Table 6. Out of eight impacts identified, according to the overall rank, increase in cost of the project and delay in completion, were ranked first and second

where as client and consultant ranked schedule delay as ranked first and contractor as second. Contractor's opinion shows that increase in project cost as the most significant impact where

as this impact ranked second by client and consultant. Increase in overall cost was ranked first in overall analysis with delay in schedule as second. The delay in schedule may be because of slow decision making process regarding the variation approval or denial. Increase in overhead cost and affecting the progress were ranked third in overall ranking causing the high

impact on completion of building construction project on time.

Strategies to Minimize Variation Order

Table 7 shows the RII values from the client, contractor and consultant based on the responses of the statements asked to them.

Table 7: Strategies to Minimize Variation Order

Strategies to minimize Variation Order	Client		Consultant		Contractor		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
The consultant should produce a concluding design and contract document	0.927	1	0.960	2	0.933	2	0.942	1
Carry out detail site investigation including detail soil investigations and consider it during tendering stage	0.818	4	0.947	3	0.900	3	0.895	3
All involved parties should plan adequately before works start on site	0.855	2	0.987	1	0.950	1	0.937	2
Complete the drawings at tendering stage	0.818	4	0.893	8	0.883	4	0.868	6
The consultant should co-ordinate closely at construction stage	0.636	14	0.893	8	0.800	13	0.789	13
Supervise the works with an experienced and dedicated supervisor	0.836	3	0.947	3	0.850	5	0.884	4
Place experienced and knowledgeable executives in the engineering and design department	0.818	4	0.893	8	0.833	9	0.853	8
Consultants should ensure that the design/specifications fall within the approved budget	0.782	9	0.907	6	0.817	12	0.842	9
Clients should provide a clear brief of the scope of works	0.764	10	0.853	12	0.833	9	0.821	10
All parties should forecast unforeseen situations	0.745	11	0.733	14	0.833	9	0.768	14
Enhance communication between all parties	0.745	11	0.880	11	0.750	14	0.800	12
Get accurate information and research with regard to procurement procedure, material and plant	0.745	11	0.840	13	0.850	5	0.816	11
Once the tender is awarded, make no changes to the specifications	0.818	4	0.933	5	0.850	5	0.874	5
Have land purchase and other social issues sorted prior to construction	0.818	4	0.907	6	0.850	5	0.863	7

(Source: questionnaire survey, 2077)

As responses were analyzed for minimization of variation order following top three statements were investigated from client, contractor and consultant. Clients ranked that the consultant should produce a concluding design and contract document with RII 0.927 as rank one, whereas consultant and contractor ranked, all involved parties should plan adequately before works start on site was ranked one with RII 0.987 and 0.950, respectively. Likewise, the consultant should produce a concluding

design and contract document, was ranked first in overall with RII 0.942 and all involved parties should plan adequately before works start on site, was ranked second with RII 0.937, respectively. Similarly, supervise the works with an experienced and dedicated supervisor, was ranked third by client and consultant whereas, carry out detail site investigation including detail soil investigations and consider it during tendering stage, was ranked third by contractors.

Kendall's coefficient of Concordance (W)

Table 8: Kendall's coefficient of Concordance (W)

Parameters	Client related factors	Consultant related factors	Contractor related factors	External related factors	Impacts	Suggestive measures
Respondent group (m)	3	3	3	3	3	3
Items Ranked (n)	5	8	5	6	8	14
Kendall's Coefficient of Concordance (W)	0.889	0.963	0.813	0.910	0.973	0.812

The computed Kendall's coefficient shows high level of agreement between all variation related factors and impact as shown in Table 8.

Conclusion

Among twenty-four causes of variation order identified and analyzed using the Likert scale and RII, the top five causes of variation order were identified as errors and omission in design, changes in owners' interests / requirements, variations in Scope of work by "additions, omissions and alterations" of the client's requirements, changes in design and drawing by consultants and inadequate working drawing details, respectively.

The top three impacts of variation orders identified were; completion schedule delay, increase in project cost, and progress is affected. Considering the responses of all groups in whole, the top five suggestive measures to minimize variation order in building construction project

were found : all involved parties should plan adequately before works start on site, complete the drawings at tendering stage, carry out detail site investigation including detail soil investigations and consider it during tendering stage, once the tender is awarded, make no changes to the specifications and the consultant should produce a concluding design and contract documents.

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