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A Study on Impacts of Variation Order in Construction Projects

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Abstract - *Variation orders are reoccurring phenomenon in construction projects. It refers to as any modification in pre-existing scope of work at any stage of construction. There are numerous causes of variation depending upon various parties involved, project complexity and type of project which can cause disputes and dissatisfaction among parties involved, increase project cost and can also reduce overall project performance. Thus, it is necessary to control variation order. This research aims at determining the important factors that lead to variations, their key effects and suggesting control measures for reduction of the same. Data collection involved a detailed questionnaire survey comprising of 30 causes, 9 effects and 8 control measures identified through comprehensive literature review. Survey was carried out among 66 construction professionals involved with construction projects in Ahmedabad. Data was analyzed in SPSS by mean score analysis method and frequency analysis method and further ranked in MS Excel. The results indicated that the most prominent causes of variation are poor planning, value engineering, project complexity, unavailability of equipments and tools and change of project scope by owner. While major effects of variation on projects are increase in project cost, increase in overhead expenses, decrease in quality of work and decrease in labour productivity. Also most significant measures to control variation order are use of work breakdown structure, reviewing the contract documents prior to construction and freezing the design after a certain stage of construction.*

Key Words: **Variation, Variation order, factors leading to variation, Ahmedabad**

1. INTRODUCTION

In recent years, the construction industry has contributed around 8.0% to Indian GDP. With the development of a dynamic economy, this trend could continue to develop. The increase in personal income will arouse people's interest in residential and commercial real estate and thus increase employment opportunities. Project management mainly focuses on optimizing the time, costs, and quality of the project. It also focuses on the efficient use of all resources necessary for the success of the project. When developing a project, you must make different decisions based on insufficient data or assumptions, and these data or assumptions undoubtedly lead to further changes. Due to the ambiguity of the project parameters, this can lead to vague estimates. The task of managing changes places a heavy burden on project management.

Variation – Definition

Variation in construction can be defined as- "Any alteration or change in pre-existing conditions or requirements on the project. This alteration or modification include cost, time and method of performance." Variation to contractual conditions, design, or construction processes during the execution of the work result in the creation of Variation orders. The Variation order can be described as a written order between units and represents any additional work, omission or change that occurs during execution.

Variation – Causes

The main reasons that can lead to variation compared to the reference works are changes associated with owners/employers, changes associated with design consultants, changes associated with contractors/employees and other changes.

Owner/Employer related variation

Owner-related changes are caused by changes in scope, owner's financial setbacks, inadequate project goals, changes in construction procedures, exchange of materials, changes in owner's specifications and schedule, etc.

- Scope change: This is the key factor for variation on any construction project. The reason for this is that the owner/employer does not keenly participate in the planning and designing phase.
- Financial setbacks of owner: The financial problems of the owner affect the overall growth and the quality of the project. This leads to alterations in work plans and specifications.
- Inadequate project goals: Since designers are limited to a certain extent, they will cause changes in future construction projects.
- Substitution/Exchange of materials and modification in procedure: Material exchange and process changes can lead to changes during the construction phase because certain methods are changed in practice.
- The stubbornness of the owner: A successful construction project involves the participation of every owner in every phase of the project. Pertinacious behaviour of owner leads to changes in every phase of the project.

- Modification in specifications by owner/employer: Changes to specifications are one of the main reasons for variations in construction projects. Changes to the owner's specifications or design requirements during implementation later lead to changes in the project.

Design Consultant-related variation

Due to design errors, conflicts between contractual documents, technological changes, value management, lack of coordination, design complexity, insufficient details on the design drawings, etc., changes can appear due to design consultants.

- Design errors: The changes in design made by the design consultant at each stage affect the overall performance of the project as this is the main reason for the consultant differences.

- Conflicts between contractual documents: Conflicts between contractual documents can lead to misunderstandings (if they are inaccurate) regarding the actual requirements of the project. As a result, this resulted in changes and delays in the project.

- Technological changes: Technological changes lead to changes during the construction phase, as construction techniques change from time to time in order to reach quality and safety parameters.

- Value management: Value management must be done in the design phase. If it is done during construction, it is costly and can lead to cost changes.

- Lack of coordination: in each phase of construction, the lack of coordination between the building parties has a negative impact on the project, which leads to dissatisfaction or even revision in work.

- Complexity of construction: The complexity of construction effects the course of construction activities and requires high skills. If the complexity arises during the construction phase, this can lead to changes.

- Inadequate details in construction drawings: Inadequate details in construction drawings cause misunderstandings about the project requirements during the execution phase, which can lead to changes. So, it must be clear and precise.

Contractor/Employee related variation

Subcontractor variation are caused by a lack of participation, unavailable equipment, unavailable labour, financial difficulties for subcontractors and expected profitability.

- Lack of participation: the participation of the contractor in the design phase is very important to improve the design. Lack of participation can lead to alterations in the design phase.

- Equipment unavailability: this is a supply problem for the contractor and can lead to variations and delays in the project.

- Contractor's economic difficulties: If the contractor's financial situation is unstable and the wages of his employees cannot be paid, this leads to changes during the execution phase.

- Profitability Required: Change is a common source of additional work that entrepreneurs may consider compensating financially. As a result, the contractor's expectations for additional profits have changed.

- Different site conditions: If the contractor cannot see them, different site conditions may increase the difference. For example, the soil conditions of a construction project.

- Lack of communication: Lack of communication between parties is one of the main reasons for changes in construction projects.

Other variations

Certain reasons which indirectly lead to changes in construction projects fall into this category. This includes weather conditions, security aspects, changes in economic conditions, etc.

- Climate Conditions: Bad Climate conditions can affect the project construction process, which can lead to changes and delays and increase costs.

- Safety Considerations: Safety is the most important factor in carrying out a construction project. Ignoring safety rules can lead to variation.

- Changes in economic conditions: In each phase of the project, changes in economic conditions may increase in different phases of construction.

Variation – Effects

The effects of variation can be divided into cost effects, quality effects, time effects, organization effects and other effects.

Effects associated to cost

- Revision in work and demolition
- Late payment
- Rise in project cost

Effects associated to quality

- Quality of over-all project
- Quality of individual activities
- Decrease in labour productivity

Effects associated to time

- Project completion time
- Procurement delay

Effects associated to organization

- Disputes between construction parties
- Increased accident rates

2. LITERATURE REVIEW

[1] (Oladapo, 2007) carried out research work to determine the importance of variation/change as a reason for time and cost overruns. For this purpose, responses from 50 construction experts on causes and subsequent effects of variations were obtained by a questionnaire survey. Also, time and cost data were collected from 30 other project participants. . All the collected data were analyzed using Importance Indices, F-test and t-test. Outcomes show that variation/change had a critical impact and represented 79% of cost escalations and 70% of delay in schedule for the project examined. The outcomes also specified that alterations in specifications and project scope by owners and consultants were the most common source of variation. [2] (Alia Alaryan, 2014), in this study identified variation orders for private and public construction projects in Kuwait. Study includes surveys of owners, contractors and consultants to find the general causes of the changes, their impact on the project and the control measures to deal with changes. Surveyed data was analyzed using Importance Index and performing hypothesis testing. The result show on an average 6%-10% cost overrun occurs due to changes and 10%-20% schedule overrun was also shown. [3] (Oluwaseum Sunday, 2017), in this research aims at determining effect of inaccuracies in design on variation cost by examining the key factors that causes variation. This research was carried out on particular projects by method of case study and personal interview. Personal interviews were conducted with construction experts and data gathered was evaluated with sum, frequency and percentages (%). From the analysis, it is stated that to diminish variation cost, it is essential to ease errors in design calculations which accounted for about 97.8%. [4] (Xavier, 2018) carried out research work to identify the main sources of change order & their impacts that lead to revision of work in Palestine highway projects. For this purpose, Questionnaire form survey was conducted to collect required data and were analyzed using mean score method. According to this study, the two main reasons for change orders were identified as financial setbacks of owner and change of scope by owner. Also the two main effects of change orders identified were cost escalations and increase in duration of project. [5] (Gowrishankar, 2015), in this article aims at identifying various reasons, impacts and control methods of change order. Using a questionnaire survey, required data were collected about causes, impacts and control methods of change order. Analysis of data was done and ranked i.e. ranking of the following causes using II- Importance Index, effects using PI- Prevalence Index and control methods using UI- Utilization Index respectively was done. The results of this research can help the engineers and contractors to increase productivity, to regulate changes in the field and to improve change management process. [6] (Aziz, 2013), in this research aims to discover factors causing variation on projects especially waste-water projects. To achieve this objective, a structured questionnaire survey was performed among various parties i.e. contractors, owners and engineers and data was gathered through personal interviews. The data was analyzed using RII method and ranked the factors driving variation/change in construction cost. The results showed that reasons for cost variation are additional work, change in project design, inadequate site investigation and the drawings are not clear. [7] (Yadeta, 2016), in this study recognized the effects of variation orders/change orders on public construction projects. For this, desk study, interview and questionnaire survey was carried. The desk survey was conducted on five projects, interviewed with experienced participants, experts consulted, questionnaires distributed to the parties involved in the project and the answers analyzed using RII. The results show that delays in the change plan, increased project costs, additional payments to contractors and increased overhead costs are the main effects of change orders. [8] (Aftab Hameed Memon, 2014), carried out research work to determine origins and effects of variation order. For this purpose, a questionnaire survey was circulated among clients, contractors and consultants engaged in projects of PWD department in Malaysia. Collected responses were analyzed with SPSS and Average Index Method. The outcomes indicated that variation orders mainly occurred due to insufficient equipment, poor execution and complexity in design. While most substantial effects were identified as increased project cost, delays in completion schedule and logistics delay. [9] (Offei-Nyako2, 2013), in this research aims at identification of origin of variation; effects of variation on Ghanaian projects and ways to decrease the impact of variation order. This study involves

primary data collection through questionnaire survey and interviews among quantity surveyors, architects and civil engineers. Mean Score Method was used to rank the factors and ANOVA test was used to test for the noteworthy difference between means. The results showed that the main origin of variation were change of design by customer and working details were insufficient. [10] (Eltahir Abu Elgassim Mohammed, 2017), discussed the reasons for variation orders in projects in Sudan. To achieve this purpose, 10 case study analysis coupled with questionnaire survey among consultants, contractors, owners and project managers were performed. The collected was analyzed using weighted Average method and ranked. The result indicated that alteration in design by customers, changes in government rules were the most prominent causes. [11] (Sunday, 2010) in this study investigates the effects of variation/change on projects in relation to managers (i.e. H. insiders and consultants). In order to accomplish desired objective, assessment of relevant literatures combined with survey was done to gather data on significant reasons for variation in projects among consultants, construction professionals and contractors. Analysis of the data was done through relative index and ranked accordingly. The results showed that the major causes of variation are inadequate working drawing details, change of plans by owner and differing site conditions. [12] (Hamzah, 2018), in this study examined the causes of the change order and the parties that led to the change order of the construction project by examining various cases and works in the literature, as well as previous research. The results showed that the parties contribute are owner, consultant and contractor. This can help improve performance in terms of time, cost, and quality of construction projects. [13] (Thakur, 2017), in this research work describes the changes. The causes and effects as well as the waste associated with change orders are also discussed. In accordance with this paper, the variation order is a written contract between the construction company, in which are specified additional work on contractual documents, omissions or reviews, the determination of price and time changes and a description of the type of tasks involved. From the research, the main causes of changes are design inconsistencies, alteration of plan by employers, replacement of materials and procedures, lack of expert manpower and contractor's financial difficulties.[14] (Patrick Keane, 2010) worked on to investigate and analyse the reasons and effects of change orders (variations) in construction projects. To achieve this goal, case studies and questionnaires were carried out with design professionals, customers, and contractors. The data analyzed by ranking it on the basis of percentage. The results showed that causes of variations are inadequate project objectives, error in design, lack of co-ordination and change in specifications during construction. [15] (Ali Alnuaimi, 2010), in this article focuses on investigating various factors causing variation and their effects in Oman's public construction projects. For this purpose, some case studies and form survey was performed among construction professionals and the data was analysed by RII and ranked. The outcomes indicated that the main factor causing variation is additional work, main effect of variation is delay in completion time of project.

3. RESEARCH OBJECTIVES

- To identify the important factors that lead to variation on construction projects in Ahmedabad city.
- To check the effects of the change order on construction projects in Ahmedabad city.
- To recommend control methods to minimize variations on construction projects in Ahmedabad city.

4. RESEARCH METHODOLOGY

The methodology of this research is as follows:

- A comprehensive and in-depth literature review was done and opinions from various construction experts were also taken, through which numerous factors leading to variations were identified. A total of 30 factors that lead to variation, 9 effects and 8 control measures were selected to be included in the survey questionnaire.
- The questionnaire was formulated by reviewing relevant literatures and research papers related to variation in construction. The survey questionnaire consists of four sections: Section one comprises of basic information related to respondent, section two comprises of causes of variations occurring on construction projects, section three comprises of effects of variation on construction projects and section four consists of control methods for minimising variation on construction projects. The respondents were required to give ranking between 1-5 for determining the weight of causes, effects and controls. The questionnaire was validated by experts for the value of information.
- A survey was carried out across construction experts through personal interviews and on online basis in which they were asked to rank these factors according to their experience. A total of 66 construction experts were surveyed, out of which 19 responses were received through personal interviews and 47 were received through online survey.
- Analysis of data was performed in SPSS to identify the main factors that lead to variation and their effect on construction projects. Also, methods to diminish them were also suggested on the basis of data gathered.

4. DATA GATHERING

A collective approach of personal interview and online survey was used to gather required data from construction experts (Consultants, Contractors, Engineers and Project Managers). Over a period of 1 month, 66 responses were collected at a response rate of 100%.

4.1 Questionnaire Design

Excessive efforts and brainstorming was done to formulate the questionnaire. It is divided into four subdivisions. The first section enlists the personal information of respondents such as: Name, Designation, Experience and Type of project they are involved with. The second section contains list of causes of variations occurring on construction projects. The third section contains effects of variation on construction projects and section four consists of control methods for minimizing variation on construction projects. The respondents were asked to rank them in accordance to their frequency of occurrence on the project The rating of most frequent factors corresponds to "very often" whereas least frequent factors corresponds to "never".

5. DATA ANALYSIS AND DISCUSSION

Analysis of gathered data was performed by entering the data in SPSS software. The entered data were analyzed by two methods: [1] Mean Score Analysis [2] Frequency Analysis. In mean score analysis, mean of causes, effects and control measures of variations were calculated and further ranked. In frequency analysis, all the variables i.e. all the 30 causes, 9 effects and 8 control measures stated in questionnaire were combined by "Multiple Response" which gave a single response variable for all the causes, effects and controls respectively that eased to calculate the frequencies. Further frequencies in percentage were obtained in SPSS and later ranked. Also, Reliability Test was performed in SPSS to check the internal consistency using Cronbach's Alpha.

5.1 Mean Score Analysis

Scores are a way to utilize the collected data for analysis. By assigning a score to each question code, makes it easier and simpler to analyze the data. Mean score analysis refers to calculating the arithmetic mean of the data to measure central tendency.

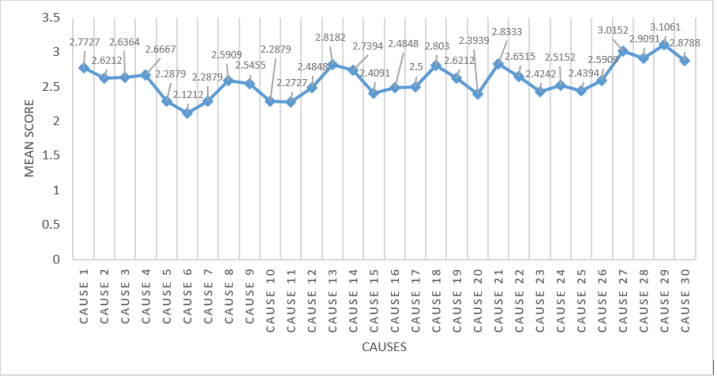

Chart -1: Mean Scores – Causes

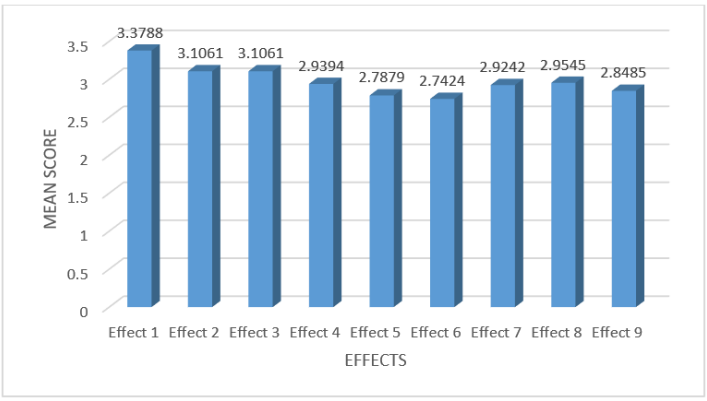

Chart -2: Mean Scores – Effects

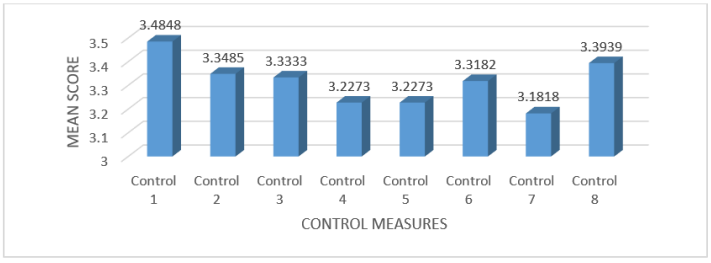

Chart -3: Mean Scores – Control Measures

The top five factors that cause variation order comes up to be: technology changes having mean score 3.1061 (rank-1), value engineering having mean score 3.0152 (rank-2), weather conditions having mean score 2.9091 (rank-3), differing site conditions having mean score 2.8788 (rank-4) and project complexity having mean score 2.8333 (rank-5). Table 1 shows the top five causes of variation order.

Table -1: Ranking of top five causes that lead to variation by mean score analysis

Sr. no.	Name	Mean Score	Rank
1	Technology changes	3.1061	1

2	Value engineering	3.0152	2
3	Weather conditions	2.9091	3
4	Differing site conditions	2.8788	4
5	Project complexity	2.8333	5

The top five effects of variation order comes up to be: increased project cost having mean score 3.3788 (rank-1), increase in duration of individual activities and increased overhead expense having mean score 3.1061 (rank-2), delay in payment having mean score 2.9545 (rank-4), decreased labour productivity having mean score 2.9394 (rank-5). Table 2 shows the top five effects of variation order.

Table -2: Ranking of top five effects of variation by mean score analysis

Sr. no.	Name	Mean Score	Rank
1	Increased project cost	3.3788	1
2	Increase in duration of individual activities	3.1061	2
3	Increased overhead expense	3.1061	2
4	Delay in payment	2.9545	4
5	Decreased labour productivity	2.9394	5

The top five control measures for reducing variation order comes up to be: contract documents are reviewed properly having mean score 3.4848 (rank-1), proper justification of variation having mean score 3.3939 (rank-2), procedure for handling variation order are clear from beginning having mean score 3.3485 (rank-3), scope of variation is made clear having mean score 3.3333 (rank-4) and variation order is strictly negotiated by knowledgeable person having mean score 3.3182 (rank-5). Table 3 shows the top five control measures for reducing variation order.

Table -3: Ranking of top five control measures of variation by mean score analysis

Sr. no.	Name	Mean Score	Rank
1	Contract documents are reviewed properly	3.4848	1
2	Proper justification of variation	3.3939	2
3	Procedure for handling variation order are clear from beginning	3.3485	3
4	Scope of variation is made clear	3.3333	4
5	Variation order is strictly negotiated by knowledgeable person	3.3182	5

5.2 Frequency Analysis

In statistics, frequency can be termed as number of times an event occurs. It is a vital area of statistics that deal with occurrences and estimates percentiles and central tendencies. Frequency analysis is a part of descriptive analysis.

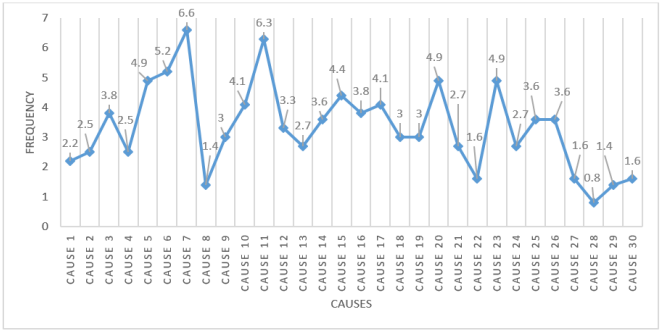

Chart -4: Frequencies – Causes

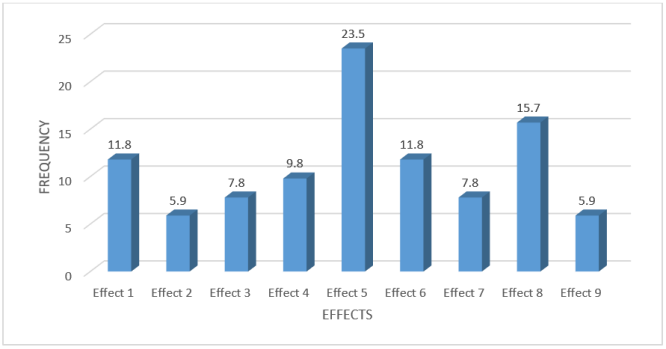

Chart -5: Frequencies – Effects

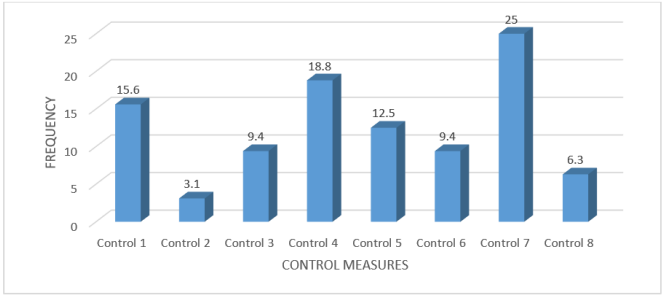

Chart -6: Frequencies – Control Measures

The top five factors that cause variation order comes up to be: poor planning with percentage frequency 6.6 (rank-1), equipment and tools required are unavailable with percentage frequency 6.3 (rank-2), scope of work for contractors is not well-defined with percentage frequency 5.2 (rank-3), changes of scope by owner and design and construction criteria is outdated with percentage frequency 4.9 (rank-4). Table 4 shows the top five causes of variation order.

Table -4: Ranking of top five causes that lead to variation by frequency analysis

Sr. no.	Name	Frequency [in %]	Rank
1	Poor planning	6.6	1
2	Equipment are tools required are unavailable	6.3	2
3	Scope of work for contractors is not well-defined	5.2	3
4	Changes of scope by owner	4.9	4
5	Design and construction criteria is outdated	4.9	4

The top five effects of variation order comes up to be: decrease in quality with percentage frequency 23.5 (rank-1), delay in payment with percentage frequency 15.7 (rank-2), increased project cost and disputes between owners and contractors with percentage frequency 11.8 (rank-3), decreased labour productivity with percentage frequency 9.8 (rank-5). Table 5 shows the top five effects of variation order.

Table -5: Ranking of top five effects of variation by frequency analysis

Sr. no.	Name	Frequency [in %]	Rank
1	Decrease in quality	23.5	1
2	Delay in payment	15.7	2
3	Increased project cost	11.8	3
4	Disputes between owners and contractors	11.8	3
5	Decreased labour productivity	9.8	5

The top five control measures for reduction of variation order comes up to be: use of work breakdown structure with percentage frequency 25 (rank-1), freeze design after certain stage with percentage frequency 18.8 (rank-2), contract documents are reviewed properly with percentage frequency 15.6 (rank-3), monthly reports or meetings with percentage frequency 12.5 (rank-4), variation order is strictly negotiated by knowledgeable person with percentage frequency 9.4 (rank-5). Table 6 shows the top five control measures for reduction of variation order.

Table -6: Ranking of top five control measures of variation by frequency analysis

Sr. no.	Name	Frequency [in %]	Rank
1	Use of work breakdown structure	25	1
2	Freeze design after certain stage	18.8	2
3	Contract documents are reviewed properly	15.6	3
4	Monthly reports or meetings	12.5	4
5	Variation order is strictly negotiated by knowledgeable person	9.4	5

5.3 Reliability Test

Table -7: Reliability test statistics for causes of variation order

Cronbach's Alpha	N of Items
0.937	30

The reliability co-efficient (Cronbach's Alpha) comes to 0.937 which is acceptable. [if cronbach's alpha is between 0.70 and 1.00 ; it is acceptable]. Also, this shows that the items i.e. the causes have relatively high internal consistency.

Table -8: Reliability test statistics for effects of variation order

Cronbach's Alpha	N of Items
0.899	9

The reliability co-efficient (Cronbach's Alpha) comes to 0.899 which is acceptable. [if cronbach's alpha is between 0.70 and 1.00 ; it is acceptable]. Also, this shows that the items i.e. the effects have relatively high internal consistency.

Table -9: Reliability test statistics for control measures of variation order

Cronbach's Alpha	N of Items
0.917	8

The reliability co-efficient (Cronbach's Alpha) comes to 0.917 which is acceptable. [if cronbach's alpha is between 0.70 and 1.00 ; it is acceptable]. Also, this shows that the items i.e. the control measures have relatively high internal consistency.

6. CONCLUSIONS

Variation has a huge impact on construction industry. It is one of the main cause of conflict on site. By recognizing the factors causing variations, overall project performance can be improved and also disputes arising on sites can be reduced. Also, by understanding the nature of variation order in any project, their impacts can be known before-hand and steps for controlling them can be taken when necessary. And by effective project management, impacts of variation orders on schedule and cost of project can be minimized to a certain extent. Based on the findings of this study, it can be concluded that:

- Out of all the factors causing variation on a construction project, the most important factors responsible for causing variation came up to be value engineering, project complexity, improper/poor planning, technology changes, unavailability of equipments and tools, differing site conditions, alteration/change of scope by owner, scope of work not well-defined and lastly weather conditions.

- Major impacts/effects due to occurrence of variation order are increased project cost, increased duration of individual activity, increased overhead expense, decreased labour productivity, reduction in quality of work and sometimes disputes among various parties involved.

- Also, control measures to reduce occurrence of variation order on a project suggested by various construction parties through the questionnaire survey came up to be proper justification of variation, use of work breakdown structure, checking the contract documents prior to construction, freezing the design after certain stage on construction and by conducting periodic meetings between parties involved.

- Further by doing reliability test, the value of cronbach's alpha for the data received through questionnaire for causes of variation order, effects of variation order and control measures to reduce variation order came up as 0.937, 0.899 and 0.917 respectively. This indicates that the data received have relatively high internal consistency as the values of cronbach's alpha in every case is greater than the acceptable limit of 0.70.

7. Recommendations

[1] Work breakdown structure helps in proper management of all project activities. By using work breakdown structure as a part of planning, flow of activities can be made smooth and project objectives can be accomplished. [2] By conducting periodic meetings, project progress can be known periodically and if any changes to be made in planning activities for future scope of work can be known and can be planned effectively. [3] By adapting new technologies on project, quality of work can be increased as it proves to be more accurate than manual practices. [4] Job plan is a systematic way to study various aspects of project and so by doing that occurrence of variation at any stage of activity can likely be determined by reviewing contract documents and creating alternatives for said variation prior to the construction. This will help in formulating a process for handling specific variation and can reduce the cost and time overrun. [5] Proper planning and using work breakdown structure will give an idea of when and which equipment to be used according to the scheduled project. This will make it easier to rent or lease the required equipment before-hand which can be helpful in reducing of cost and time overrun which in-turn can minimize or completely eliminate the occurrence of variation in a project because of unavailability of equipment. [6] Rework and demolition plays an important role is increasing variation in cost on construction project. This occurs due to not freezing the design at a certain stage. Many times contractors hesitate to execute the work given to them as they fear of revisions. This has an impact on duration of activity, labour productivity and can also cause dispute between owner and contractor. Thus, scope of work for contractor shall be made clear to avoid such circumstances on project and to create a healthy working environment. [7] Owners should understand the complexity of construction i.e. they should take into account the impacts of their decisions on their projects. Owners should state their requirements prior to execution of construction to ease the execution process, avoid rework and maintain a smooth flow of work and a healthy working environment. [8] At the time of preparing contract document, the scope of variation under such situations should be mentioned clearly so as to take measures accordingly and reduce conflicts between parties involved.

REFERENCES

1. Alaryan, A., Emadelbeltagi, Elshabat, A. and Dawood, M (2014) Causes and effects of change orders on construction projects in Kuwait, International Journal of Engineering Research and Applications, Vol.4 No.7, pp. 01-08.
2. Alnuaimi, A., Taha, R., Mohsin, M. and Al-Harthi, A. (2010) Causes, effects and remedies of change orders on public construction projects in Oman, Journal of Construction Ebgineering and Management, Vol.136 No. 5 .
3. Asamaoh, R. O. and Offei-Nyako, K. (2013) Variation determinants in building construction: Ghanaian professionals' perspective, Journal of Construction Engineering and Project Management.
4. Aziz, R. F. (2013) Factors causing cost variation for constructing wastewater projects in Egypt, Alexandria Engineering Journal, Vol.52, pp. 51-66.
5. Gobana, A. and Thakur, A. S. (2017) Critical review on causes and effects of variation order on construction project, International Research Journal of Engineering and Technology, Vol.4 No.12.
6. Gokulkarthi, M. and Gowrishankar, K. S. (2015) A study on impacts of change order in construction projects, International Journal of Science and Engineering Research, Vol.3 No.4.
7. Kaene, P., Sertyesilisik, B., Ross, A. (2010) Variations and change orders on construction projects, Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, pp. 89-96.
8. Memon, H. M., Rahman, I. A. and Abul hasan, M. H. (2014) Significant causes and effects of variation orders in construction projects, Research Journal of Applied Sciences, Engineering and Technology, Vol.7 No.21.
9. Mohammad, E., Mohammad, S. Y. and Hassan, A.S. (2017) Factors causing variation orders in building projects in Khartoum state-Sudan, International Journal of Engineering Sciences and Research Technology, Vol.6 No.11.
10. Mohammad, N. and Hamzah, Z. (2019) A review of causes of variation order in the construction of terrace housing projects in Malaysia, EDP Sciences.
11. Oladapo, A. (2007) A quantitative assessment of the cost and time impact of variation orders on construction projects, Journal of Engineering, Design and Technology, Vol. 5 No.1, pp.35-48 (6).
12. Sunday, O., Dosumu and Aigbavboa (2017) Impact of design errors on variation cost of selected building project in Nigeria, Elsevier.
13. Sunday, O. A. (2010) Impact of variation order on public construction projects, Elsevier.
14. Varghese, A. and Xavier, S. (2018) Study of causes and effects of change orders in construction sites, International Journal of Scientific & engineering Research, Vol.9 No.4.
15. Yadeta, A. E. (2016) The impacts of variation orders in public building projects, International Journal of Construction Engineering and Management, Vol.5 No.3, pp. 86-91.

BOOKS

[1] Kothari, C.R. (2004) Research Methodology: Methods and Techniques. 2nd revised ed. New Age International (P) Limited.