



Research Paper

Experimental Analysis of Variations in Construction Projects in Nashik Region

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ABSTRACT: A significant issue in construction projects is change requests or variety orders. It is common in a wide range of construction project and assumes a significant part in deciding the last expense and term of project. The research investigates the reasons of variances in building projects in Nashik, studies their impacts on the projects, and suggests solutions to connected issues. A survey of 60 construction sites was done using a questionnaire that included 30 consultants and 30 contractors in order to collect the opinions of consultants and contractors in the industry. The investigation had the option to disengage 24 basic reasons for changes in orders. It was resolved that "customer's extra work, course change or degree by expert and adjustments to configuration" were the main sources of progress request. This research looked into a variety of aspects that should be synthesized using AHP analysis. Analytical Hierarchy Process (AHP) is a multiple-criteria decision-making process that uses pairwise comparisons to provide priority ratings among elements that cause variation orders and their impacts on building projects. This study presents the results of a systematically collected data through construction sites of Nashik region and it is hope that it will contribute to many areas of construction industries throughout the states and country.

KEYWORDS: Analytical Hierarchy Process (AHP); Defect Liability Period (DLP); Variation Factors: Public project: Private project: Likert Scale Analysis

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I. INTRODUCTION

The construction industry is currently dealing with a number of challenges, beginning with conceptual design and continuing through project completion, including the defect liability period (DLP), which is also defined in the document contract [1]. The entirety of the previously mentioned concerns will affect the project's success. The project performance can be estimated from the cost, time, quality, efficiency factor and so forth. Effective administration of variety orders and claims start even before beginning of development [4]. Variation orders are one of the most important difficulties in the construction business since they have a significant influence on the project's cost and schedule. The goal of this research is to eliminate or at the very least minimize such concerns to a minimal or acceptable level. Furthermore, these concerns will cast an unfavorable light on the separate professions of architects, engineers, quantity surveyors, and all other parties involved in the building sector. Variation orders should be avoided or minimized to ensure that project performance remains as stipulated in the contract [2,5].

Variation order is one of the significant issues in our construction industry. Project postponement and cost invade are the most widely recognized effect that has happened because of variety request. Taking into account the abovementioned, there are different causes could prompts those effects and this examination is to recognize the reason for variety orders during the development stage. Moreover, it is to zero in on those causes that are identified with the shortcomings in the pre-construction stage [6,3]. As there are a major number of gatherings that includes in these two stages, likely event of variation order can't be stayed away from anyway can be limit with the help by the individuals who is include in the business. As referenced above, there are numerous different elements that added to the variation order issues and could makes serious effect the undertaking for example project delay, cost overwhelm, low quality of workmanship, low productivity and presumably resistance to the safety and healthy prerequisite. This research will concentrate on the most prevalent consequences, which include project delays and cost overruns. Furthermore, measures for minimizing the incidence of variation orders during the pre-construction stage will be investigated. [7].

Construction modification orders are issued for a variety of reasons in major building construction contracts. It might be the result of the owner's requirements evolving further. It might be due to a lack of availability, a delay in receiving essential supplies, or the need to amend contract document flaws and omissions. Understanding the causes of variation order is critical for avoiding or minimizing future project modifications [8]. The purpose of this research is to look into the causes and consequences of construction modification orders in big construction projects. This examination will help the two owners and contractors for hire to design successfully prior to beginning a project and during the plan stage to limit and control changes and change impacts. This examination will likewise establish the framework for additional investigation regarding the matter [9].

The extent of study for this point will be an investigation on the reasons for variation orders on construction project. Study on the reasons for the variety orders will be identified with the impacts that happen after the variety orders are taken. The space of work of the examination will zeroed in on four contextual analyses of development projects that engaged with variety orders works. Data will be gathered via journals, articles, the internet, and questionnaires filled out by associated professionals who are knowledgeable about the issues. Following the comprehensive study, an appropriate remedy will be provided and proposed to reduce the difficulties caused by variation orders. [10].

II. METHODOLOGY

The study will be carried out by conducting questionnaire interviews with construction businesses, rating reasons that cause variance orders and their consequences according to their relevance, and determining which element has a large and small influence on building projects. [11].

2.1 Likert Scale Analysis

Step 1- Specify the variables that produce variation: The research was able to recognize 24 major reasons of order alterations. A complete list of the effects of variant orders was developed based on a review of prior works, which included documented observations, opinions, and perspectives from numerous professionals and professionals with over 20 years of experience in the subject [12]. From the perspective of all project participants, these reasons were assessed using a mean score and relative importance index.

Step 2- Collection of Data: A survey study was conducted at 70 building sites in Maharashtra's Nashik district (India). The bulk of these companies work on residential and commercial construction projects. The poll was conducted among the firms' clients, consultants, and contractors. The respondents were quantity surveyors, lecturers, directors, site managers and civil engineer. The poll was separated into four fundamental parts. The initial segment mentioned foundation data about respondents, the subsequent part centered on reasons for variety arranges, the third part analyzed the impacts of variety orders and fourth part examined controls of variety orders in construction projects [13].

Step 3- Data Analysis: The evaluation of the mean score and relative important index revealed the overall ranking of the most significant elements causes, impacts, and techniques of variation orders control on construction projects.

The mean score for each factor was calculated by the following formula:

$$MS = \frac{\sum F \times S}{N} \quad \dots (1)$$

Where,

S = Score assigned a score to each element ranging from 1 to 5, with 1 indicating strongly disagree and 5 indicating strongly agree;

F = Frequency of responses to each rating 1to5 for each factor; and N is total number of respondents for that factor.

The following equation was used to determine the relative important index. According on survey results, this equation was used to calculate the relevance of variation factors [15].

$$RII = \frac{\text{Total Point Score}}{5 \times N} \quad \dots (2)$$

Table No. 1. Causes of Variation Orders in Construction Projects

Sr. No.	Causes of Variation Orders
1	Change of plans by owner
2	Owner's financial problems
3	Owner's change of schedule
4	The objective of the project is not well defined
5	Substitution of materials or procedures
6	Conflict between contract documents

7	Change in design by consultant
8	The scope of work for the contractor is not well defined
9	Errors and omissions in design
10	The lack of coordination between contractor and consultant
11	Value engineering
12	Technology changes
13	Differing site conditions
14	Contractor's desire to improve his financial situation
15	The contractor's financial difficulties
16	The required labour skills are not available
17	The required equipment and tools are not available
18	Workmanship or material not meeting the specifications
19	Poor project management by contractor
20	Lack of involvement in design by contractor
21	Overcrowded work area
22	Safety consideration
23	Weather conditions
24	Acceleration of work
25	New government regulations
26	Change in economic conditions
27	Unforeseen problems
28	Strikes
29	Socio-cultural factors
30	Political pressure
31	Conflict in project site

2.2 AHP Analysis

Prof. Thomas L. Saaty invented the Analytic Hierarchy Process (AHP), which is a multi-criteria decision-making process. In a nutshell, it's a technique for calculating ratio scales from paired comparisons. Actual measurements, such as price and weight, or subjective opinions, such as satisfaction sentiments and preferences, might be used as input. AHP allow some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value.

Then, the following steps of AHP Analysis are as follows:

1. Synthesizing the pair-wise comparison matrix
2. Calculating the priority vector for a criterion such
3. Calculating the consistency ratio
4. Calculating λ_{max}
5. Calculating the consistency index CI
6. Selecting appropriate value of the random consistency ratio from

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

7. Checking the consistency of the pair-wise comparison matrix to check whether the decision maker's comparisons were consistent or not.

Table No. 2. Pair-wise comparison matrix for Owner related VO factors

Pair-wise comparison matrix for Owner related VO factors						
ORF	A	B	C	D	E	
A	1					
B		1				
C			1			
D				1		
E					1	

1. Owner Related Factors

Table No. 3. Owner Related Factors

Code	Description
A	Substitution of materials or procedures
B	Change of plans by owner
C	Owner's change of schedule
D	Owner's financial problems
E	The objective of the project is not well defined

2. Consultant Related Factors

Table No. 4. Consultant Related Factors

Code	Description
A	Errors and omissions in design
B	Lack of coordination between contractor and consultant
C	Change in design by consultant
D	Conflict between contract documents
E	Technology changes
F	The scope of work for the contractor is not well defined

3. Contractor Related Factors

Table No. 5. Contractor Related Factors

Code	Description
A	Contractor's desire to improve his financial situation
B	The contractor's financial difficulties
C	The required labour skills are not available
D	Differing site conditions
E	Workmanship or material not meeting the specifications
F	The required equipment and tools are not available

4. Miscellaneous Factors

Table No. 6. Miscellaneous Factors

Code	Description
A	Change in government rules and regulations
B	Safety consideration
C	Political pressure
D	Weather conditions
E	Socio-cultural factors
F	Change in economic conditions

III. RESULTS

RII and AHP analysis average score and weightage of causes, effects and controls of variation orders are comparing as per consultant's and contractor's view in private and public projects. According to weightage important factors causing variation orders in private and public projects are identified.

3.1 Comparison of Factors Causing Variation Orders in Private Projects

Table No. 7. Ranking of causes of variation orders as Consultant's and Contractor's view

Sr. No.	Factors Causing Variation Orders	Ranking by Consultant	Ranking by Contractors
Owner Oriented			
1	Change of plans by owner	1	1
2	Owner's financial problems	3	5
3	Owner's change of schedule	4	7
4	The objective of the project is not well defined	13	12
5	Substitution of materials or procedures	2	3
Designer Oriented			
6	Conflict between contract documents	7	6
7	Change in design by consultant	10	4
8	The scope of work for the contractor is not well defined	12	10
9	Errors and omissions in design	6	2
10	Lack of coordination between contractor and consultant	5	8
11	Value engineering	11	11
12	Technology changes	18	14
Contractor Oriented			
13	Differing site conditions	14	9
14	Contractor's desire to improve his financial situation	9	15
15	The contractor's financial difficulties	8	18
16	The required labor skills are not available	15	16
17	The required equipment and tools are not available	19	19
18	Workmanship or material not meeting the specifications	17	13
Miscellaneous			
19	Safety consideration	16	21
20	Weather conditions	20	22
21	Change in government rules and regulations	21	17
22	Change in economic conditions	24	24
23	Political pressure	22	20
24	Socio-cultural factors	23	23

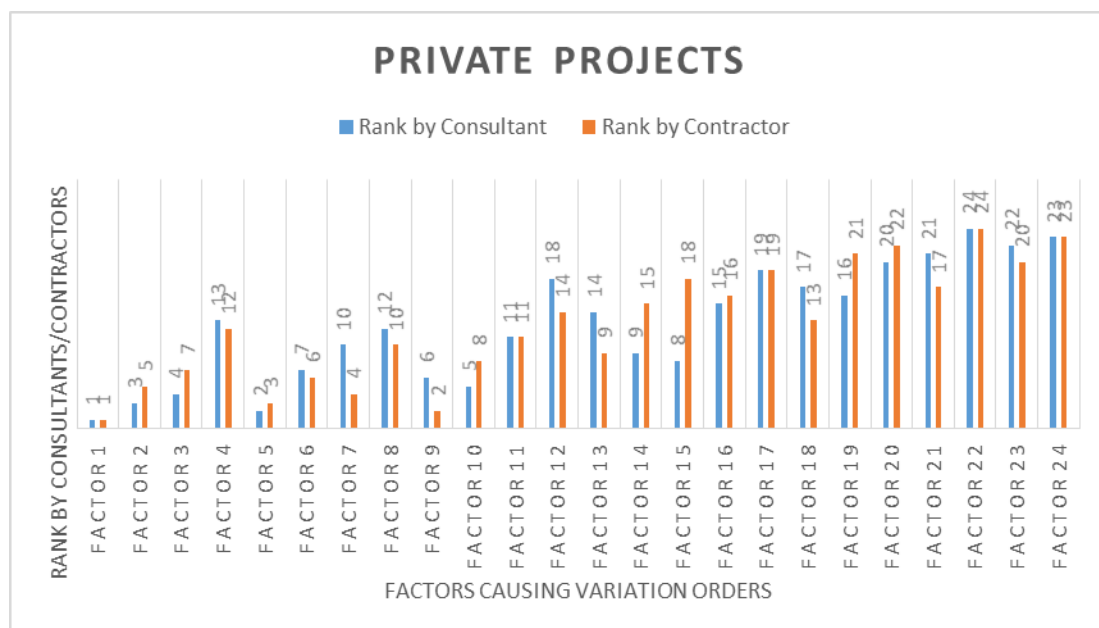


Fig. 1. Ranking of causes of variation orders as Consultant's and Contractor's view

3.2 *Comparison of Factors Causing Variation Orders in Public Projects*

Table No. 8. Ranking of causes of variation orders as Consultant's and Contractor's view

Sr. No.	Factors Causing Variation Orders	Ranking by Consultants	Ranking by Contractors
Owner Oriented			
1	Change of plans by owner	1	1
2	Owner's financial problems	3	2
3	Owner's change of schedule	2	6
4	The objective of the project is not well defined	9	14
5	Substitution of materials or procedures	5	5
Designer Oriented			
6	Conflict between contract documents	6	9
7	Change in design by consultant	14	3
8	The scope of work for the contractor is not well defined	15	15
9	Errors and omissions in design	8	4
10	Lack of coordination between contractor and consultant	7	13
11	Value engineering	20	17
12	Technology changes	21	21
Contractor Oriented			
13	Differing site conditions	10	7
14	Contractor's desire to improve his financial situation	11	18
15	The contractor's financial difficulties	13	16
16	The required labor skills are not available	12	20
17	The required equipment and tools are not available	19	19
18	Workmanship or material not meeting the specifications	4	12
Miscellaneous			
19	Safety consideration	23	24
20	Weather conditions	24	23
21	Change in government rules and regulations	17	10
22	Change in economic conditions	22	22
23	Political pressure	16	8
24	Socio-cultural factors	18	11

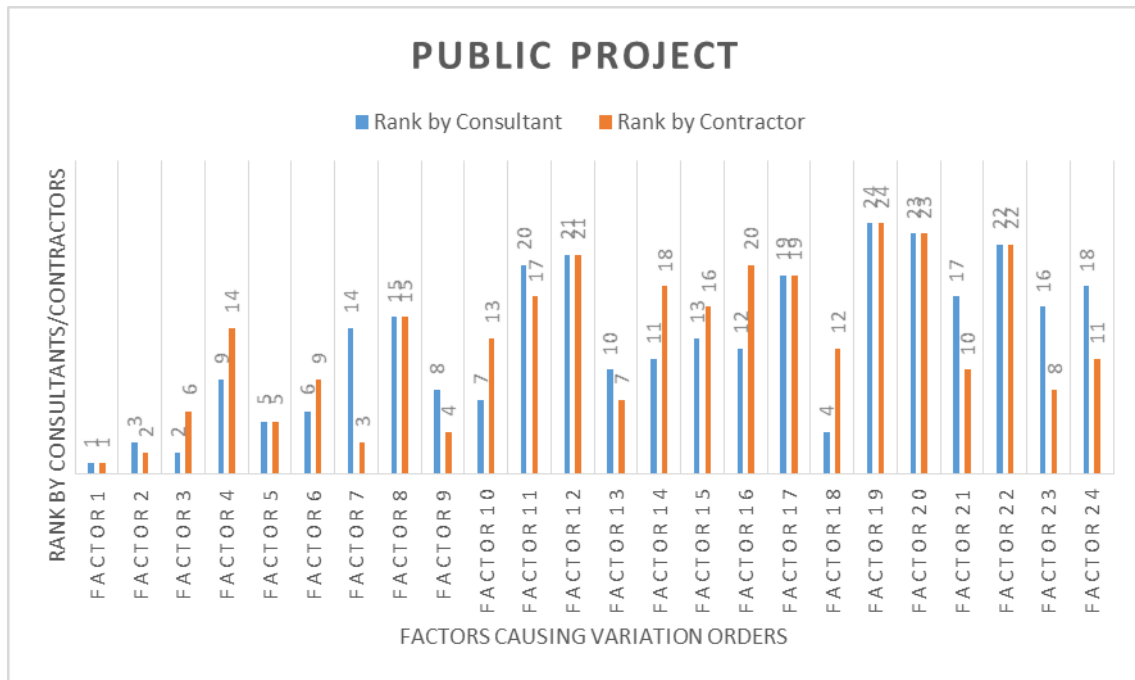


Fig. 2. Ranking of causes of variation orders as Consultant’s and Contractor’s view

3.3 Likert Scale Analysis

1. RII of factors causing variation orders as Consultant’s view for Private project

Table No. 9. RII of causes of variation orders as per Consultant's view

Sr. No.	Factors Causing Variation Orders	Consultant's view							R
		5	4	3	2	1	MS	RII	
Owner Oriented									
1	Change of plans by owner	14	8	5	1	2	4.03	82.02	1
2	Owner’s financial problems	11	8	7	3	2	3.74	75.96	3
3	Owner’s change of schedule	10	8	7	3	2	3.70	75.13	4
4	The objective of the project is not well defined	8	7	8	5	2	3.47	70.31	13
5	Substitution of materials or procedures	11	10	4	3	2	3.83	77.89	2
Designer Oriented									
6	Conflict between contract documents	10	9	6	3	3	3.65	73.32	7
7	Change in design by consultant	9	8	6	4	3	3.53	71.02	10
8	The scope of work for the contractor is not well defined	9	9	5	5	3	3.52	70.66	12
9	Errors and omissions in design	10	8	5	5	2	3.63	73.76	6
10	Lack of coordination between contractor and consultant	10	8	6	4	2	3.67	74.44	5
11	Value engineering	8	7	5	4	4	3.39	67.42	18
12	Technology changes	8	7	7	5	2	3.48	70.68	11
Contractor Oriented									
13	Differing site conditions	7	8	8	5	2	3.43	69.62	14
14	Contractor’s desire to improve his financial situation	9	8	8	3	3	3.55	71.32	9
15	The contractor’s financial difficulties	9	8	7	3	3	3.57	71.71	8
16	The required labor skills are not available	9	7	5	6	3	3.43	68.96	15
17	The required equipment and tools are not available	7	9	3	5	6	3.20	62.13	19
18	Workmanship or material not meeting the specifications	8	6	6	8	2	3.33	67.56	17
Miscellaneous									
19	Safety consideration	8	7	6	6	3	3.37	67.58	16

20	Weather conditions	5	9	5	4	7	3.03	58.02	20
21	Change in government rules and regulations	5	6	7	5	7	2.90	55.27	21
22	Change in economic conditions	3	5	7	7	8	2.60	48.40	24
23	Political pressure	4	5	8	5	8	2.73	51.16	22
24	Socio-cultural factors	5	5	4	8	8	2.70	50.47	23

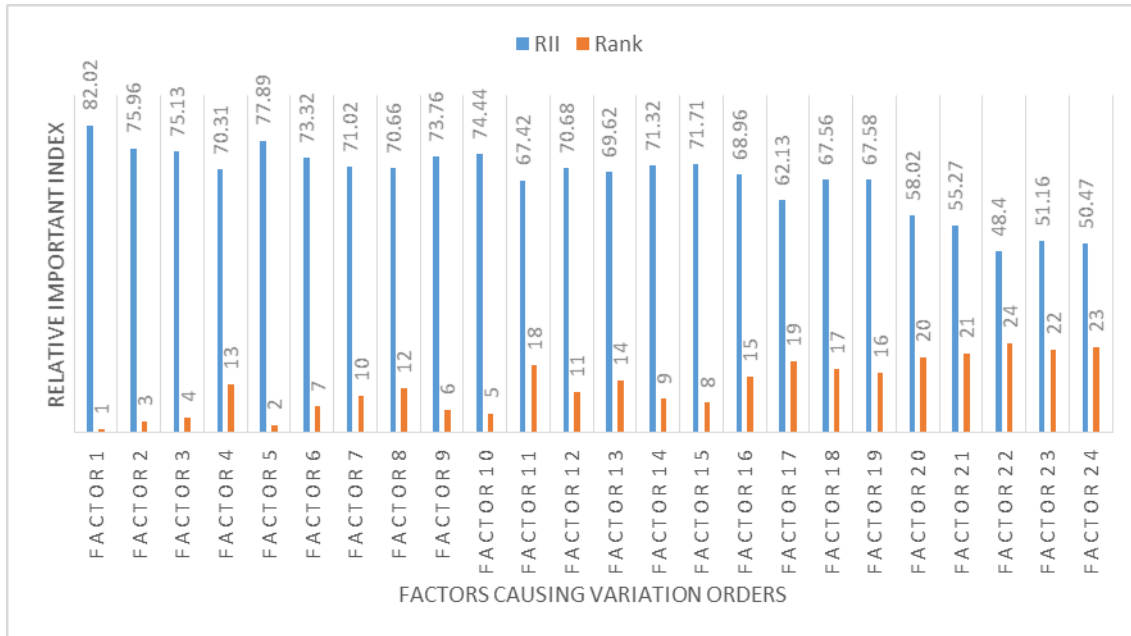


Fig. 2. Rank and RII of factors causing variation orders as Consultant's view

2. RII of factors causing variation orders as Consultant's view for Public projects

Table No. 10. RII of causes of variation orders as per Consultant's view

Sr. No.	Factors Causing Variation Orders	Consultant's View							R
		5	4	3	2	1	MS	RII	
Department Oriented									
1	Change of plans by Government authority	14	6	5	2	1	4.07	83.62	1
2	Financial problems for project	11	9	6	3	2	3.77	76.63	3
3	Change of schedule by Government authority	11	10	4	3	2	3.83	77.89	2
4	The objective of the project is not well defined	9	8	8	3	3	3.55	71.32	9
5	Substitution of materials or procedures	10	8	6	4	2	3.67	74.44	5
Designer Oriented									
6	Conflict between contract documents	10	8	5	5	2	3.63	73.76	6
7	Change in design by consultant	7	8	8	5	2	3.43	69.62	14
8	The scope of work for the contractor is not well defined	9	7	5	6	3	3.43	68.96	15
9	Errors and omissions in design	9	8	7	3	3	3.57	71.71	8
10	Lack of coordination between contractor and consultant	10	9	6	3	3	3.65	73.32	7
11	Value engineering	5	9	5	4	7	3.03	58.02	20
12	Technology changes	5	6	7	5	7	2.90	55.27	21
Contractor Oriented									
13	Differing site conditions	9	8	6	4	3	3.53	71.02	10
14	Contractor's desire to improve his financial situation	8	7	7	5	2	3.48	70.68	11
15	The contractor's financial difficulties	8	7	8	5	2	3.47	70.31	13
16	The required labor skills are not available	9	9	5	5	3	3.52	70.66	12
17	The required equipment and tools are not available	7	9	3	5	6	3.20	62.13	19
18	Workmanship or material not meeting specifications	11	8	5	4	2	3.73	75.82	4
Miscellaneous									
19	Safety consideration	3	5	7	7	8	2.60	48.40	24

20	Weather conditions	5	5	4	8	8	2.70	50.47	23
21	Change in government rules and regulations	8	6	6	8	2	3.33	67.56	17
22	Change in economic conditions	4	5	8	5	8	2.73	51.16	22
23	Political pressure	8	7	6	6	3	3.37	67.58	16
24	Socio-cultural factors	8	7	5	4	4	3.39	67.42	18

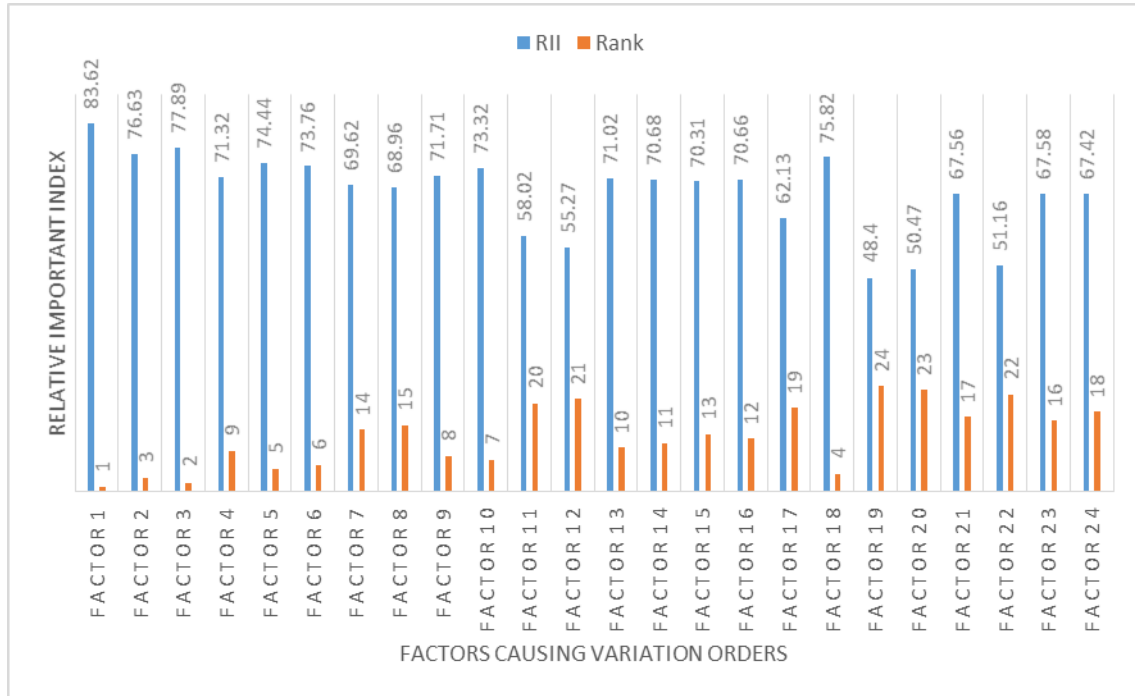


Fig. 4. Rank and RII of factors causing variation orders as Consultant's view

3.4 AHP Analysis

A. Variation Order factors for Private Projects (Consultant's view)

1) Owner Related Factors

Table No.11. Owner Related Factors

ORF1	A	B	C	D	E
A	1	1/3	3	3	5
B	3	1	3	3	7
C	1/3	1/3	1	1/3	3
D	1/3	1/3	3	1	5
E	1/5	1/7	1/3	1/5	1
Column Totals	4.8667	2.1429	10.3333	7.5333	21.0000

Table No. 12. Consistency check for ORF

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.223	22.3%	Consistency OK	1.0841	5.4303	0.1075
0.463	46.3%	10%	0.9925		
0.112	11.2%		1.1576		
0.152	15.2%		1.1445		
0.050	5.0%		1.0514		

2) Consultant Related Factors

Table No. 13. Consultant Related Factors

CNRF2	A	B	C	D	E	F
A	1	1/3	3	3	5	7
B	3	1	3	3	7	9
C	1/3	1/3	1	1/3	3	9
D	1/3	1/3	3	1	5	5
E	1/5	1/7	1/3	1/5	1	1
F	1/7	1/9	1/9	1/5	1	1
Column Totals	5.0095	2.2540	10.4444	7.7333	22.0000	32.0000

Table No. 14. Consistency check for CNRF2

AHP	Consistency check	CA	λ_{max}	CI	CI/RI	
0.217	21.7%	Consistency OK	1.0847	6.5922	0.1184	0.095
0.440	44.0%	10%	0.9907			
0.113	11.3%		1.1823			
0.147	14.7%		1.1395			
0.047	4.7%		1.0384			
0.036	3.6%		1.1562			

3) Contractor Related Factors

Table No. 15. Contractor Related Factor

CRRF3	A	B	C	D	E	F
A	1	1/3	3	1	5	7
B	3	1	5	3	7	9
C	1/3	1/5	1	1/3	3	5
D	1	1/3	3	1	3	5
E	1/5	1/7	1/3	1/3	1	1
F	1/7	1/9	1/5	1/5	1	1
Column Totals	5.6762	2.1206	12.5333	5.8667	20.0000	28.0000

Table No. 16. Consistency check for CRRF3

AHP	Consistency check	CA	λ_{max}	CI	CI/RI	
0.179	17.9%	Consistency OK	1.0145	6.3110	0.0622	0.050
0.470	47.0%	5%	0.9958			
0.087	8.7%		1.0868			
0.170	17.0%		0.9999			
0.054	5.4%		1.0814			
0.040	4.0%		1.1324			

4) Miscellaneous Factors

Table No. 17. Miscellaneous Factors

MRF4	A	B	C	D	E	F
A	1	1/5	3	1	5	7
B	5	1	5	3	5	9
C	1/3	1/5	1	1/3	3	5
D	1	1/3	3	1	3	5

E	1/5	1/5	1/3	1/3	1	1
F	1/7	1/9	1/5	1/5	1	1
Column Totals	7.6762	2.0444	12.5333	5.8667	18.0000	28.0000

Table No. 18. Consistency check for MRF4

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.146	14.6%	Consistency OK	1.1211	6.6198	0.1239
0.487	48.7%	10%	0.9952		
0.089	8.9%	1.1216			
0.167	16.7%	0.9810			
0.069	6.9%	1.2352			
0.042	4.2%	1.1651			

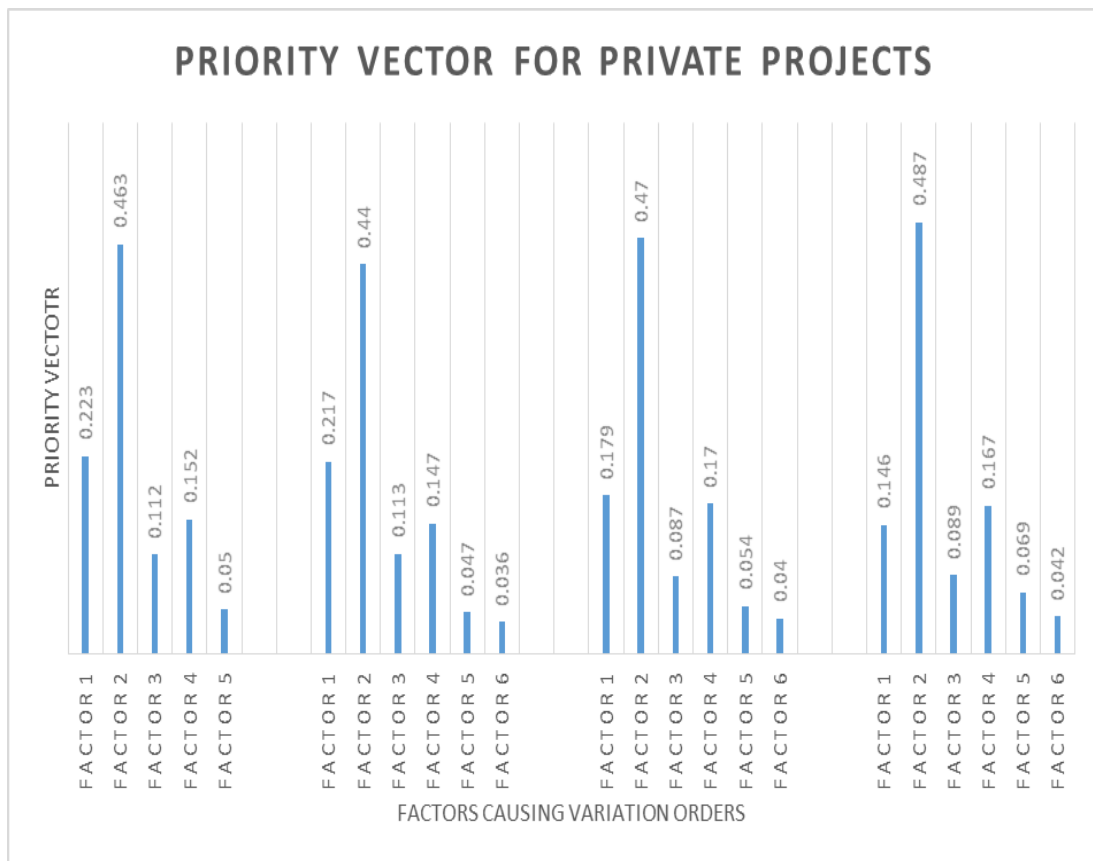


Fig. No. 5. Priority Vector for factors causing variation orders as Consultant's view

B. Variation Order factors for Public Projects (Consultant's view)

1) Owner Related Factors

Table No. 19. Owner elated Factors

ORF5	A	B	C	D	E
A	1	1/5	1/3	1/5	1/7
B	5	1	1/5	1/7	1/7
C	3	5	1	1/3	1/3
D	5	7	3	1	1
E	7	7	3	1	1

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Column Totals	21.0000	20.2000	7.5333	2.6762	2.6190
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Table No. 20. Consistency check for ORF5

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.058	5.8%	Consistency OK	1.2081	5.4271	0.1068
0.061	6.1%	10%	1.2237		
0.135	13.5%		1.0184		
0.371	37.1%		0.9918		
0.376	37.6%		0.9849		

2) Consultant Related Factors

Table No. 21. Consultant Related Factors

CNRF6	A	B	C	D	E	F
A	1	1/5	1/3	1/5	1/7	1/7
B	5	1	1/5	1/7	1/7	1/7
C	3	5	1	1/3	1/3	1
D	5	7	3	1	1	3
E	7	7	3	1	1	1
F	7	7	1	1/3	1	1
Column Totals	28.0000	27.2000	8.5333	3.0095	3.6190	6.2857

Table No. 22. Consistency check for CNRF6

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.044	4.4%	Consistency OK	1.2293	6.5625	0.1125
0.043	4.3%	9%	1.1763		
0.118	11.8%		1.0063		
0.335	33.5%		1.0076		
0.281	28.1%		1.0167		
0.179	17.9%		1.1260		

3) Contractor Related Factors

Table No. 23. Contractor Related Factors

CRRF7	A	B	C	D	E	F
A	1	3	1/3	1/5	1/7	1/5
B	1/3	1	1/5	1/7	1/7	1/7
C	3	5	1	1/3	1/3	3
D	5	7	3	1	1	3
E	7	7	3	1	1	5
F	5	7	1/3	1/3	1/5	1
Column Totals	21.3333	30.0000	7.8667	3.0095	2.8190	12.3429

Table No. 24. Consistency check for CRRF7

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.053	5.3%	Consistency OK	1.1352	6.5380	0.1076
0.040	4.0%	9%	1.1987		
0.132	13.2%	1.0393			
0.329	32.9%	0.9896			
0.349	34.9%	0.9851			
0.096	9.6%	1.1900			

4) Miscellaneous Factors

Table No. 25. Miscellaneous Factors

MRF8	A	B	C	D	E	F
A	1	1	1/3	3	1	1/3
B	1	1	1/3	1	3	1/5
C	3	3	1	5	3	3
D	1/3	1	1/5	1	1	1/5
E	1	1/3	1/3	1	1	1/3
F	3	5	1/3	5	3	1
Column Totals	9.3333	11.3333	2.5333	16.0000	12.0000	5.0667

Table No. 26. Consistency check for MRF8

AHP	Consistency check	CA	λ_{max}	CI	CI/RI
0.109	10.9%	Consistency OK	1.0132	6.5821	0.1164
0.110	11.0%	9%	1.2477		
0.398	39.8%	1.0074			
0.066	6.6%	1.0522			
0.094	9.4%	1.1264			
0.224	22.4%	1.1350			

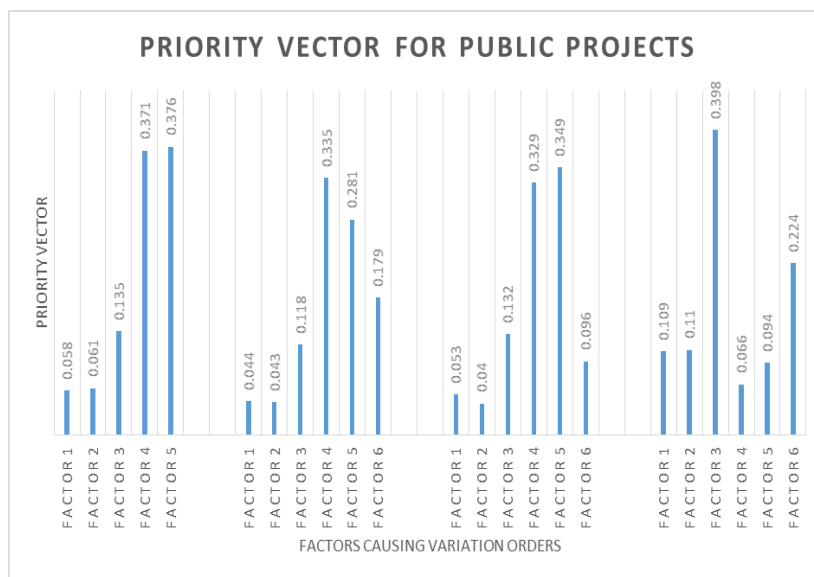


Fig. No. 6. Priority Vector for factors causing variation orders as Consultant’s view

IV. CONCLUSION

Change orders have a variety of reasons, and their impacts on project cost and schedule are determined by a number of connected factors. Predicting and preparing for project changes is challenging due to the risk and uncertainty involved. The goal of this research was to conduct a literature analysis and field survey to identify significant drivers of change, their influence on projects, and control mechanisms used in big construction projects in the Nashik region.

Based on the field survey conducted the following can be concluded:

1. According to the data gathered from the general industry, the following facts are true: Vast-scale construction contractors are large in size, and the majority of them have more than 15 years of expertise.
2. The owner is the main source of changes in large building projects. Change of plans by owner is the main cause of changes.
3. Substituting materials and or procedures is the second source of change orders generated by the owner.
4. Change orders have two major effects: an increase in project cost and a longer project time. Labor productivity declines and labor conflicts scored lower and are less common.

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