Evaluation of Factors Causing Rework in Construction Projects

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Abstract Construction project generally experience cost overruns and schedule overruns. Rework is an important aspect that directly contributes to these overruns. The aim of this research to identify, evaluate and ranking of rework factors and calculate total rework cost in construction project. For the ranking of these Rework factors an onsite questionnaire survey was done and the data obtained were analyzed by multi-criteria decision and relative importance methods which gives the relative significance of these variables, further rework cost was calculated. According to this study the most contributing factors are client related factor, contractor field management and external environment factors and study on rework cost shows that it affects overall project cost.

Keywords Rework, analytical hierarchy process, IMPI method, critical activity, critical path, construction management .

I. INTRODUCTION

Construction rework is defined as an activity that was incorrectly executed at the first time. In any construction project the possibility of happening of rework affects the cost and schedule alteration of project activities. Since the rework affect the project path by same amount of cost and schedule. This cost affected should be measured which will be useful for project practitioner to reduce the project cost that might be affected by rework.

Neglecting towards errors, omissions and poor management may result into quality failure which may result into rework. Rework is no worth adding process which affects the quality and performance of the work.

On average the direct rework cost alone ranging from 5-20% of the contract value has significant implications on project success **GUI YE AND ZHIGANG JIN MARTIN SKITMORE (2015).** As one investigation of the main causes of rework are lack of use of information technologies, client involvement in the construction project, lack of clearly explain working procedures, changes made by the contractor to better quality of construction WORK **PETER E.D. LOVE AND DAVID J.EDWARDS (2010)**.

The cost of rework was found to be 2.75-3% of the original contract value and was due to errors and faults expected by contractors, the mean cost growth shown 11% of the original contract value and mainly involved extensions to project scope needed by client **NURIAN FORCADA AND MARATA (2017)**. A comparison between the awarded and corrected budget, revealed that the awarded budget was 16.4% more than the corrected budget. This condition occurred because of a detailed analysis of construction works was not managed during the design process, there was a lack of use of information technologies during the design process. **NURIA FORCADA AND ANGELA P.(2017)**

The main object of this research to identify, evaluates and raking of rework factors and calculate the total rework cost in construction projects.

II. OBJECTIVE

1. To identify and evaluate the main sources of rework.

2. to distinguish the factors responsible for rework in construction.

3.. Ranking of rework factors.

4.. Calculate the total rework cost in construction project.

III. SOURCES OF REWORK FACTORS

total 35 rework factors are taken by literature study who is most responsible for rework in construction and these factors are classified into 5 main groups as shown in table. 3.1.

table-3.1: lists of factors causes rework in construction projects.

Sr no.	Group	Factors
1	Contractor field management	Poor quality of construction technique
		Lack of use of advanced mechanical equipment's
		Use of poor construction material
		Poor supervision of admission material/equipment
		Frequent change of subcontractor

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		Ineffective use of construction management standard
		Inappropriate construction methods
2	Client related factors	Lack of experience and knowledge of design and construction process
		Lack of funding allocated for site investigation
		Lack of client involvement
		Inadequate time and money spent on briefing process
		Poor communication with design consultants
		Payment of low fees for preparing contract documentation
		New request by the client to improve standard during construction
3	External environment factors	Poor site conditions
		New request from end user to improve standards during construction
		Adverse natural condition
		Change in government regulation
		Shortage of construction materials/equipment's
		Effect of social and cultural factors
		New request from end users final inspection and certification stage
4	Design management factors	Poor coordination between design team members
		Design error due to many design tasks
		Lack of attention to detail
		Scope and design changes
		Insufficient data collection and survey before design
		Poor used of advanced engineering
		Incomplete design at the time of tender
5	Human performance group factors	Inadequate knowledge of action required to complete task successfully
		Lack of domain-specific skill
		Deficiencies in personnel tanning
		Violation of rules or policy
		Lack of motivation
		Poor decision making process
		Poor monitoring and control

The table 3.1 will be used for analyzing the data to find the relative importance of the factors by AHP & IMPI.

IV. RESEARCH METHODOLOGY

For achieving the goal of this research two approaches are used first one is relative importance of factors and second is rework cost mechanism. The analytical hierarchy process is found by the relative importance of main factors and co-factors of each group and IMPI is used to calculate the relative importance of all factors. And the other approach is found out the total rework cost.

4.1. Analytical hierarchy process (AHP)

This multi criteria decision making method is used to compare the factors of rework of Table 3.1 which is done by pair wise comparison of alternatives followed by normalization of matrix such that each alternatives sum to 1 by evaluating priority vectors and calculating the consistency index of each value and analyzing the same by consistency ratio which should be less than 10% or 0.1. the consistency is calculated by using the following formula-

sr no.	Factors	Formula
1.	Consistency index	$CI=\frac{\lambda_{max}-n}{n-1}$ Where, λ_{max} is maximum Eigen value. N is number of comparisons
2.	Consistency ratio	$CR=\frac{CI}{RI}$ Where, RI random consistency index

This analysis is used for evaluating rework cost as shown in Table-4.3.1.

4.2. Importance index (IMPI)

This research methodology is done in two stages. The first stage incorporated a literature search and meeting. The factors were derived through books, articles, web and worldwide project administration diaries causing rework. As a result of this stage, 35 causes of rework is find out. These causes were classified into 5 groups. The second stage incorporates arrangement of data for positioning of causes of rework in construction projects by calculating Frequency index and severity index.

Table 4.2.1

Sr no.	Factors	Formula
1	IMPORTANCE INDEX(IMPI)	IMPI= (F.I.*S.I.)/100
2	FREQUENCY INDEX(F.I.)	$F.I.=\sum a \frac{n}{N}*\frac{100}{4}$

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		Where, **a, is the constant expression weight given to each responses** **n, is the frequency of responses** **N, is the total no. of responses**
3	**SEVRITY INDEX(S.I.)**	**S.I.=** $\sum a \frac{n}{N} * \frac{100}{4}$ **a, is the constant expression weight given to each responses** **n, is the frequency of responses** **N, is the total no. of responses**

4.3. Rework cost mechanism in construction project

In any construction project the possibility of happening of rework affects the cost and schedule alteration of project activities. Since the rework affect the project path by same amount of cost and schedule. This cost affected should be measured which will be useful for project practitioner to reduce the project cost that might be affected by rework.

In project the critical activities plays vital role. If critical activities undergo rework project cost affected most, hence these critical activities should be effectively worked and their rework factors should be studied carefully and the most affecting factors must be practiced, such factors which mostly affect are provided in the list of table 5.1.1 the most affected one having maximum prioritization value is calculated and the cost of rework by such factors calculated for the duration of that critical activities. Following this will calculate the rework cost for all the critical activities which will give the total cost which may be saved for whole project. This saved cost should be compared with site survey and should be approximately same.

Table- 4.3.1

Sr No.	FACTORS	FORMULA
1	REWORK AMOUNT	$R_A = D_C * R_{AW}$ **Where,** R_A **= rework amount** D_C **= duration of critical activities** R_{AW} **=weightage of rework activities**
2	REWORK COST	$R_C = \sum C_C * \sum R_A$ **Where,** R_C **=rework cost** $\sum C_C$ **=total critical activity cost** $\sum R_A$ **=total rework amount**

V. DATA ANALYSIS

5.1. Data analysis by AHP

AHP is used to determine the relative importance of the main group and the co-factors corresponding to particular group.

Table-5.1.1 Group comparison and ranking

Factors	weight	Rank
Contractor field management factors	.286	2
Client related factors	.451	1
External environment factors	.115	3
Design management factors	.096	4
Human performance group factors	.051	5

The relative importance & ranking of the main group is shown in table 5.1.1

Table-5.1.2 Ranking of contractor field management factors

Factors	weight	Rank
Poor quality of construction technique	.349	1
Lack of use of advanced mechanical equipment's	.250	2
Use of poor construction material	.047	6
Poor supervision of admission material/equipment	.042	7
Frequent change of subcontractor	.056	5
worthless use of construction management standard	.135	3
Improper construction methods	.120	4

The relative importance & ranking of the factors under the influence of contractor field management factors is shown in 5.1.2

Table-5.1.3 Ranking of client related factors

Factors	weight	Rank
Lack of experience and knowledge of design and construction process	.304	1
Lack of funding allocated for site investigation	.055	7
Lack of client involvement	.063	6
Inadequate time and money spent on briefing process	.102	4
Poor communication with design consultants	.172	3
Payment of low fees for preparing contract documentation	.241	2
New request by the client to improve standard during construction	.064	5

The relative importance & ranking of the factors under the influence of client related factors is shown in table 5.1.3

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Table-5.1.4 Ranking of external environment factors

Factors	Weight	Rank
Poor site conditions	.040	6
New request from end user to improve standards during construction	.065	5
Adverse natural condition	.363	1
Change in government regulation	.152	3
Shortage of construction materials/equipment's	.105	4
Effect of social and cultural factors	.240	2
New request from end users final inspection and certification stage	.035	7

The relative importance & ranking of the factors under the influence of external environment factors is shown in 5.1.4

Table-5.1.5 Ranking of design management factors

Factors	Weight	Rank
Poor coordination between design team members	.118	4
Design error due to many design tasks	.055	5
Lack of attention to detail	.241	2
Scope and design changes	.136	3
Insufficient data collection and survey before design	.043	6
Poor used of advanced engineering	.370	1
Incomplete design at the time of tender	.036	7

The relative importance & ranking of the factors under the influence of design management factors is shown in table 5.1.5

Table-5.1.6 Ranking of human performance group factors

Factors	Weight	Rank
Inadequate knowledge of action required to complete task successfully	.032	7
Lack of domain-specific skill	.186	3
Deficiencies in personnel tanning	.076	5
Violation of rules or policy	.046	6
Lack of motivation	.089	4
Poor decision making process	.365	1
Poor monitoring and control	.206	2

The relative importance & ranking of the factors under the influence of human performance group factors is shown in table 5.1.6

5.2. Data analysis by IMPI

IMPI process is used to find out the relative importance index and ranking them. The overall ranking and index is given glow in table 5.2.1

Table- 5.2.1 Overall ranking of the factors

Factors	Weight in %	Overall rank
Poor quality of construction technique	74.93	2
Lack of use of advanced mechanical equipment's	68.16	5
Use of poor construction material	37.11	24
Poor supervision of admission material/equipment	17.66	32
Frequent change of subcontractor	47.72	14
Ineffective use of construction management standard	49.79	13
Inappropriate construction methods	38.79	23
Lack of experience and knowledge of design and construction process	77.42	1
Lack of funding allocated for site investigation	22.82	30
Lack of client involvement	40.58	21
Inadequate time and money spent on briefing process	41.29	19
Poor communication with design consultants	51.42	11
Payment of low fees for preparing contract documentation	51.00	12
New request by the client to improve standard during construction	72.00	3
Poor site conditions	28.12	26
New request from end user to improve standards during construction	16.71	33
Adverse natural condition	57.31	7
Change in government regulation	45.83	15
Shortage of construction materials/equipment's	43.42	17
Effect of social and cultural factors	53.07	10
New request from end users final inspection and certification stage	41.02	20
Poor coordination between design team members	43.17	18
Design error due to many design tasks	33.30	25
Lack of attention to detail	66.76	6

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Scope and design changes	**45.44**	**16**
Insufficient data collection and survey before design	**25.55**	**27**
Poor used of advanced engineering	**70.50**	**4**
Incomplete design at the time of tender	**14.33**	**34**
Inadequate knowledge of action required to complete task successfully	**10.57**	**35**
Lack of domain-specific skill	**25.26**	**28**
Deficiencies in personnel tanning	**18.69**	**31**
Violation of rules or policy	**39.85**	**22**
Lack of motivation	**24.68**	**29**
Poor decision making process	**56.01**	**8**
Poor monitoring and control	**55.58**	**9**

The relative importance and overall ranking of all the factors is shown in table 5.2.1

VI. CONCLUSION

Rework is a comprehensive problem in construction and civil engineering industry. Rework affects the construction project cost and schedule. The data collected from various construction projects through a questionnaire survey so The important conclusion withdrawn from the research is that the rework caused by client related factor and contractor field management is most critical sources for rework in construction.

Based on the analytical hierarchy process and importance index methods raking of 5 main groups respectively are client related factors, contractor field management factors, external environment factors, design management factors and human performance group factors which were evaluated.

Based on the probabilistic approach find that the total rework cost is 15-20% of total project cost in construction projects.

VII. SUGGESTION

For reduction of rework cost overruns and schedule overruns some suggestion are as follows:-

- Rework can be reduced by proper knowledge and experienced of design and construction process and good communication with design team members and good communication between client and contractor.
- Proper inspection of material and equipment's and proper construction methods is implemented in construction projects and the effective use of construction management standard are also useful for reducing rework in construction industr

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