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Evaluation of Rework Factors Affecting Cost and Schedule Performance in Construction Projects.

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Abstract: - Rework is a tenable problem in construction industry. The additional cost and duration due to rework can have effect on overall project performance work. The research represented in this paper aims to identify the rework factors and calculate the total rework cost in construction projects. Using a questionnaire survey, the data was analyzed from various infrastructure projects and from the past researches the four main factors and their sub factors are selected which is most responsible for rework in construction projects. The ranking of rework factors is done by the analytical hierarchy process and rework cost can be calculated by the probabilistic approach.

Author Keywords: - project management, rework cost, AHP, critical path, schedule overruns.

1. Introduction: -

Rework is an ordinary situation in construction projects and has been identified as the factors that can increase construction project cost, project duration and reduce the construction project performance. Abandon defects, errors, poor management and non-conformance may result into cost growth and schedule growth in construction projects. Rework is defined as the activity that was improperly performed at the first time in construction.

The main factors can affect the project performance is lack of use of information technology, client involvement, unclear working procedure, changes made by the client **PETER E.D. LOVE (2010).** The direct cost of rework is 12.4% of total construction cost **BURATI et al (1992).** And the rework cost is 11% of the contract value in construction project **NURIA FORCADA (2017)**. The awarded budget is approximately 17% of the corrected budget.

This condition of rework in construction is occurred due to the insufficiency in details analysis of construction work and during the design process lack of use of technology in construction work **NURIA FORCADA AND ANGELA P (2017).** The rework schedule overrun is 38.26% of the total construction project duration and approximately 10 % cost overrun of the total construction project cost **L.O. OYEWOBI, A.A. OKE (2011).**

The main object of this research is to identify the rework factors and classify the rework factors according to there weightage which is most responsible for rework in construction industry and calculate the total rework cost in construction projects.

2. OBJECTIVE: -

1. To identify rework factors and ranking of the rework factors.

2. Calculate the total rework cost in construction project.

3. SOURCES OF REWORK: -

Total 20 factors of rework are taken in study and these rework factors are classified into 4 main groups as shown in table. 3.1.

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

Sr no.	Group	Factors
1	design related factors	Poor used of advanced engineering
		Inadequate details collection before preparing design
		Poor communication between members of design team
		Design mistake due to numerous design
		Insufficiency of attention on design details
2	Client related factors	Money and time spent on preparation of work
		Poor coordination with design consultants
		Insufficiency of experience and understanding of design
		Shortage of funding for site investigation
		Lack of client participation
3	Contractor related factors	Imperfect construction technique
		Unsuitable construction methods procedure
		Low quality of construction materials
		Imperfect observation of acceptance material/equipment's
		Insufficiency of mechanical equipment's
4	Extraneous environment factors	Changes rules and regulation by the government
		Construction work affected by social and cultural factors
		Improper site condition
		Improve standard by the end users
		Dangerous natural climate and atmosphere

The table 3.1 will be used for analyzing the data to find the rank of rework alternatives and relative importance of the rework alternatives by analytical hierarchy process.

4. Research Methodology: -

The goal of this research is done by two strategies first is the relative importance of 4 main factors and there sub factors is evaluated by the analytical hierarchy process and total rework cost is calculated by the probabilistic approach.

4.1 Analytical hierarchy process: - AHP is a multi-criteria decision making tool used for designate the alternatives by pair wise comparison of each criteria's which is accomplished by comparing pair wise alternatives this is done by following steps:-

1. Construct the model of decision matrix.
2. Evaluate the priorities of each criteria's.
3. Evaluate the priorities of sub criteria's.
4. Evaluate the alternatives with highest priorities or weightage, by evaluating consistency index followed by consistency ratio which should be less than 10%.

Table 4.1.1

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-4.1.1

4.2 Rework Cost Mechanism: - the method generated for calculating rework amount and rework cost

$$R_A = D_{C*}R_{AW}$$
$$R_C = C_C * R_A$$

Where,

D_C= this is the critical activity duration.

R_{AW} = the weightage of rework activities, which is obtained by evaluating the priorities weightage of each criteria's which is maximum of all.

C_C = total cost which is associated with each critical activity.

R_A =the amount of rework which is related to the cost of rework, as the rework increases, cost of project increases hence result in increasing in rework cost.

The critical activity is the one which significantly affect the project cost, hence the above methodology is adopted for critical activities.

5. Data analysis:-

5.1Data analysis by analytical hierarchy process

The relative importance of main group and there sub groups is determined by analytical hierarchy process.

Table-5.1.1 Main Group ranking

Factors	weight	Rank
Design related factors	**.085**	**4**
Client related factors	**.512**	**1**
Contractor related factors	**.292**	**2**
Extraneous environment factors	**.111**	**3**

The ranking of the main group is s hown in table 5.1.1

Table-5.1.2 Ranking of design related factors

Factors	weight	Rank
Poor used of advanced engineering	**.260**	**2**
Inadequate details collection before preparing design	**.077**	**5**
Poor communication between members of design team	**.172**	**3**
Design mistake due to numerous design	**.099**	**4**
Insufficiency of attention on design details	**.393**	**1**

The ranking of the factors under the influence of design related factors is shown in 5.1.2

Table-5.1.3 Ranking of client related factors

Factors	weight	Rank
Money and time spent on preparation of work	.163	3
Poor coordination with design consultants	.200	2
Insufficiency of experience and understanding of design	.467	1
Shortage of funding for site investigation	.096	4
Lack of client participation	.075	5

The ranking of the factors under the influence of extraneous environment factors is shown in 5.1.3 **Table-5.1.4 Ranking of contractor related factors**

Factors	weight	Rank
Imperfect construction technique	.473	1
Change of sub-contractor	.095	3
Low quality of construction materials	.072	4
Imperfect observation of acceptance material/equipment's	.060	5
insufficiency of mechanical equipment's	.300	2

The ranking of the factors under the influence of contractor related factors is shown in 5.1.4

Table-5.1.5 Ranking Of Extraneous Environment Factors

Factors	weight	Rank
Changes rules and regulation by the government	.158	3
Construction work affected by social and cultural factors	.337	2
Improper site condition	.065	5
Improve standard by the end users	.074	4
Dangerous natural climate and atmosphere	.366	1

The ranking of the factors under the influence of extraneous environment factors is shown in 5.1.5

Table-5.1.6 Global Ranking

Factors	weight	Rank
Insufficiency of experience and understanding of design	.288	1
Imperfect construction technique	.266	2
Poor use of advanced engineering	.133	3
Dangerous natural climate and atmosphere	.111	4
insufficiency of mechanical equipment's	.100	5

The ranking of the factors under the influence of client related factors is shown in 5.1.6

5.2 Rework cost calculation: -

In this research study Calculate the rework amount and rework cost, take an example for calculation of rework amount and rework cost. activity A,B,C,D,E,F and there duration and normal cost are show in example. And the network diagram of these activity is also shown,

Activity	Duration (days)	Normal cost (₹)
A	120	12,000/-
B	20	1,800/-
C	40	16,000/-
D	30	1,400/-
E	40	3,600/-
F	60	13,500/-

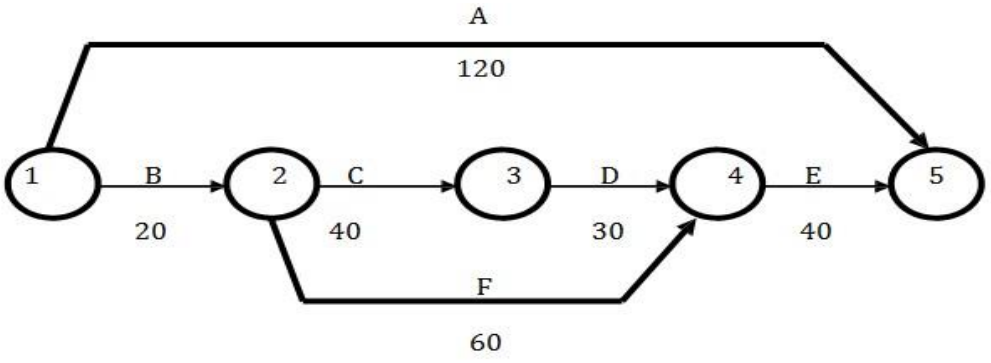

FIG. 1 ACTIVITY NETWORK DIAG.

Table 5.2.1 cost calculation for critical activity B

FACTORS	DURATION (DAYS)	COST	WEIGHTAGE	REWORK AMOUNT	REWOK COST (₹)
Lack of experience and knowledge of design and construction process.	20 DAYS	1800	.288	5.76	103.68
Poor quality of construction technique			.266	5.32	95.76
Poor use of advanced engineering			.133	2.66	47.88
Adverse natural condition			.111	2.22	39.96
Lack of use of advanced mechanical equipment's			.100	2	36.00

The total rework cost for activity B is shown in table 5.2.1

Table 5.2.2 cost calculation for critical activity C

FACTORS	DURATION (DAYS)	COST	WEIGHTAGE	REWORK AMOUNT	REWORK COST (₹)
Lack of experience and knowledge of design and construction process.	40 DAYS	16000	.288	11.52	1843.2
Poor quality of construction technique			.266	10.64	1702
Poor use of advanced engineering			.133	5.32	851.40
Adverse natural condition			.111	4.44	710.40
Lack of use of advanced mechanical equipment's			.100	4.0	640

The total rework cost for activity C is shown in table 5.2.2

Table 5.2.3 cost calculation for critical activity D

FACTORS	DURATION (DAYS)	COST	WEIGHTAGE	REWORK AMOUNT	REWORK COST (₹)
Lack of experience and knowledge of design and construction process.	30 DAYS	1400	.288	8.63	120.96
Poor quality of construction technique			.266	7.98	110.46
Poor use of advanced engineering			.133	3.99	55.86
Adverse natural condition			.111	3.33	46.62
Lack of use of advanced mechanical equipment's			.100	3.00	42.00

The total rework cost for activity D is shown in table 5.2.3

Table 5.2.4 cost calculation for critical activity E

FACTORS	DURATION (DAYS)	COST	WEIGHTAGE	REWORK AMOUNT	REWORK COST (₹)

Lack of experience and knowledge of design and construction process.	**40 DAYS**	**3600**	**.288**	**11.52**	**414,72**
Poor quality of construction technique			**.266**	**10.64**	**383.04**
Poor use of advanced engineering			**.133**	**5.32**	**191.52**
Adverse natural condition			**.111**	**4.44**	**159.84**
Lack of use of advanced mechanical equipment's			**.100**	**4.0**	**144.00**

The total rework cost for activity E is shown in table 5.2.4

The total rework cost for critical path B-C-D-E IS 7740/- and the total project cost for overall project is 48300/- according to these data the total rework cost is 18.40% of the total project cost in construction industry.

Conclusion:-

The important conclusion withdraw from this research study is the client and contractor related factors are most responsible for rework in construction projects. And the ranking of four main groups respectively are client related factors, contractor related factors, extraneous environment factors and design related factors.

Lack of experience and knowledge of design and construction process, poor quality of construction technique and poor used of advanced engineering are more responsible for rework in construction process.

The total rework cost is approximately 15-20% of the total project cost in construction work based on the probabilistic approach.

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