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"Investigation of Time-Cost Effectiveness on Construction Projects"

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Abstract: *Development projects undertaken in various sectors of economy and finance are building blocks of national economy. This paper examines the time-cost effectiveness on construction projects by quantification of 16 different project performance parameters applied on 49 construction projects (both public and private sector projects). A questionnaire was drafted to test the parameters and criteria adopted when assessing the success of construction projects. The results shows that for general group of construction projects all 16 parameters have significant impact on cost growth.*
Keywords :*Contracts Management, Cost Growth, Project Partnering, Time Growth.*

I. Introduction :

In the recent surveys and analysis, it is seen that construction projects in India are suffering with time and cost growth. Also, Govt. of India in its 11th five year plan (2007-2012) has mentioned need to use innovative contract management for successful execution of contracts.85% of management contracts were performed within budget as compared to 50% of traditionally executed contracts and 87% of management contracts were performed within time schedule as compared to 62% of traditionally executed contracts (Naoum[22], 1994). 60% to 70% of the project value is being sub-contracted by the main contractor to effectively allocate risk outside its own organization (Maturana et. al. , 2007).Projects that began as formal partnerships were the most stable with 2/3rd (i.e. 69%) ending as they began. Guarded adversarial was the least stable with fewer than 30% maintaining this kind of relationship at the end of project. Of those relationships that changed, ½ (i.e. 53%) regressed to an adversarial relationship, while ½ (i.e. 47%) progressed to some form of partnership. (Drexler& Larson[11], 2000).

The study highlights the requirement of contract management tool for successful execution of contract. The basic parameter which are used for successful execution of construction contracts were identified from literature review and statistical survey analysis was done with the help of MINITAB for windows software on the construction projects from India. The two statistical tools, Principal Component Factor Analysis (PCFA) and multiple regression analysis were used to analyze the survey data on 49 construction projects.

II. Quantification of project performance parameters :

The data collected through questionnaire, permitted the calculation and quantification of 16 project performance parameters. Each of these parameters mathematically describes some performance measure of a project.

Table 2.1 :Quationnaire adopted for data collection

Project Parameters	1	2	3
1.Contract type			
2.What was working relationship (Adverserial or Informal Partners)			
3.Were the periodic meetings scheduled for all stakeholders. If yes at what intervals.			
4.Were the contract conditions resonably satisfying, based on standard documents of FIDIC or MOS&PI.			
5.Was the project hampered due to insufficient geotechnical reports.			
6.Was the payment process satisfactory. If not, what was the problem.			
7.Was the project delayed due to land acquisition,encroachments. If yes who was responsible for that (client or contractor)			
8.Award price			
9.Final cost of project			
10.Were there extra items in the project. If yes then were they claimed with fore-warnings to the client by contractor.			

11.Nos. of change orders /extra items.			
12.Actual contract durtion (days charged)			
13.Project duration at time of award (total days allowed)			
14.Additional days granted.			
15.Nos. of days of liquidated damage (LDs)			
16.LDs cost per day.			
17.Nos. of claims (out of scope &no change order received).			
18.Total cost of claims.			
19.Nos. of disputes went to arbitration.			
20.Total cost of these disputes.			
21.Time required to settle these disputes.			

2.1 Award Price

It is the original contract amount which provides a method to separate projects based on their relative financial size.

2.2 Percentage cost growth

Cost growth (CG) is a standard measure of project performance. It is defined as the change in contract amount with respect to original contract amount.

$$CG = \frac{\text{Final Contract Amount} - \text{Original Contract Amount}}{\text{Original Contract Amount}}$$

This number can then be converted to a % of growth over original contract amount.

2.3 Lack of periodic meetings

This factor is useful to study the impact of lack of periodic meetings on a project success in terms of cost growth, time growth, claim cost and dispute cost. The projects with lack of periodic meetings were marked as 1 and project which were having some schedule for periodic meetings were marked as 0.

2.4 Lack of geotechnical investigation

This parameter is useful to study the impact on cost growth and time growth of a project due to lack of geotechnical investigations before the start of project. Projects are mainly hampered at foundation levels due to improper or no geotechnical investigation. The project in which work was not hampered due to sufficient geotechnical survey was marked as 0 and projects which were hampered due to geotechnical problems encountered at the time of execution were marked as 1.

2.5 Working relationship

This factor is useful to study, the working relationships between the contractor and client for a project. Working relationships were categorized as adversarial, guarded adversarial and partners. The project was marked as 1, 0.5 and 0 for above working relationships.

2.6 Extra items

This parameter is useful to study the impact of contract quality on project performance. This parameter quantifies the number of times the owner and the contractor had to reach an agreement.

2.7 Lack of fore warnings to extra items

This factor is useful to study whether there was lack of communication as and when extra work was identified in a project. The project was marked as 1, if there was no forewarnings to extra items which may result to claims and disputes at the end of project. The project was marked as 0 if respondent had good communications regarding extra items.

2.8 Cost per change order (c/co)

This factor allows developing an idea of the order of magnitude of changes that occur on typical project.

$$C/CO = \frac{\text{Final Contract Amount} - \text{Original Contract Amount}}{\text{Number of Change Orders}}$$

2.9 Percentage increase per change order (% inc /CO)

It is the measure of incremental cost growth. A contract with no change orders would be the perfect situation and have no cost growth. The larger the average percent increase per change order the higher the

probability that some errors of design were contained in the project. This parameter is described by the following equation;

$$\%/CO = \frac{\text{Cost Growth (\%)}}{\text{Number of Change Orders}}$$

2.10 Percentage time growth (% TG)

Time growth (TG) is the change in time with respect to the original contract completion date. Time growth is generally a result of changes in scope of the project. Time growth can be either positive (when the project is completed later than the original completion date) or negative (when the project is completed earlier than the original completion).

$$TG = \frac{\text{Days Charged} - (\text{Total Days Allowed} + \text{Additional Days Granted})}{\text{Total Days Allowed} + \text{Additional Days Granted}}$$

2.11 Percentage equivalent liquidated cost (%ELDC)

The data collected on 49 projects indicated sever time growth (up to 30-60%). Though, liquidated damage clause was included in almost all projects, it was seen that, in very few cases it was applied. This shows that either project was not planned properly or time was not the essence of the project. But still, to study the impact of liquidated damage cost on project performance in terms of cost and time growth, above parameter is useful. It is necessary to study this parameter because, in every project having LD clause it is expected that time should be the essence of project.

$$LD = \frac{\text{LDs Cost}}{\text{Total Contract Cost}}$$

2.12 Percentage claim cost (% CC)

Claims are requested by contractors for compensation for the work performed that the contractor believes is outside the scope of the contract. Generally, claims begin as contractor requests for a change order and become claims when the owner rejects the change order request.

The percentage claim cost can be calculated from the following equation,

$$CC = \frac{\text{Total Cost of Claims}}{\text{Original Contract Cost}}$$

2.13 Percentage dispute cost (% DC)

When claims are disagreed, it results in disputes. The partnering suggests the establishment and use of an issue escalation system which results in significantly low numbers of disputes. Disputes cost as a percentage of original cost is calculated as follows

$$DC = \frac{\text{Total Cost of Disputes}}{\text{Original Contract Cost}}$$

2.14 Lack of standard draft conditions

This parameter is useful to study, the quality of contract document in terms of contract conditions. Ministry of Statistics and Programme Implementation (MOS&PI), Govt. of India, along with Construction Industry Development Council (CIDC) in their Annual report has suggested to domestic construction organizations to draft contract conditions on the principles of standard draft conditions published by MOS&PI document. For global tenders it is suggested to follow FIDIC document while drafting contract conditions. In this survey, project which followed some of the standard contract document were marked as 0 and projects with unsatisfied contract conditions were marked 1.

2.15 Improper payment process

Payment process is one of the cause for delays in projects which results in cost growth, disputes etc. The projects in which respondent thought that there was improper payment process were marked as 1 and o for vice versa.

2.16 Issues related on client part

This parameter is useful to study the impact of issues such as land acquisition, land encroachments, material supply, clearance to site entry, electric supply etc on project progress, which are to be fulfilled by the

client. The projects which were suffering due to above reasons were marked as 1. The projects which did not suffered due to above reasons were marked as 0.

III. Analysis of Survey Results

After quantification of all the 16 parameters for the survey data on 49 construction projects including private sector and public sector, the groups were formed for further statistical analysis. The groups formed were as follows

A) General group of projects (49 projects).
B) Public sector group of projects (25 projects).
C) Private sector group of projects (24 projects).
D) Building sector projects (26 projects).
E) EPC contract projects (17 projects).
F) Item rate contract projects (32 projects).

Two statistical tools, Principal Component Factor Analysis (PCFA) and Multiple Regression, were used to analyze data from the survey questionnaire. Factor analysis was used to identify the component factors; whereas, multiple regression was used to seek the strongest predictors from the component factors for cost growth (%CG).The analysis was conducted using the *MINITAB* for Windows software package that provides a comprehensive range of statistical programs suitable for statistical analysis. The analysis is provided in Table 3.1.

Table 3.1: Quantified data on 49 projects with 16 identified project performance parameters (continued……)

Sr. No.	Prj. / Perfomance Factors	Award price	% CG	Lack of perd mtngs	Lack of geot. Invtgn	Wrkg rlshp	Ext. Itm	lack of fore warng to ex. itm	C/CO	% inc / CO	% TG	% ELDC	% CC	% DC	Lack of std. drft condn	impr pamt pro.	Issues reltd on client part
1	Bldg1.Pr.IR	35000000	4.3	0	0.5	0	8	0	187500	0.53	10	0.22	4.3	0	0.5	0	1
2	Bldg2.Pr.IR	5800000	6.9	0	0.5	0	20	0	20000	0.35	0	0	6.9	0	0.5	0	1
3	Bldg3.Pr.IR	11500000	11.3	0	0.5	0	24	0	54167	0.47	3.33	0.13	11.3	0	0.5	0	1
4	Bldg4.Pr.IR	17500000	28.6	0	0.5	0.5	75	1	66666	0.38	33.33	25.71	29.7	0	1	1	0
5	Bldg5.Pr.IR	20000000	55	0	0	0.5	30	0	366666	1.83	25	0.9	5.5	0	1	0	0
6	Bldg6.Pr.IR	6000000	38.3	0	1	0.5	15	0	153333	2.6	20	0.75	38.3	0	1	1	0
7	Bldg7.Pr.IR	40000000	13.3	0	0.5	0.5	17	0	311746	0.8	33.33	0.225	13.3	0	1	1	0
8	Bldg8.Pr.IR	36500000	16.4	0	0.5	0.5	25	0	240000	0.7	66.66	0.49	34.2	0	1	1	0
9	Bldg9.Pr.IR	16500000	36.4	0	0	0	29	0	206896	1.25	33.33	0.22	36.4	0	1	0	0
10	Bldg10.Pr.IR	13000000	30.8	0	1	0	20	1	200000	1.538	40	0.35	7.7	0	0	0	0
11	Bldg11.Pr.IR	5600000	26.8	0	1	0.5	70	0	21428	0.38	21.73	0.2	3.57	0	0	1	1
12	Bldg12.Pr.IR	7000000	0	1	0	0.5	0	1	0	0	0.5	1	0	0	1	0	0
13	Bldg13.Pr.IR	7000000	42.9	0	1	0.5	20	1	0	0	42.85	0.32	40	40	1	1	0
14	Bldg14.Pr.IR	65766000	14	1	1	1	15	1	610200	0.93	-10	0	3.04	0	1	1	0
15	Bldg15.Pr.IR	382000000	29.8	1	1	1	105	1	1085714	0.283	266	4.71	44.5	0	1	1	1
16	Bldg16.Pr.EPC	1800000	22.2	0	0	0	7	0	57142	3.2	37.5	0.4	11.1	8.33	0	0	1
17	Bldg17.Pr.EPC	8800000	5	0	1	1	4	0	110000	1.25	16.6	0.1	2	0.28	0	1	1
18	Bldg18.Pu.EPC	14900000	60.4	1	0	1	128	0	70312	0.47	31.25	1	0	0	1	1	0
19	In.bldg1.Pr.IR	5400000	26	0	1	1	60	0	23333	0.43	27.27	0.25	18.5	18.5	0	1	1
20	In.bldg6.Pr.IR	62400000	212	1	0	0	23	0	5765217	9.21	200	2.88	0	0	1	1	0
21	In.bldg2.Pr.EPC	70000000	28.6	0	0.5	1	20	1	1000000	1.43	85.71	0.25	12.9	11.4	1	0	0
22	In.bldg3.Pr.EPC	90000000	11.1	0	0.5	0.5	28	1	357142	0.4	27.3	0.2	8.33	8.33	1	0	0
23	In.bldg7.Pr.EPC	636500000	11.1	0	1	0	25	1	2820000	0.44	33.3	0.35	0.78	0	0	0	0
24	In.bldg8.Pr.EPC/LS	175000000	1.42	0	0	0	3	0	833333	0.47	28.57	0.03	0	0	1	0	0
25	In.bldg5.Pr.IR	4500000	116	0	1	0.5	20	1	260000	5.8	100	1	11.1	0	1	0	0

(continued…..)

Sr. No.	Prj. / Perfomance Factors	Award price	% CG	Lack of perd mtngs	Lack of geot. Invtgn	Wrkg rlshp	Ext. Itm	lack of fore warng to ex. itm	C/CO	% inc / CO	% TG	% ELDC	% CC	% DC	Lack of std. drft condn	impr pamt pro.	Issues reltd on client part
26	In.bldg4.Pu.EPC	100000000	13	0	0	0.5	30	1	433333	0.43	55.5	0.75	12.5	10.5	0	0	0
27	WatSup1.Pu.IR	54000000	9.52	0	1	0.5	3	1	1666666	3.1	24.65	0.16	9.25	9.25	0	0	1
28	WatSup2.Pu.IR	100000000	10	0	1	0.5	0	1	0	0	11.16	0.16	10	5	0	0	1
29	WatSup3.Pu.IR	65000000	15.5	0	1	0.5	0	1	0	0	91.1	0.51	15.5	7.76	0	0	1
30	WatSup4.Pu.EPC	16000000	24.3	1	1	1	1	0	3893156	24.3	200	4.5	3.35	0	1	1	1
31	WatSup5.Pu.EPC	135100000	28.3	1	1	0.5	32	0	1193750	0.88	150	4	13.7	0	1	1	1
32	Drng1.Pu.IR	25000000	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
33	Drng2.Pu.IR	28030000	24.9	0	1	0.5	3	1	2323333	8.28	42.46	0.27	0.89	0.89	0	0	1
34	Drng3.Pu.IR	30080000	33	0	1	0	5	0	1984000	6.6	43.83	0.53	0	0	0	0	1
35	Road1.Pu.IR	15000000	16.7	0	1	0.5	3	0	833333	5.56	5.56	0.05	0	0	0	0	1
36	Road2.Pu.IR	150000000	66.7	0	1	0	5	1	20000000	13.34	13.76	0.025	16.7	10	0	0	1
37	Bridge1.Pu.EPC	205200000	15.6	0	1	0	15	0	2143666	1.04	-20	0	3.65	0	0	0	0
38	Bridge2.Pu.IR	31500000	6.74	0	0	0.5	2	0	1062500	3.37	8.33	0.28	3.17	0	1	0	1
39	Bridge3.Pu.EPC	6450000	0	1	0	0.5	0	0	0	0	125	1.16	0	0	1	1	1
40	Bridge4.Pu.IR	10762000	72.8	1	1	1	7	0	1119714	10.4	0	0	27.8	0	0	1	0
41	Bridge5.Pu.IR	23019594	14.7	0	1	0.5	4	0	845101	3.7	0	0	6.5	0	0	1	1
42	Bridge6.Pu.EPC	6142616	51.6	0	0	0	0	0	0	0	0	0	50	0	0	0	0
43	Bridge7.Pu.EPC	95000000	37.4	0	0	0	5	0	7096800	7.48	0	0	15.7	0	1	0	0
44	Bridge8.Pu.EPC	152500000	26.2	0	1	0	8	0	4993750	3.275	14.2	0.29	14.8	0	1	0	0
45	bridge9.Pu.IR	25000000	-12	0	0	0.5	0	1	0	0	100	0.18	0	4.8	0	1	0
46	Road3.Pu.BOT	850000000	1.47	0	1	0	4	1	3125000	0.36	24.65	0	1.47	0	0	0	1
47	Road4.Pu.IR	12826876	0	1	0	1	0	0	0	0	142	2.33	0	0	1	0	1
48	Power1.Pu.IR	11400000	2.67	0	0	0	1	0	350000	2.67	13.2	1.84	3.15	35	0	1	0
49	Power2.Pu.EPC	30000000	0	1	1	0	0	0	0	0	25	0.5	0	0	0	0	0

Prior to principal component factor analysis (PCFA) and multiple regression analysis, all the identified parameters (variables) and the sample size were tested for potential outliers and normality using SPSS for Windows statistical software package.

(i) Bartlett's test of sphericity: This test is used to test the null hypothesis that the variables (identified parameters) in the population correlation matrix are uncorrelated. If the observed significance level (p-value) is less than 0.05 then, it can be taken as small enough to reject the hypothesis. It can then be concluded that, the strength of relationship among the variables (identified parameters) is strong and it is good idea to precede a factor analysis for the data.

(ii) Normality test for sample: Normality test is useful to study whether our sample data is normal or not. We can assess population normality with a normal probability plot, which plots the ordered data values against values that we expect them to be near if the sample's population is normally distributed. If the population is normal, the plotted points will form an approximately straight line. Thus sample is adequate for regression analysis (Chan[4]et al., 2004).

It was manifested from the test results that all samples satisfied the basic assumptions of a linear regression model and were confirmed acceptable and reliable.

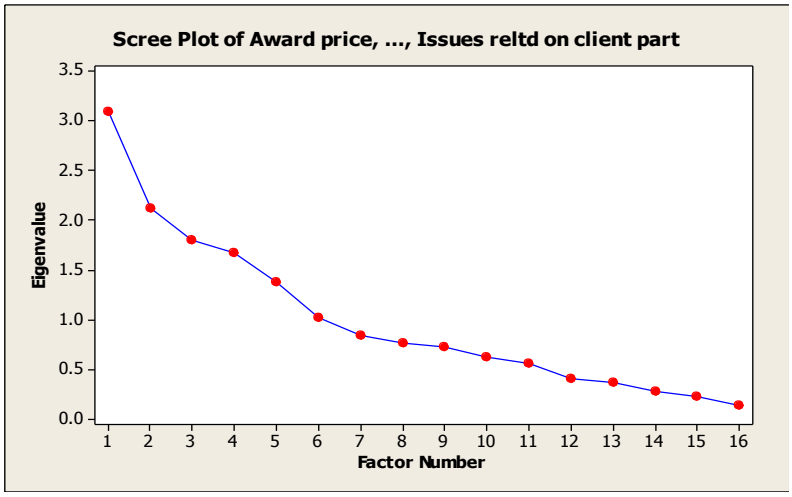
3.1Analysis of general group (49 projects)

The above group contains 49 projects including public sector, infrastructure sector and private sector projects. Since the Bartlett's test of sphericity was significant at p=0.000 with approx. Chi-square value =218.230 and df =120, Principal component factor analysis (PCFA) was performed on 16 identified project performance parameters (see Table 3.1).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.474
Bartlett's Test of Sphericity	Approx. Chi-Square	218.230
	df	120
	Sig.	.000

Also following the Eigen value greater than one rule, four factor solution was performed. The Scree plot of 16 identified parameters for general group is as follows –



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Welcome to Minitab, press F1 for help.

Factor Analysis: 16 Parameters as listed below

Principal Component Factor Analysis of the Correlation Matrix-VARIMAX rotation

Sorted Rotated Factor Loadings and Communalities

Variable	Factor1	Factor2	Factor3	Factor4	Communality
Wrkgrlshp	**0.774**	-0.217	0.100	-0.051	0.659
imprpamt pro.	**0.718**	-0.033	-0.148	0.057	0.541
Lack of perdmtngs	**0.674**	0.236	0.172	0.268	0.612
% TG	**0.671**	0.345	-0.023	-0.031	0.571
Ext. Itm	**0.547**	-0.121	-0.445	-0.082	0.518
% inc / CO	0.131	**0.793**	0.284	-0.026	0.727
C/CO	-0.225	**0.788**	0.030	-0.277	0.748
% CG	0.150	**0.703**	-0.340	0.161	0.658
Issues reltd on client part	0.185	-0.008	**0.683**	-0.327	0.607
% CC	0.140	0.011	**-0.639**	-0.144	0.449
% ELDC	0.399	0.027	**-0.415**	-0.073	0.338
% DC	-0.089	-0.160	**-0.310**	-0.269	0.202
Lack of geot.Invtgn	0.166	0.090	0.236	**-0.717**	0.605
lack of fore warng to ex. itm	0.011	-0.033	-0.298	**-0.686**	0.560

Award price	-0.117	0.103	-0.029	**-0.570**	0.350
Lack of std. drftcondn	0.407	0.165	-0.403	**0.445**	0.553
Variance	2.8371	2.0548	1.9073	1.9009	8.7002
% Var	**0.177**	**0.128**	**0.119**	**0.119**	**0.544**

Factor Score Coefficients

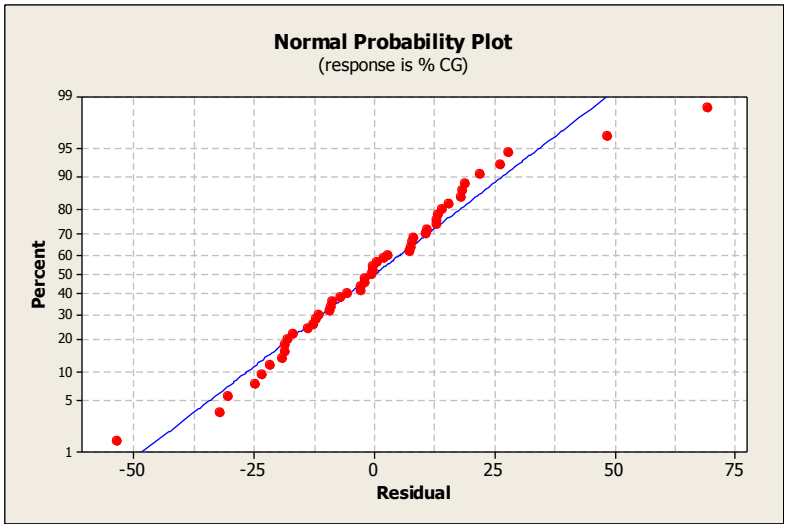
Variable	Factor1	Factor2	Factor3	Factor4
Award price	-0.028	0.049	-0.046	-0.299
% CG	-0.014	0.351	-0.187	0.079
Lack of perdmtngs	0.242	0.082	0.150	0.124
Lack of geot.Invtgn	0.106	0.019	0.117	-0.381
Wrkgrlshp	0.309	-0.150	0.121	-0.059
Ext. Itm	0.177	-0.077	-0.198	-0.082
lack of fore warng to ex. itm	0.010	-0.018	-0.182	-0.376
C/CO	-0.110	0.396	-0.032	-0.126
% inc / CO	0.032	0.377	0.143	0.001
% TG	0.232	0.137	0.031	-0.040
% ELDC	0.117	0.004	-0.197	-0.068
% CC	0.006	0.014	-0.342	-0.102
% DC	-0.039	-0.070	-0.180	-0.152
Lack of std. drftcondn	0.093	0.078	-0.177	0.211
imprpamt pro.	0.255	-0.048	-0.020	-0.004
Issues reltd on client part	0.137	-0.037	0.377	-0.161

In the rotated factor loading table above, the parameters whose loadings are marked bold under the respective factors represents that principle component factor. The interpretation of component factors is as follows -

Factor 1: Lack of contract management: Working relationship, improper payment process, lack of periodic meetings, %TG, and extra items.

Factor 2: Lack of planning at pre-contact stage:% increase per change order and cost per change order.
Factor 3: Improper contract execution:issues related on client part, % claim cost, % equivalent liquidated damage cost, % dispute cost.
Factor 4: Inadequate contract document: Lack of geotechnical investigation, lack of forewarning to extra item, award price, lack of standard draft conditions.

Minitab calculates factor scores by multiplying factor score coefficients and data after they have been centered by subtracting means. Factors scores are used to examine the behaviour of observations and in other analysis such as regression or MANOVA. The below graph shows straight line of plotted points for general group of parameters, thus sample is normal and adequate for regression analysis.



Regression Analysis: % CG V/s 4 component factors

The regression equation is

% CG = 26.7 + 5.31 Improper contract management

+ 24.9 Poor pre-contract planning - 12.0 Improper contract execution

+ 5.69 Inadequate contract document

Predictor	**Coef**	**SECoef**	**T**	**P**
Constant	26.672	3.095	8.62	0.000
Improper contract management	5.308	3.127	1.70	**0.047**
Poor pre-contract planning	24.919	3.127	7.97	**0.000**
Improper contract execution	-12.036	3.127	-3.85	**0.000**
Inadequate contract document	5.690	3.127	1.82	**0.056**

S = 21.6643 **R-Sq = 65.8%** **R-Sq (adj) = 62.6%**

Results:

All the four principal component factors, i.e. Improper contract management (p=0.047), Poor pre-contract planning (p=0.000), Improper contract execution (p=0.000) & Inadequate contract document (p=0.056) are significant with p-values less than and closer to 0.05.

Therefore, all the 16 identified performance parameters are significantly contributing to the variance of percentage cost growth (%CG) i.e. **In general group of construction projects all 16 parameters have significant impact on cost growth.**

IV. Conclusion and Recommandation :

As per statistical analysis, all groups of projects are badly suffering due to impact of basic project performance parameters. These parameters none other than the part of a contract between client and contractor. Therefore there is only need of professional approach to execute the contract processes. This can be done efficiently by project partnering.The study also highlights the requirement of contract management tool for successful execution of contract

From the study following recommandations can be drawn -

(1) Time should be the essence of the project i.e. for successful implementation of project partnering, the given project must be truly 'time bound'.

(2) There must be proper planning, documentation and foresightedness at pre-contract stage for successful implementation of project partnering.

(3) Proper planning must be followed by appropriate estimation of quantities and scope of project must be well defined for smooth process of project partnering.

(4) Contract conditions must be harmonized on basis of standard contract conditions published by MOS&PI or FIDIC which are recommended by Government of India. This will help to implement project partnering effectively.

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