

Mitigating Resource Management Related Factors Affecting Time and Cost Performance in Construction Projects

Abdul Qadir Memon*, Aftab Hameed Memon, Mohsin Ali Soomro

Civil Engineering Department, Quaid-e-Awam University of Engineering Science and Technology, Nawabshah, Pakistan

Corresponding author: Abdul Qadir Memon (e-mail: aqmemon@quest.edu.pk)

Abstract- Construction time and cost are basic parameters for measuring project performance. Unfortunately, construction projects are facing poor time and cost performance globally. This poor performance is occurred due to several factors among which resource related factors play very important role. Hence, it is very essential to control the factors affecting performance of time and cost. This study assessed significance level of the resource related factors and determined effective measure to mitigate the factors. Gathering of data was done by questionnaire survey with the practitioners representing client, consultant and contractors involved in handling execution works. Statistical analysis of gathered responses revealed that High cost of machinery and its maintenance; and fluctuation of prices of materials on site are significant resource related factors affecting project cost performance while in affecting time performance, the significant factors are financial difficulties faced by contractors and high cost of machinery and its maintenance. This study also assessed the effectiveness level of the mitigation measures for improving time and cost performance. The results of this study will assist to improve the performance of time and cost of the projects.

Index Terms—Time performance, cost performance, mitigation measure, resource related factors, construction industry, Pakistan

I. INTRODUCTION

Time and cost are always considered as basic parameters for measuring performance or success of any project. Although numerous efforts have been put forward by the researchers and practitioners but yet poor time and cost performance is a major impediments to successfully completing projects (Alhammadi and Memon, 2020, Rahman et. al. 2019). Poor cost performance results in significant cost overruns, putting a unnecessary financial burden on the client. According to a study conducted in the US, approximately 77 percent of the road projects experience cost overrun (Cantarelli et al. 2010). Ravisankar et.al (2014) stated that, the World Bank confirmed that overrun in cost of project ranges in between 50-80% while in UAE, an important project Dubai metro was delayed by 5 years and required 85% additional cost as compared to original estimated cost resulted from disputes; changes in design and scopes (Wilks 2015).

In Pakistan construction sector contributes 12.3% in industrial sector and in GDP its share is 2.34%. It has contributed 318,064 PKR Million in 2019 (Trading Economics, Pakistan, 2020). Unfortunately, Pakistani construction project are also facing severely from poor time and cost performance (Hussain S, et al., 2018, Memon et. al. 2019). Poor performance of the time and cost is resulted from different factors such as poor site management, financial management and resource management which are very essential to control. Among the factors, resource

related factors play very important role and have significant effect on the project cost (Rahman et. al. 2013). Mitigating resource factors will help in improving time and cost factors. Hence, this paper has focused on assessing significance level of various resources related factors on time and cost performance and also determining mitigation measure to control the resource related factors.

II. LITERATURE REVIEW

Time and cost performances are considered as prime measures for obtaining success in any project (Frimpong et. al. 2003; Olawale & Sun 2010). Unfortunately, global construction world is suffering from unsatisfactory level of performance in terms of time and cost resulting in a significant overrun. Time and cost performance does not only indicate profitability of any organization and also intimates the productivity of any firm. It provides a measure for assessing the performance of any work against the estimated or planned target. Flyvbjerg (2003) emphasizing the severity of this problem, mentioned that the trend of this problem is alarming since last 70 years globally.

Poor time and cost performance are frequent issues faced in construction projects. Time overruns are linked to cost overrun that often burdens capital resources. The amount of time spent on the projects varies considerably from project to project. The factors and the importance level reported were found to vary both from one region to another and from one country to other

(Herrera et. al. 2020). This poor performance occurs due to different attributes such as lack of experience and financial stability of the contractors which are very essential to identify. Among the contributing factors, resource related issues are reported as major contributor affecting the performance of construction projects (Memon et. al. 2013). Murali and Kumar (2019) drew attention that material management affects time management significantly. Faridi and El-Sayegh (2006) found out that shortage of resources, shortage of human resources, the productivity of workforce and skills of the workforce are the major factors leading to delay in construction.

III. RESEARCH METHODOLOGY AND DATA COLLECTION

Response of construction practitioners regarding resource related factors was recorded with the help of a questionnaire. Also, mitigation measures were assessed to determine the level of effectiveness in improving time and cost performance. Questionnaire form was consisted of 8 resource related factors identified from literature. For each factor, several possible mitigation measures identified from literature were also presented to the practitioners. Level of significance for each factor affecting time and cost performance as well as the effectiveness level of the mitigation measures was measured through 5- point Likert scale as in table I.

TABLE I
MEASUREMENT SCALE

Scale	Level of Significance	Level of Effectiveness
1	Not severe	Not effective
2	Slightly severe	Slightly effective
3	Moderately severe	Effective
4	Highly severe	Highly effective
5	Extremely severe	Extremely effective

To verify whether the data is accurate, it is necessary to understand the context of the respondents; hence, the questionnaire is designed in two parts where the first section gathered the information about respondent's expertise level.

IV. RESULTS AND DISCUSSION

A total of 300 questionnaire forms were distributed among the practitioners working in construction industry through email address, in person by visiting construction sites. Of these, 139 filled questionnaire forms were received back. Among these questionnaire forms, 8 forms were incomplete which were discarded and remaining 131 questionnaire forms were used for data analysis. Prior to analyses the factors and mitigation measures, demographic information of the respondents was analyzed as presented in table II.

TABLE II
RESPONDENT'S PROFILE

Characteristics	Frequency	% of Total
Type of Organization		
Client	41	31%

Consultant	44	34%
Contractor	46	35%
Position in Organization		
Site Engineer	43	33%
Project Manager	20	15%
Assistant Engineer	18	14%
Resident Engineer	12	9%
Construction Managers	38	29%
Academic Qualification		
B. E	66	50%
M. E	46	35%
Ph.D.	03	2%
Others	16	13%
Years of Experience		
0-5	39	30%
06-10	51	39%
11-15	28	21%
16-20	03	2%
21-25	04	3%
More than 25	06	5%

Table II shows that majority of the respondents is working with contractors representing 35% of the respondents whereas 34% of the respondents are working with consultants and 31% of the respondents are representatives of the client. These respondents holding several professional positions where majority i.e. 43 (33%) of the respondents are site engineers followed by construction managers with 29% of the respondents. Other respondents were working as project manager, Assistant engineer and Resident engineer. The respondents involved in this survey have gained technical level of education where majority of respondents with 50% have completed engineering degree, followed by 35% of the respondents have achieved post graduate level of education. Table 3 also demonstrates a wide range of expertise i.e. 39% of the respondents having 6-10 years experience, while 30% of the total respondents have experience up to 5 years. The proportion of engineers with 11 to 15 years' experience was equal to 21 % only 5% of engineers had experience between 16 to 25 years.

In order to evaluate the impact of the factor and ranking purpose, Relative importance index (RII) calculation was used. RII was calculated using the following equation adopted from Hossain et.al. 2019

$$RII = (\sum a_i n_i) / (5 N)$$

Where,

i = index of response category and i = 5,4,3,2,1 for extremely, highly, moderately, slightly and not effective, respectively.

a_i = weight given to the ith response and

n_i = frequency of the ith response. Furthermore, the higher rank was assigned to the factor with higher value of RII accordingly and so on.

N = total no. of the respondents

The data was analyzed statistically to calculate RII value and standard deviation (SD) for each factor in order to

rank for assessing the effect level on cost and time performance. The results obtained from analysis for raking in affecting cost

performance is presented in table III

TABLE III
RANKING OF THE FACTORS AFFECTING COST PERFORMANCE

S. No	Factor	Overall			Client			Consultant			Contractor		
		RII	SD	Rank	RII	SD	Rank	RII	SD	Rank	RII	SD	Rank
1	High cost of machinery and its maintenance	0.62	1.237	1	0.52	1.14	5	0.65	1.188	1	0.67	1.254	1
2	Fluctuation of prices of materials on site	0.6	1.246	2	0.55	1.285	4	0.63	1.238	2	0.63	1.204	3
3	Delay in Material procurement	0.59	1.172	3	0.52	1.161	6	0.61	1.219	4	0.63	1.081	2
4	Financial difficulties faced by contractors	0.59	1.189	4	0.55	1.067	3	0.63	1.34	3	0.6	1.135	4
5	Relationship between management and labor	0.55	1.282	7	0.47	1.135	8	0.57	1.34	7	0.59	1.306	5
6	Lack of modern Equipment	0.58	1.301	5	0.59	1.224	1	0.58	1.344	5	0.58	1.354	6
7	Poor Quality of materials	0.54	1.257	8	0.47	1.09	7	0.57	1.268	6	0.57	1.349	8
8	Low productivity of labor	0.56	1.203	6	0.57	1.315	2	0.54	1.095	8	0.57	1.217	7

From table III, it can be seen that High cost of machinery and its maintenance is reported as the most significant factor and is ranked 1st place by the respondents. Contractors and consultants considered this factor as the most significant factor while client representative argued that this is moderately significant and placed it 5th rank. Fluctuation of prices of materials is reported as 2nd most significant factor and agreed by the consultants. Contractor representatives have ranked this factor at 3rd place

while client's representatives considered this factor as 4th ranked factor. Poor quality of the materials has been ranked as the lowest significant factor and is agreed by the contractor, while client's respondents ranked this factor at 7th place and consultants ranked this factor at 6th place. Significance level of the factors in affecting the time performance was also evaluated based on RII and SD values as shown in table IV.

TABLE IV
RANKING OF THE FACTORS AFFECTING TIME PERFORMANCE

S. No	Factor	Overall			Client			Consultant			Contractor		
		RII	SD	Rank	RII	SD	Rank	RII	SD	Rank	RII	SD	Rank
1	Financial difficulties faced by contractors	0.62	1.152	1	0.6	1.245	1	0.65	1.188	2	0.61	1.032	4
2	High cost of machinery and its maintenance	0.62	1.215	2	0.49	1.119	8	0.65	1.188	2	0.72	1.066	1
3	Delay in Material procurement	0.59	1.169	3	0.5	1.003	6	0.62	1.273	3	0.64	1.114	2
4	Relationship between management and labor	0.59	1.261	4	0.53	1.315	4	0.61	1.14	4	0.62	1.303	3
5	Fluctuation of prices of materials on site	0.58	1.077	5	0.51	0.976	5	0.67	1.123	1	0.56	0.987	7
6	Lack of modern Equipment	0.58	1.33	6	0.54	1.312	3	0.61	1.38	5	0.58	1.303	6
7	Low productivity of labor	0.56	1.152	7	0.54	1.059	2	0.53	1.18	7	0.6	1.202	5
8	Poor Quality of materials	0.55	1.203	8	0.5	1.247	7	0.59	1.228	6	0.54	1.129	8

Table IV shows that financial difficulties faced by contractors is the most critical factor affecting time performance and is agreed by the client. Consultants have ranked this factor as 2nd most significant factor while contractors placed this factor at 4th rank. High cost of machinery is reported as 2nd major factors affecting time performance and is agreed by consultant. Contractor reported this factor as the most significant factor while client consider this factor as the lowest significant factor. In order to

improve the time and cost performance, it is very essential to control the factors affecting time and cost performance. Hence, effective mitigation measures were determined in this study. For this, the practitioners were provided with the list of possible mitigation measures for each factor to indicate the level of effectiveness in improving time and cost performance. Responses collected from the practitioners were analyzed statistically to calculate Effective Index (EI) and Rank of the

mitigation measure in improving time cost performance. The results of the mitigation measures are presented in table IV.

TABLE IV: RANKING OF THE MEASURES MITIGATING RESOURCE RELATED FACTORS

Factor	Mitigation Measure	Effect on Cost		Effect on Time	
		EI	Rank	EI	Rank
High cost of machinery and its maintenance	Trained operators and repair staff be deployed	0.735	1	0.776	2
	Operators be provided with necessary training of service and repair	0.718	2	0.782	1
	Practice good preventive maintenance be adopted	0.712	3	0.753	3
	Rental and shorthand used machinery be arranged	0.629	4	0.694	4
	Adopt predictive maintenance practices	0.612	5	0.571	5
Financial difficulties faced by contractors	Development of a comprehensive financial plan and cash flow	0.753	1	0.759	2
	Assess the financial strength, working capital levels, contractors' organization market liability, contract performance record, credit rating rather than lowest quote	0.700	2	0.729	4
	Progress payment to contractors should be followed according to schedule	0.665	3	0.706	5
	Check current financial status of the contractor before awarding the projects	0.665	3	0.700	6
	A thorough and detailed risk analysis before bid decision to cover payment clauses, stage and milestone related payments, forex currency forecast and fluctuations, cash flow-based project plan	0.665	3	0.618	7
	To adopt market price-based escalation formulae than indices based, to prevent mismatch between price rise and escalation compensation	0.647	4	0.765	1
	Development of a cost monitoring and periodical reporting of critical and long lead items	0.559	5	0.753	3
	Align payment milestones to be in synchronization with contractor's vendor payment terms	0.524	6	0.524	9
	Retaining a fixed percentage sum of usually 4% to 10% of cash from contractor bills be practiced	0.506	7	0.600	8
Poor Quality of materials	Clarify required materials specifications in contract	0.629	1	0.629	1
	Adopt Proper quality control and third-party Inspections	0.612	2	0.565	3
	Adopt supplier pre-qualification system	0.594	3	0.582	2
Relationship between management and labor	Inspire and offer incentives	0.735	1	0.741	1
	Promote healthy work/life balance	0.700	2	0.594	4
	Help employees to feel valuable	0.647	3	0.653	2
	Offer career development	0.559	4	0.612	3
	Promote dialogue and communication	0.559	4	0.594	4
	Focus on company mission and values	0.541	5	0.571	5
Fluctuation of prices of materials on site	Use domestic materials	0.735	1	0.682	3
	Unnecessary delays in project implementation should be avoided	0.700	2	0.735	1
	Proper planning and scheduling should be Adopted	0.647	3	0.665	4
	Purchasing bulk of materials before starting construction activities	0.576	4	0.700	2
	Government should intervene to control the market fluctuations	0.500	5	0.629	5
Low productivity of labor	Proper supervision and organization of construction processes	0.753	1	0.735	2
	Setting realistic targets for employees	0.647	2	0.676	3
	Motivation of workers via salary increase	0.518	3	0.759	1
Lack of modern Equipment	Increase use of advanced techniques such as prefabrication	0.682	1	0.682	1
	Improve construction equipment maintenance	0.647	2	0.647	2
	Improve construction productivity training	0.576	3	0.624	3
	Increase investment to arrange modern equipment	0.559	4	0.612	4

Delay in Material procurement	Improve safety training	0.541	5	0.571	5
	Estimate accurate material quantities	0.647	1	0.700	2
	Penalty on supplier for late delivery	0.629	2	0.712	1
	Early placement of items for long lead items	0.629	2	0.594	3
	Implement an effective logistics management for materials delivery	0.612	3	0.700	2

From table IV, it can be seen that for the factors high cost of machinery and its maintenance, most effective measure is “Trained operators and repair staff be deployed” in improving cost performance while in improving time performance, the same measures is ranked as 2nd effective measure. On the contrary, “Operators be provided with necessary training of service and repair” is reported as 2nd ranked effective measure for controlling High cost of machinery and its maintenance in improving cost performance while the same is reported as most effective measure in improving time performance. Similarly, the respondents mentioned that “Development of a comprehensive financial plan and cash flow” is the most effective measure for mitigating the factor “Financial difficulties faced by contractors” in improving cost performance while the same is reported as 2nd ranked effective factor in improving time performance. For mitigating this factor, it is suggested that prior to award the contract to any contractor, consultant should assess the financial strength and working capital levels of the contractors.

V. CONCLUSION

This study was carried out to assess the significance level of resource related factors in affecting time and cost performance of the construction projects in Pakistan. It also evaluated the effectiveness level of the measured to mitigate the factors for improving time and cost performance. This assessment was done based on the perception of the practitioners handling construction projects. A total of 131 collected responses through questionnaire survey amongst clients, consultants and contractors were analyzed statistically which revealed that high cost of machinery and its maintenance; and fluctuation of prices of materials on site are significant resource related factors affecting project cost performance while in affecting time performance, the significant factors are financial difficulties faced by contractors and high cost of machinery and its maintenance. Effectiveness of the possible measure to mitigate the factors affecting the performance of time and cost was also determined which will be useful for the practitioners to make necessary arrangement for improving time and cost performance.

REFERENCES

- [1] A.S.A.M. Alhammadi and A.H.Memon, “Inhibiting Factors of Cost Performance in UAE Construction Projects”, *International Journal of sustainable Construction Engineering and Technology*, vol. 11, no. 2, pp. 126-132, 2020
- [2] I.A. Rahman, L.C. Foo, A.H. Memon and S. Nagapan, “Schedule and Cost Behaviour In Construction Works Of Malaysia”, *Pakistan Journal of Science*, vol. 71 (4Suppl.), pp. 74-77, 2019.
- [3] C.C. Cantarelli, B. Flyvbjerg, B. van Wee, and E.J.E. Molin, “Lock-in and Its Influence on the project performance of Large-Scale Transportation Infrastructure Projects Investigating the Way in Which Lock-in Can Emerge and Affect Cost Overrun”, *Environment and Planning B: Planning and Design*, vol. 3, no. 5, pp/ 792-807, 2010
- [4] K.L. Ravishankar, Dr. S. Ananadkumar and V. Krishnamoorthy, “Study on the Quantification of Delay Factors in Construction Industry”, *Vol.4, no. 1*, pp. 105-113, 2014
- [5] S. Wilks, “The century’s most troublesome construction projects”, *Construction Manager Magazine*, 7th October 2015.
- [6] Trading Economics, Pakistan GDP from Construction, Trading economics (2019) report accessed from <https://tradingeconomics.com/pakistan/gdp-from-construction> on 20-02-2019.
- [7] S. Hussain, F. Zhu, Z. Ali, H. D. Aslam and A. Hussain, “Critical delaying factors: public sector building projects in Gilgit-Baltistan, Pakistan”, *Buildings*, Vol. 8, no. 6, pp. 1-16 2018.
- [8] A.Q. Memon, A. H. Memon, M. A. Soomro and I. A. Rahman, “Common Factors Affecting Time and Cost Performance of Construction Projects in Pakistan”, *Pakistan Journal of Science*, Vol. 71, no. (4 Suppl.): pp. 64-68, September 2019.
- [9] I.A. Rahman, A. H Memon, and A.T. Abd. Karim, “Relationship between factors of Construction Resources Affecting Project Cost”, *Modern Applied Science*, Vol. 7, no. 1, pp.67-75, 2013.
- [10] Muhammad Nasir Khan, Syed K. Hasnain, Mohsin Jamil, Sameeh Ullah, “Electronic Signals and Systems Analysis, Design and Applications International Edition,” in *Electronic Signals and Systems Analysis, Design and Applications: International Edition*, River Publishers, 2020.
- [11] Khan, Muhammad Nasir, Hasnain Kashif, and Abdul Rafay. "Performance and optimization of hybrid FSO/RF communication system in varying weather." *Photonic Network Communications* vol. 41, no. 1, pp. 47- 56, 2021.
- [12] Jamil, Mohsin, Muhammad Nasir Khan, Saqib Jamshed Rind, Qasim Awais, and Muhammad Uzair. "Neural network predictive control of vibrations in tall structure: An experimental controlled vision." *Computers & Electrical Engineering*, vol. 89, pp. 106940, 2021.
- [13] Khan, Muhammad Nasir, Mohsin Jamil, Syed Omer Gilani, Ishfaq Ahmad, Muhammad Uzair, and H. Omer. "Photo detector-based indoor positioning systems variants: A new look." *Computers & Electrical Engineering*, vol. 83, pp. 106607, 2020.
- [14] Kashif, Hasnain, Muhammad Nasir Khan, and Ali Altalbe. "Hybrid optical-radio transmission system link quality: link budget analysis." *IEEE Access*, vol. 8, pp. 65983-65992, 2020.
- [15] Khan, Muhammad Nasir, and Fawad Naseer. "IoT based university garbage monitoring system for healthy environment for students." In *2020 IEEE 14th International Conference on Semantic Computing (ICSC)*, pp. 354-358. IEEE, 2020.
- [16] Uzair, Muhammad, R. Dony, Mohsin Jamil, K. B. Ahmad Mahmood, and Muhammad Nasir Khan. "A no-reference framework for evaluating video quality streamed through wireless network." *Turkish Journal of Electrical Engineering & Computer Sciences*, vol. 27, no. 5, pp. 3383-3399, 2019.
- [17] Khan, Muhammad Nasir, Syed Omer Gilani, Mohsin Jamil, Abdul Rafay, Qasim Awais, Bilal A. Khawaja, Muhammad Uzair, and Abdul Waheed Malik. "Maximizing throughput of hybrid FSO-RF communication system: An algorithm." *IEEE Access*, vol. 6, pp. 30039-30048, 2018.
- [18] Khan, Muhammad Nasir, Syed K. Hasnain, and Mohsin Jamil. *Digital Signal Processing: A Breadth-first Approach*. Stylus Publishing, LLC, 2016.
- [19] Khan, Muhammad N. "Importance of noise models in FSO communications." *EURASIP Journal on Wireless Communications and Networking* vol. 2014, no. 1, pp. 1-10, 2014.
- [20] Md. A. Hossain, D. Raiymbekov, A. Nadeem and J. R. Kim, “ Delay causes in Kazakhstan’s construction projects and remedial measures”, *International Journal of Construction Management*, pp. 1-20, 31 Jul 2019.