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KEY PERFORMANCE INDICATORS IN UPHOLDING SCOPE CREEP MANAGEMENT IN ROAD PROJECTS

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ABSTRACT

Scope creep has been a day-to-day occurrence in almost every major road project causing a considerable cost overrun with no early dimple. This paper offers a critical appraisal on the dominant causes behind scope creep in the road projects. A comprehensive literature survey was undertaken to explore the factors specifically contributing scope creep and various control measures that are adopted, among other purposes, in at least reducing the impact due to scope creep in the final delivery of road projects. The study included interviews with 15 experts to identify major issues and add their hands-on experience. A questionnaire survey was subsequently administered among 100 industrial personnel having a cost management background in order to evaluate the effectiveness of the key performance indicators (KPIs) in terms of taming scope creep. Results from the study showed that concomitant client instructions on additional features, unclear scope and incremental changes cause scope creep throughout the project. Among 53 KPIs identified, the most effective KPI that enables adequate control of scope creep in road projects is the cost efficiency ratio. The results enable comprehending the causes of scope creep and its resultant net effect on cost control.

Keywords: *Cost controlling techniques; Cost overrun; Key Performance Indicators (KPIs); Road projects; Scope creep.*

1. INTRODUCTION

Cost overruns are inevitable even in projects delivered well (Zwikael, 2009). Nivehithan (2017) revealed that cost overrun can even result in early cessation. Thus, it is necessary to implement cost control mechanisms to ensure no deviations. The study done by Malkanthi *et al*., (2017) has revealed that cost variance can be reduced as much as 50% through the use of appropriate cost control techniques. As such, most of the literature has focused on various cost control techniques for general application (Koushki *et al*., 2005). The effectiveness of a cost controlling technique will depend on the measure of its performance (Neely *et al.*, 2005). Performance measurement is to objectively reckon the efficiency and effectiveness of a given task. It allows making judgments against certain predetermined criteria (Neely *et al.*, 2005; Basheka and Tumutegyereize, 2011). KPIs are therefore essential in terms of finding the current status as well as the 'remaining balance'. Swan and Kyng (2004) contend that monitoring KPIs are critical in any project. Thoor

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and Ogunlana (2010), together with Humaidi and Said (2011), suggested that KPIs are helpful to compare the actual with estimated performance in terms of effectiveness. KPIs are outcomes from an industry-led self-improvement initiative rather than a top-down imposition from government (Kumaraswamy *et al*., 2017). In 30 mega infrastructure projects in India, road projects are found to have largest amount of time and cost overruns (Narayanan *et al.*, 2019). Among a host of reasons, scope creep, is exceptional in road projects in a way it is silently contributing cost overrun in long run. Most projects seem to sustain scope creep (Larson and Larson, 2009). A few researchers have attempted to gauge the effectiveness of KPI however no research is found in reference to their application in scope creep. Hence, the research problems considered in this paper are 'Is there any particular KPI that effectively works in taming scope creep in road projects?

This research aims to enhance awareness among the construction practitioners to successfully cope with scope creep that take place in road construction projects. The objectives encompassing this study are to, (1) identify the factors contributing scope creep resulting in cost and schedule overrun, (2) identify the various cost management functions and key performance indicators in the sphere of scope creep management, and (3) statistically measure the level of their effectiveness in taming cost overrun in road projects.

2. FACTORS CONTRIBUTING SCOPE CREEP

As such, many researchers have identified a gamut of factors that cause scope creep in road projects and the associated KPI and recommended for the adoption during the project execution stage (refer Table 1).

Table 1: Factors contributing to scope creep in road projects & KPIs

#	Author	Factors contributing scope creep in road projects	KPI recommended
1	Arditi *et al*. (1985)	Substitution of materials as a result of resource shortages	Net scope change (add and omit schedule)
2	Dlakwa and Cuplin (1990)	Unstable interest rates, too many temporary diversions than planned	Budgeted cost of work done
3	Hendrickson (1998)	Cascading effects due to less productivity	Lead time, productivity ratio
4	Larson and Larson (2009)	Change in specifications	Reduced timing, productivity ration, variation log
5	Smith and Love (2001)	Abortive work, lasts minute adjustments by the end user	Number of Rework approved
6	Smith and Love (2001)	Incremental design changes	Claims
7	Sonuga *et al*. (2002)	Change in elevations, sections and plans	Under measure added, variation log, EI instructions responded, design changes authenticated
8	Aibinu and Jagboro (2002)	Unexpected incremental price increases on daily basis	Cash flow yield

#	Author	Factors contributing scope creep in road projects	KPI recommended
9	Gurlen (2003)	Unintended directions	Approved varied work
10	Baloi and Price (2003)	fluctuation of exchange rates, sub surface works where the theoretical quantities exceed	Cash flow margin
11	Baloi and Price (2003)	Continuous design changes	Variation log, potential change notices approved,
12	Koushki and Kartam (2004)	Change in line, level and alignments, change in super elevation, change in specifications as to mix of asphalt, mix of concrete, type of soil	Site log book signed and confirmed, variation log
13	Koushki and Kartam (2004)	Plant idling	Mark up eroded
14	Hanna and Gunduz (2004)	Low labour productivity	Cost benefit ratio, productivity ratio
15	Chester and Hendrickson (2005)	Labour inefficiency, wrong estimate in quantities	Employer Instruction (EI) the cost of which is confirmed in principle
16	Koushki *et al*. (2005)	Verbal instructions at site level	Log notes confirmed, variation log
17	Iyer and Jha (2005)	High scope of temporary works, plant idling	Efficiency ratio, waiting time
18	Chester and Hendrickson (2005)	Labour inefficiency, plant idling	Contract rate vs. actual rate, productivity ratio
19	Cotton *et al.* (2005)	Labour inefficiency	Productivity ratio
20	Yahya and Boussabaine (2006)	Wastage of materials, labour, omitted works, missing items in the bill of quantities,	Abortive work schedule approved
21	Walsh *et al.* (2006)	Wrong method of resource handling, change in sequence of site operations	Cost performance index (CPI), schedule performance index
22	Dixon (2006)	additional functionalities	Return on investment
23	Berman (2006)	Low productivity	Productivity ratio
24	Walsh *et al.* (2006)	Wrong methods of resources handling	Amount of loss recovered
25	Yahya and Boussabaine (2006)	Change in the sequence of work and methods statement	Productivity ratio
26	Owens (2007)	Additional works in small quantities	Mean absolute deviation
27	Azhar *et al*. (2008)	Unstable costs of the manufacturing materials.	Cost target

#	Author	Factors contributing scope creep in road projects	KPI recommended
28	Ward and Chapman (2008)	Incremental change in the original scope of the work and its time impact	Schedule performance index (SPI),
29	Pewdum (2009)	Changes in source of supply of materials	Number of claims settled
30	Shane *et al*. (2009)	Idling of machinery	Cost limit
31	Turk (2010)	Ambiguous, vague scope fi work reticence could be a precursor to failure.	Variation log, Reduced preliminaries
32	Olawale and Sun (2010)	Design changes from time to time	Variation log
33	Fang and Ng (2011)	Wastage in handling materials	Approved Day Work Schedule
34	Jayalath (2011)	Original contract scope increased substantially, change in invert levels, change in mix proportions, change in intervals in joints, bases, thresholds etc.	Schedule variance
35	Jayalath (2011)	Changes in the method of execution	Actual cost of works performed
36	Wijekoon and Attanayake (2011)	Changes in end user requirements	Burn rate, variation log, omitted work schedule, day work schedule approved
37	Fang and Ng (2011)	Wastage during heavy usage of raw materials	Attendance fees settled
38	Jayalath (2011)	Deviation as to the methods of execution as planned. Slight changes allowed to the original project scope	Work certified to date, variation approved
39	Fang and Ng (2011)	Wastage, in the use of materials	Billing analysis
40	Jayalath (2011)	Additional functionalities	Return on investment
41	De Marco (2013)	Little changes to the planned base line, work scope and schedule	Claimed vs. approved (variations log)
42	Wijekoon and Attanayake (2013)	Low precision of the estimates, inaccurate site investigation,	Request for Information (RFI) responded, schedule for approved day work
43	De Marco (2013)	Changing the planned base line, work scope and schedule.	Variations
44	Shrestha (2014)	Last minute adjustments to project scope in order to rectify design errors	Budgeted cost of work performed

#	Author	Factors contributing scope creep in road projects	KPI recommended
45	Ghoddousi and Poorafshar (2015)	Plant idling, protracted delay in approval process	Number of variations finalized, Disputed amount vs. effective contract sum
46	Ghoddousi *et al*. (2015)	Works done on, trial and error basis	Productivity ratio, budgeted cost of work completed
47	Baek *et al*. (2016)	Incomplete drawings	Potential change notices (PCN) approved
48	Saidu and Shakantu (2016)	Large amount of materials wastage, labour inefficiency, concomitant changes in weather conditions, price increases	Standing time, budgeted cost of work completed
49	Kerzner (2017)	Additional features and functionalities	Cost variance
50	Veen *et al*. (2017)	Disruptive events due to a series of individual changes	Cost per km

The foregoing literature review essentially carries out the detailed elaboration of various factors contributing scope creep and key performance indicators as a set of quantifiable measurements used to gauge the overall long-term performance in taming scope creep.

3. RESEARCH METHODOLOGY

The study used the mixed research method. Mixed research approach being a combination of qualitative and quantitative approaches can overcome the weakness of the two approaches (Creswell, 2014). It can also enhance the rationality and consistency of the results of a study while enabling strong recommendations (Amaratunga *et al*., 2002). The study commenced with a detailed literature survey to identify the factors affecting cost overrun and cost controlling techniques and used semi structured expert interviews to collect the qualitative data required. 15 experts were selected using purposive sampling. Interview findings were transcribed and analysed using NVivo 11 code-based content analysis software and used to develop the questionnaire to evaluate the effectiveness. Interview findings were used to identify the most prevalent scope creep management tools in road projects. The profile of 15 interviewees are basically senior quantity surveyors with more than 20 years' experience working in road projects (refer Table 2).

Questionnaire surveys allow collection of data from a large number of respondents in a standard manner without any influence from the researcher (Bhattacherjee, 2012; MacDonald and Headlam, 2008). 100 project level quantity surveyors working in different capacities and authorities were selected using purposive sampling (refer Table 2). Questionnaires were despatched via email and the response rate was 84%.

The index of Mean Item Square (MIS) is the sum of the respondents' actual scores given by all the respondents as a proportion of the sum of all maximum possible scores on the 5-point scale. Weighting was assigned to each responses ranging from one to five for the responses of 'strongly disagree' to 'strongly agree' and 'Extremely unlikely' to 'Extremely likely', when expressed mathematically as given in Equation (01).

$$MIS= (1n1 + 2n2 + 3n3 +4n4+5n5) / \Sigma N \quad (01)$$

Where; n_1 = Number of respondents for extremely unlikely or strongly disagree; n_2 = Number of respondents for unlikely of disagree; n_3 = Number of respondents for neutral; n_4 = Number of respondents for likely or agree; n_5 = Number of respondents for extremely likely or strongly agree; N = Total number of respondents. After mathematical computations, the criteria are then ranked in descending order of their MIS (from the highest to the lowest).

Table 2: Profile of the questionnaire survey respondents

Work experience / No. of years / Designation	11-15	16-20	21-25	Above 25	Total
Senior QS	22	14	5	-	**41**
Chief QS	4	11	17	-	**32**
Cost Controller	-	-	6	-	**6**
Commercial Manager			2	-	**2**
Director	-		1	1	**2**
Managing Director				1	**1**
	26	**25**	**21**	**2**	**84**

4. RESEARCH FINDINGS AND DISCUSSION

48 authors revealed a gamut of reasons behind scope creep in road projects. The causes such as plant idling, wastage, incremental changes to design are of frequent occurrence. In the meantime, these scholars recommended nearly 50 tools that are adoptable at site level; broadly classifiable into three mail groups based on the function it serves, namely technical, contractual and commercial. Expert interviewees were requested to map, the first ten scope creep management tools as identified in the order of prevalence, in the literature to the real-life project scenario, together with their measurement scales, which are literally the KPIs in managing costs in road projects. Some tools were identified as being used rarely, some as being used commonly, and others as being used quite frequently. The most prevalent KPIs in managing scope creep are basically variation orders, potential change notices and day work schedules. The perception of 84 respondents who participated in the questionnaire survey was derived in a 5-point Likert scale in order to gauge the effectiveness of KPI (refer Table 3).

The functions 'contract administration' 'earn value management and cost planning are the most effective functions in taming scope creep. The most effective tool of contract administration that gives the highest effectiveness in controlling scope creep is variation log. Net change in scope and potential change notice schedules ranked the second and third in terms of effectiveness respectively. 'The highest number of KPIs, which is eleven have been identified for the cost management function, interim and final accounting. 'Mark-up eroded' and 'billing analysis' are the most significant KPIs among them. The KPI 'cost performance index' of the function 'earn value management 'obtained the highest MWR of 4.950 while the KPI 'return on investment' of the function; contingency management' obtained the lowest MWR of 2.013. A mapping of the first ten KPIs with the highest ever ($\overline{x}$) values recorded in the questionnaire survey is presented in Table 3.

Table 3: Effectiveness of KPIs of each cost management tool

Pf	R	KPIs	$\bar{x}$	σX	R
Contract administration	1	Potential change notices (PCN) approved	4.568	0.856	1
		Net scope change (add and omit schedule)	3.965	0.829	2
		Claimed vs. approved (variations log)	3.850	0.783	3
		Site logbook signed and confirmed	3.560	0.820	4
		Request for information (RFI) responded	3.546	0.747	5
		Approved day work schedule	3.517	0.642	6
		Employer instruction (EI) the cost of which is confirmed in principle	3.442	0.531	7
		Number of rework approved	3.418	0.782	8
		Abortive work schedule approved	3.250	0.653	9
Earn value management	2	Cost performance index (CPI)	4.750	0.782	1
		Schedule performance index (SPI)	4.243	0.834	2
		Cost variance	3.943	0.734	3
		Schedule variance	3.759		4
		Budgeted cost of the work performed	3.724	0.750	5
		Actual cost of works performed	3.452	0.838	6
Cost planning	3	Cost per km	4.750	0.750	1
		Cost limit	4.439	0.820	2
		Cost target	4.129	0.765	3
Cash flow forecasting	4	Cash flow yield	4.320	0.735	1
		Cash flow margin	4.200	0.851	2
Cost value reconciliation	5	Over measure deducted	3.580	0.745	1
		Under measure added	4.002	0.869	2
Schedule perform variance	6	Productivity ratio	4.455	0.745	1
		Efficiency ratio	3.875	0.647	2
		Waiting time	3.900	0.836	3
		Lead time	3.745	0.829	4
		Standing time	3.410	0.683	5
Contingency management	7	Current ratio	2.760	0.870	1
		Burn rate	3.875	0.740	2
		Mean absolute deviation	3.743	0.622	3
Interim/final cost reporting	8	Mark up eroded	3.660	0.551	1
		Billing analysis	3.616	0.772	2
		Contract rate vs. actual rate	3.251	0.693	3
		Variations	3.875	0.781	4

Pf	R	KPIs	$\bar{x}$	σX	R
		Claims	3.799	0.832	5
		Timing of payments	3.560	0.734	6
		Number of variations finalized	3.416		7
		Disputed amount vs. effective contract sum	3.250	0.751	8
		Retention released	3.100	0.830	9
		Percentage of supplier account settled	2.856	0.759	10
		Attendance fees settled	2.564	0.821	11
		Amount of loss recovered	3.650	0.826	12
		Work certified to date	3.620	0.829	13
		Number of claims settled	3.555	0.787	14
Value engineering	9	Cost benefit ratio	3.479	0.827	1
		Advanced milestones	3.200	0.744	2
		Bonus for early completion	3.120	0.652	3
		Reduced preliminaries	3.340	0.531	4
		Enhanced functional value	3.247	0.782	5
		Reduced timing	3.233	0.643	6
Life cycle costing (LCC)	10	Value for money	3.082	0.782	1
		Return on investment	2.930	0.734	2
		Cost benefit ratio	2.884	0.735	3

Pf = Project function, σX = Standard deviation; $\bar{x}$ = Mean item score; R = Rank

5. CONCLUSIONS AND RECOMMENDATIONS

The results of the survey data analysis reveal that KPIs vary according to user's perspective. Further analysis displayed a substantial difference between scholars and practitioners' perceptions. However, ten indicators, the Mean Item Square for which was fallen within the 4 to 5 in the scale reported as being most useful. 'Contract management' is the most significant technique and its most important KPIs are Cost performance index (CPI), Cost per km and Potential change notices (PCN) approved. Experts concluded that most of the KPIs used are post contract lagging measures that do not provide the opening to make any adjustments. The most critical causes are client changes, unforeseen risk and unclear scope. The major effects are delays in project completion time and increasing cost of projects. Hence, it is imperative that a proper scope creep management tool is agreed upfront, constantly monitored and actions taken to avoid it changing in a way that exceed budget and the timescale. As an important contribution, a couple of prescriptions for mitigating the incidence of scope creep has been suggested. Further research could also be carried out to investigate in detail the cost impact of scope creep, in a quantifiable way.

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