Measuring Project Performance and Success Factors of Construction Sites

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***Abstract*- Project performance is crucial issue for the construction industry. The need for performance measurement systems is critical in the construction. In projects, timely completion and client satisfaction are often used to determine success. The effective performance of the construction project manager to perform his job functions with intended efficacy is important for the success of the construction project. Because the industry has intricacy in its nature because it contains large number of parties such as contractors, clients, consultants, government agencies, stakeholders etc. Construction projects suffer from many problems and complex issues in performance some of which includes cost, time and quality. Therefore for measurement of performance and then optimizing it, measurement of set of desired targets is necessary for the control of variability of the main and sub- process within the processes involved in a project. This paper reviews the methods for performance measurement, identification of KPIs and then methods for finding KPIs specific to a region or a project.**

Index Terms- Performance measurement, project success, project manager, control, KPIs.

I. INTRODUCTION

The construction industry in India contributes to around 11% of the gross domestic product. Size of the India's construction industry expected to be USD 1 trillion by 2025 (makeinindia.com/sector/construction, web page). Therefore, improvements in construction industry performance have a major economic impact. Systematic performance improvement demands also systematic means to measure performance and its development according to J. Salminen, 2005.

Due to highly unstructured Indian construction market, there is little to none efforts made in analysing the performance of a project which leads to underperformance in the form of poor utilization of time and finance and resources. There is a lack of appropriate project management system to improve construction performance.

Performance measurement means collecting and analysing the data regarding the volume of input and the subsequent volume of output, basically the efficiency and productivity of a project (OECD, 2001, p.11). Performance measurement in the construction industry is difficult due to spectrum of variables and factors being exceedingly large and complex. It is difficult to define output and differentiate it from the input and therefore to measure it (Djellal and Gallouj, 2013). Therefore there is a need to find out Key Performance Indicators (KPIs) which affects the construction projects the most. These can be project specific or generalized factors depending on the scope of the work. Indicators help in the measurement by specifying the critical areas. Therefore defining the KPIs play an important role in project delivery.

II.PERFORMANCE MEASUREMENT

A main objective in management is to improve the competitive ability of a company. Performance is something that is very closely connected to a company's competitiveness as said by Juha Salminen (2005)[1]

Brown (1995) ties performance measurement strongly to the organization process, which consists of inputs, process, and outputs and also the long-term results and final goals of the company. Financial results and process efficiency still play a central role, but factors related to business environment and employees are equally important. The six elements of performance, according to Brown, are:

- financial performance,
- product/service quality,
- supplier performance,
- customer satisfaction,

- process and operational performance, and
- employee satisfaction.

Brown and Adams (2000) [3] obtained an evaluation framework to measure the efficiency of building project management (BPM) by using conventional economic analysis tools such as time, cost and quality. Lehtonen (2001)[4]stated that performance measurement systems are imminent in the construction firms. Samson and Lema (2002)[5] stated that effective and efficient management of contractors' organizational performance requires commitment to effective performance measurement in order to evaluate, control, and improve performance today and in the future.

Kagioglou et al. (2001) [13] argued that traditional indicators such as cost, time and quality do not in isolation, provide a balance view of the projects‟ performance. Researchers further stated that implementation of three traditional indicators in construction projects is apparent at the end of the project and therefore they can be classified as „lagging‟ indicators of performance. Salminen (2005)[1] developed a system for measuring construction site performance. The researcher analysed the measurement results to determine the success factors for a construction site. Kagioglou et al. (2001) [13] mentioned that the project performance would be addressed on an induction basis by all companies involved in the project. The measures will therefore include both company and project performance issues. It was noted that there are different applications of key performance indicators (KPIs) in construction. Chan and Chan (2004)[6] developed a set of KPIs to measure success of construction projects.

Integrated Performance Index – R&D Projects				
	Different Phases of a project life cycle			Overall Project Life cycle
	Project Selection Phase	Project Execution Phase	Implementation Phase	
Major Concerns	Project screening Detailed evaluation Project selection	Technology development Product development Performance demonstration	Production Sales Marketing	Customer delight ROI
Key Factors/ Performance indicators	Benefit Risk Special consideration (category)	Progress deviation Cost deviation Decision effectiveness	Production Cost effectiveness Customer commitment	Integrated Performance
Stakeholders	Sponsoring organisation	Project management team	Customer	All stakeholders
Existing Models for performance measurement	Profile charts Check lists Scoring models Economic indices Frontier models Risk models Portfolio models AHP models Fuzzy models	Gantt chart Slip chart CPM PERT Earned value	Production rate & Yield Product Quality Sales volume	Cash Flows Customer feedback Growth potential
Proposed Model	Integrated Performance Measurement for all phases of the project life cycle by linking the key factors from each phase using INTEGRATED PERFORMANCE INDEX			

Source: Adopted and Modified from Pillai *et al.* (2002)

The performance indicators are divided into various groups like time, cost, quality, design changes, human resources, finance etc, with this, project performance can be measured. However, Time, cost and quality are the three predominant performance evaluation dimension. According to Shahrukh and Milind (2017)[14], Construction projects are a balance between cost, time and quality. It is conceivable to have high quality and minimal cost, but at the expense of time, and conversely to have high quality and a fast project, but at a cost. In an event where both time and cash are limited, then quality is likely to suffer. High quality is not always generally the primary objective for the client; time or cost may be more important. It is only realistic to specify an exceptional standard of quality if the budget is available to achieve that standard.

KEY PERFORMANCE INDICATORS

Key Performance Indicators (KPI) are compilations of data measures used to assess the performance of a construction operation. They are the methods management uses to assess quality of a particular activity or task. These assessments typically compare the actual and estimated performance in terms of productivity, efficiency, and quality in terms of both workmanship and output. (Shahrukh and Milind (2017))[14].

Indicators are used for the measurement of different aspects of construction. A KPI is a measure of a factor critical to the success, productivity, efficiency or the performance of the project. Traditionally KPIs are mainly used to benchmark the construction activites or projects against each other to analyse the shortcoming and find out whether the activity can be performed more efficiently. But this has less significance in the execution phase or control phase as these are primarily used for benchmarking. Feurer & Chaharbaghi [11] suggested to focus of measurement on activites rather than on the functions of the project

K. N. JHA & K. C. IYER (November 2006) [15] inspected the factors that adversely affected the performances of projects and activities were: conflict among project participants; hostile socio-economic environment; harsh climatic condition; Project manager's ignorance & lack of knowledge; Inadequate project conceptualization; and aggressive competition during tendering.

Cheung et al (2004) [16] remarked seven main key indicators for performance which are: time, cost, quality, client satisfaction, client changes, business performance, and safety and health. Navon (2005) [17] stated that a number of research efforts to fully automate project performance control of various project performance indicators have been carried out in recent years. These are also briefly described together with the concept of measuring indirect parameters and converting them into the required indicators. These are (1) labor and earthmoving efficiency based on measuring the location of workers or earthmoving equipment at regular time intervals; (2) progress based on the above data; (3) a comprehensive control of construction materials starting by monitoring orders and purchasing up to the movement of the materials on site.

Pheng and Chuan (2006) [18] stated that project performance can be determined by two common sets of indicators. The first set is related to the owner, users, stakeholders and the general public which are the groups of people who will look at project performance from the macro viewpoint. The second are the developer, a non-operator, and the contractor which are the groups of people who will look at project performance from the micro viewpoint. Jin et al (2006) [19] studied the relationship-based factors that affect performance of general building projects in China. Thirteen performance metrics was used to assess the success level of construction projects. These factors were categorized into four groups namely cost, schedule, quality and relationship performance. It was recommended that foreign firms that have entered or are going to enter the Chinese construction industry should learn how to build cooperative and harmonious relationships with Chinese partners and finally achieve satisfactory project performance by paying sufficient attention to the aforementioned factors.

Source	Design KPIs	
Gann et al. [14] DQI_buildings	➢ Functionality (use, access, space, character & innovation) ➢ Impact (form &materials, internal environment, urban & social integration) ➢ Build quality (construction, engineering systems, performance)	
Hansen & Vanegas, [12]_buildings	➢ Contextual compatibility & response ➢ Functional performance ➢ Physical performance ➢ Cost ➢ Time ➢ Quality / reliability	➢ Safety / security ➢ Risk ➢ Constructability ➢ Maintainability ➢ Health and ➢ Sustainability
Anderson, D.K. & Merna, T. [2]	➢ Scope ➢ Concurrency ➢ Specifications ➢ Technical validation	➢ Commercial validation ➢ Practicality ➢ Quality ➢ Innovation
CIRIA [8]	➢ Design process ➢ Integration of design with supply chain ➢ Internal time/cost management ➢ Risk ➢ Reuse of design experience ➢ Innovation ➢ Client/user satisfaction	
DETR [9]	➢ Predictability-cost ➢ Predictability-time ➢ Waste (product was designed for minimum waste materials) ➢ Energy use (designed) ➢ Main water use (designed) ➢ Impact on biodiversity	
Ugwu and Haupt [21] _infrastructure	➢ Environmental impacts ➢ Innovative solutions that optimize the use of resources including design for durability, constructability and deconstruction ➢ Material reuse ➢ Recycle and waste management ➢ Impact of design decisions on the wider ecosystem ➢ Innovative construction methods and technology	

Table 1: Summary of the literature review on the existing design KPIs
(Source: Haponava Tatsiana & Al-Jibouri Saad "Identifying the KPIs for the design stage based on the main design sub-processes")

Project Success

Success of a project is a relative term. It depends of the expectations of different stakeholders involves in the project. The project objecives and specific success criteria are different with every stakeholder.

Al-Momani (2000) [20] stated that the success of any project is related to two important features, which are service quality in construction delivered by contractors and the project owner's expectations. Managing the construction so that all the participants perceive equity of benefits can be crucial to project success. It is obtained that the complete lack of attention devoted to owner's satisfaction contributes to poor performance. Reducing market shares, low productivity and efficiency , and the rapid construction cost escalation also leads to poor performance. Nitithamyong et al (2004) [21] said that the success of construction projects depends up on technology, process, people, procurement, legal issues, and knowledge management which must be considered equally.

Pheng and Chuan (2006) [16] defined project success as the completion of a project within acceptable time, cost and quality and achieving client's satisfaction. Project success can be achieved through the good performance of indicators of the project. So, success refers to project success and performance refers to performance of indicators such as project managers. Wang and Huang (2006) [22] stated that Project success has been widely discussed in the project management (PM) literature. The focus of most studies of project success is on dimensions of project success (how to measure it) and factors influencing project success. Wang and Huang (2006) [22] studied that how the engineers evaluate project success and to what extent key project stakeholders' performance correlates with project success. It is obtained that project owners play the most important role in determining project success, and project management organizations' performance as the single point of project responsibility

Munns and Bjeirmi (1996) [23] state that evaluation of project management success is a complicated matter. Project success is usually evaluated only at the end of the project, which yields only a partial picture of the project manager's success in the long term. Often the objectives of project management and other stakeholders conflict. In addition, as measurement of cost and time is so easy, involving comparison of results to the budget and schedule, success elements that are qualitative or not easily measured are neglected. The authors also argue that a distinction should be drawn between the success or failure of the project and that of project management.

Baccarini (1999) [24] too divides project success into two components, product success and project management success. Project management success consists of 1) meeting time, cost, and quality objectives; 2) the quality of the project management process; and 3) satisfying project stakeholders' needs related to the project management process. Product success means 1) meeting the project owner's strategic organizational objectives, 2) satisfaction of users' needs, and 3) satisfaction of stakeholders' needs when related to the product.

III. METHODOLOGY

A questionnaire survey is used to collect the data for the study as a primary source, to establish the most significant or critical key performance indicators for construction projects. Professionals such as architects, quantity surveyors, electrical engineers, mechanical engineers, structural engineers, civil engineers, construction managers, project managers and construction project manager, are selected as the target population for the survey. Questionnaires are distributed randomly to respondents in both the private and public sector. The secondary data is collected from a thorough review of related literature; it is through this thorough literature review that the key performance indicators for construction are identified. Using a five point Likert scale, the respondents are asked to rate the most significant construction industry KPI's, the studied factors were ranked based on the mean item score.

Mean item score.

The five-point scale is transformed to mean item score (MIS) for each of the factors of causes and effects as assessed by the respondents. The indices are then used to determine the rank of each item. The ranking makes it possible to cross compare the

relative importance of the items as perceived by the respondents. This is the method used to analyse the collected data from the issued questionnaires in the study. Likert scaling is a bipolar scaling method, measuring either positive or negative response to a statement (Sukamolson, nd: 20). After the questionnaire is completed, each item may be analysed separately or item responses may be summed to create a score for a group of items. Hence, Likert scales are often called summative scales.

The computation of the relative mean item score (MIS) is calculated from the total of all weighted responses and then relating it to the total responses on a particular aspect. This is based on the principle that respondents' scores on all the selected criteria, considered together, are the empirically determined indices of relative importance. The index of MIS of a particular factor is the sum of the respondents' actual scores (on the 5-point scale) given by all the respondents' as a proportion of the sum of all maximum possible scores on the 5-point scale that all the respondents could give to that criterion (Pilot & Hungler, 1995:33). Weighting is assigned to each responses ranging from one to five for the responses of 'strongly disagree' to 'strongly agree' and 'Extremely unlikely' to 'Extremely likely'. This is expressed mathematically below. The mean item score (MIS) is calculated for each item as follows:

$$MIS = \frac{1n1 + 2n2 + 3n3 + 4n4 + 5n5}{\Sigma N} \quad \text{Equation 1.0}$$

Where;

n1 = Number of respondents for extremely unlikely or strongly disagree;

n2 = Number of respondents for unlikely of disagree;

n3 = Number of respondents for neutral;

n4 = Number of respondents for likely or agree;

n5 = 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 mean item score (from the highest to the lowest).

IV. CONCLUSION

End-project goals can be best achieved by a better understanding of construction processes.

Benchmarking can help in increasing the sector's performance because it allows the continued improvement of the organizations and their processes, by comparing and evaluating their performance with respect to best practices. In fact, benchmarking has been a very useful practice, not only in achieving superior performance but also in identifying the organizational problems.

It is also concluded that the performance measurement and benchmarking should be used as a way to generate value for companies and stakeholders through the optimization of their construction processes and products, i.e. increasing the levels of effectiveness and efficiency.

After reviewing the literature on the most significant key performance indicators, it revealed that, quality and scope were the most significant KPIs for construction projects, further review revealed that time, cost and quality are the three basic and most critical performance indicators in construction projects followed by safety, functionality and client satisfaction. It was observed that execution time, profitability, management of project, material ordering, handling and management, risk management, quality assurance, client satisfaction (product), safety, time predictability (design, project, construction), client satisfaction (service), productivity were the ten most significant key performance indicators for construction projects.

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