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ENHANCING PRODUCTIVITY AND PROFITABILITY BY DETERMINATION OF POOR QUALITY COST, USING DASHBOARD MANAGEMENT INFORMATION SYSTEM

***S. Mahmood*[1], *N.I. Kureshi*[2]**
[1]University of Engineering and Technology Taxila, Islamabad-Pakistan
[2] Center of Advance Studies in Engineering, Islamabad-Pakistan

ABSTRACT

Companies are facing 17to 27% losses in their revenues due to Cost of Poor Quality (COPQ) as revealed in the research conducted over past many years. The disturbing fact is that these hidden failure costs are not reflected in the existing accounting and management information systems. Thus management fails to initiate corrective actions. COPQ adversely affects the productivity of resources and profitability of construction companies. Therefore an effective mechanism is needed to identify and measure the failure costs along with a management information system, so that corrective actions are initiated to control further hidden losses. A COPQ measurement and dashboard Management Information System was designed by the researchers to show the extent of losses during project execution along with reasons for the losses with the help of charts/graphs and summaries. The system/tool was used in an actual construction project to validate its effectiveness. The research purpose was to examine the effectiveness of the proposed system in reducing COPQ and its corresponding effect on profitability and labor productivity.

Keywords: *Construction Industry, Cost of Poor Quality, dashboard management information system, Internal Failure Cost, Productivity, Profitability.*

1) INTRODUCTION

Management can be termed as an art of getting objectives achieved using services of the individuals in formally structured groups. The major functions a manager performs in an organization include planning, organizing, recruiting, controlling, and directing. Management cannot be performed without effective communication between organizational sections and feedback/information about their business processes.

Availability of reliable information is critical to the quality of decisions taken by senior managers and boards. Together with the intuition of managers, reliable information can be a critical source of competitive advantage. As a corollary, if managers and boards are presented with faulty, incomplete or unreliable information, they will, almost certainly, not be able to take good decisions.

With reliable information having such a game-changing role in competitive settings, it seems only natural that companies would establish robust Management Information Systems that will provide reliable information for high quality decision making. However, available empirical evidence suggests otherwise.

The MIS system ensures collection of appropriate data from the various sources, and after processing sends the information to all the respective destinations and departments. The system is required to process and sort out the information according to the requirements of an individual, a team/section, the lower, middle and top management functionaries. Very high-quality soft-wares are now available for computer based MIS, but in order to serve the specific purpose they have to be designed for said specific business activity or objective (Bhargava-2009).

MIS requirements have improved intensely over the past few years. Producing a report to analyze data is not enough, it is more important now to have a reporting tool/system, having a capability of showing consolidated and arranged results of the most important information on a single screen through visual display so that real-time data can be monitored at a glance (UNDP-2011). In a Computer based MIS, data can be summarized and information can be presented in a dashboard style, showing required achievements, comparisons and indicators etc. in visual format. Digital dashboards make it possible for managers to monitor the progress and contribution of their various departments/sections.

The MIS also provides operational data for planning, scheduling and control, helpful for the lower and middle management for decision making at the operations level to rectify the problem areas. It provides assistance to the middle management to carry out short-term planning, goal setting and also monitoring/controlling the processes and improving business functions. The MIS also empowers the top management in strategic planning, target setting, and developing their future business plans.

Information technology (IT) so far has not been able to make an effective contribution for improvement of the construction industry. Mak (2001) observes that the construction industry is slow in utilizing IT to manage projects. IT application has been carried out in piecemeal, isolation and in non-systematic way. In order to make better decision making in the construction industry, managing information for construction projects and use of IT is very crucial.

The COPQ (internal failure costs) are normally not recorded separately in the existing accounting reports and auditing system, therefore it are difficult to be traced or identified (Dian et al -2010; Barbará et al – 2008, James and William-2005). Rao et al. (1996) states that placing a cost figure on quality is difficult and existing accounting systems are incapable to capture the "true" cost of quality. The Management only understands the language of numbers and figures especially the financial effect. COPQ remains hidden and cannot be extracted from the traditional accounting systems, therefore gravity of its adverse effects is not realized by most of the project managers and consequently they fail to initiate corrective actions.

The researchers have carried out an experimental study for COPQ identification and measurement on a construction project during its execution stage. The COPQ measurement data is useful and meaningful when management is able to understand the gravity of problems and identify the problem areas of their projects; it not only helps to set priorities but also triggers prompt corrective actions to control project's internal failure costs/losses. The researchers therefore designed a dashboard management information system (DMIS) for presenting the summaries of internal failure cost data to the project management. The purpose of dashboard reporting was to elaborate the components of internal failure losses, with the help of charts, graphs and figures etc. by providing comparisons, trend charts etc. so that prompt corrective actions from project management could reduce internal failure costs.

2) LITERATURE REVIEW

Bhargava (2009) treats data as raw material, which after processing is converted to information. Information is the blood line of any organization and an essential ingredient for decision making. Information is considered to be a valuable element of any organization. Information is based on processed data and is furnished to management in a format that is suitable for decision making (Koontz & Weiharich - 1989). Wilcox and Bourne (2002) contend that decision making is carried out for the future activities, therefore there is a need to chalk out a predictive model by using available data to improve organizational decision making. It is not enough to understand the existing organizational performance; the data and information should be capable of developing predictive models of management, while Hemmingway (2006) also supports the idea of enhancing data analyzing capabilities for improvement of decision making. Davenport and Harris (2007) with the help of research evidence conclude that decision making can be improved with appropriate use of information. Raymond (1987) defines the Project Management Information System (PMIS) as supportive to the accomplishment of project objectives and the execution of project strategies, and it provides vital information of project to project managers on the cost and time performance factors and level of interrelationship of these parameters.

2.1) Management Information System (MIS)

The MIS concept has evolved in the last about two decades. It has been defined and described in different ways. It has been called by various names like the Information System, the Information and Decision support System, and the Computer- based information System.

Bhargava (2009) has listed many definitions of MIS, some of them are as under:

i) Management Information System provides vital information required for reaching better decisions in the organization.
ii) MIS integrates man and machine to generate and provide the information required for the management, the operations, and formulate better decisions in the organization.

iii) It is a database system based on data extracted from organizational functions, developed to fulfill information needs of internal customers of the organization. It is a Computer based Information System.

iv) The Management Information System is a planned/organized system of gathering, storing and processing data and dispersing the information required to carry out the managerial functions.

v) According to Koontz & Weiharich (1989) it is a formal system to gather, process, integrate, compare, analyze and disperse internal and external information to the enterprise in a timely, effective and efficient manner.

Bhargava (2009) recognizes the following purposes of MIS**:**

i) **Data Capturing:** MIS captures data from different internal as well as external sources of organization. Data can be captured through manual effort or computer terminals.

ii) **Processing of Data:** The captured data is processed to convert it in to information. Data processing is carried out by sorting, computing, categorizing, analyzing and summarizing.

iii) **Storage of Information:** MIS also creates a database by storing the processed and unprocessed data for future use. Information is saved for later use as an organization record, if it is not immediately required.

iv) **Retrieval of Information:** Information can be retrieved from the database as and when required by any user.

v) **Dissemination of Information:** Information is the end product of data processing and MIS; it is disseminated and distributed to the internal customers of the organization through computer terminals.

The MIS through a range of systems fulfills the different requirements of its end users, like Enquiry Systems, Modeling Systems, Analyzing Systems, and Decision Support Systems (DSS). It also assists in Strategic Planning, Operational Control, Management Control, Process Control and Business Processing. This well-organized information reporting system generates an organized data and a knowledge-base for organization and its users. The easy to use information is made available to managers for saving their valuable time (Bhargava-2009).

2.2) Dashboards Reports

Defining dashboard report Few (2006) states that it is a visual display of the most important and vital information required to achieve various objectives, it is consolidated and arranged on a single screen so that the information can be observed at a glance. A dynamic dashboard remains alive and keeps updating its charts and graphs with the addition/change of input data. According to UNDP (2011) unlike "regular" reports, dashboard reports provide at a glance visual insight in to the data to be analyzed, making it possible for the decision-makers to leverage/use the valuable information in real time project by making use of visually rich, reactive and personalized business-intelligence dashboards. It helps to accomplish better data interpretation and leads to more informed decision making.

According to Aaron (2001) the Project Management Dashboard (PMD) is a tailored Project Management Information System comprising a variety of quality-based project tracking and control metrics. The PMD enhances the capabilities of the project manager to effectively monitor the "vital signs" of a project, for early identification of problems and to activate corrective actions in a timely manner. Every project is unique and requires its own specific set of controls, whereas, some common informational needs also exist across various projects. The dashboard concept is applicable and suitable for managing any complex project.

Dashboard reports provide an outline of consolidated business information, generally in a visual format, focused on key performance indicators, metrics and risks, end-users of the reports use them regularly and initiate appropriate actions. The layout of a dashboard report is tailor made keeping in view the requirements of end-users; the report provides triggers for further actions if required. Business performance is not only about the financial performance, operational performance is equally an important measure. Dashboard reports should also provide information about operational measures to improve decision making (CPA Australia Ltd).

Meredith and Mantel (2006) concluded that IT utilization makes it possible to resolve all complications and difficulties, arising during various phases of Project lifecycle, by making use of computer software such as, dashboard reports. These reports may help in providing vital information for decision making for project planning, scheduling, monitoring, and controlling.

Activities are normally divided into functional areas during execution of construction projects, they are carried out by various disciplines including sponsors, architects, engineers, & contractors, all of them operate and work independently. Decision making is normally carried out by each discipline in isolation and without evaluating its impact on the others. Uncoordinated information system ultimately leads to misunderstanding, increased errors, time waste and unnecessary costs leading to rework and material wastage. It has generally been observed to be the main factor for overrun of time and cost in construction projects (Love-2002-i). Additionally, improper utilization of information technology in information handling can aggravate the quantum of wastage and rework that arises in a project (Love-2002-ii, Love et al-1999).

Therefore, according to Love and Irani (2002) there is a need for an Information System that can be used to manage quality, making it possible to monitor the performance of organizations and determine quality costs. It will also make organizations able to describe their quality failure costs (especially wastage of resources and reworks) and initiate preventive measures. They also contend that so far very little effort has been made to develop a quality costing systems for construction projects, due to the complex reasons associated with data collection from various sections of organization and managing information with different approaches to of quality management.

2.3) Quality in Construction

It is difficult to define according to Chung (1999), because, the product is a unique piece of work with specific characteristics, it is normally not repetitive. Furthermore, the needs of client and along with expectations of the community are to be satisfied, with whom the completed project will integrate. The cost of project along with delivery time are two important factors of quality. Rumane (2011) has summarized various definitions of quality as: meeting the customer’s needs, fitness of use and conforming to standards and specifications. Agreed project scope, its cost and delivery time define the construction project quality and needs of the owner’s to be fulfilled after project completion.

2.4) Cost of Quality (COQ)

According to Juran (1989) quality is the "*fitness for use*" and "*conformance to specifications*", these are the two prime dimensions used to define quality for COQ purpose. Rao et al (1996) contend that the third dimension to measuring quality is the "*value based* approach". It is determined by the customer by balancing between product cost and product value. Deming (1986) finds quality as uniformity and as a way to achieve correct target. Construction quality defined by David and Stanley (2000), is the most suitable for the construction industry, according to them quality can be considered as a dynamic state that is linked with people, processes, products, services, and environment, meeting or exceeding customer needs/expectations and contract requirements/ standards. Therefore quality is the degree of conformance to meet the contractual requirements. There can also be some implied requirements like non-violation of ethical, legal and religious issues, no inconvenience to general public and wild life, no adverse environmental effects and fulfilling Corporate Social Responsibility (CSR) etc.

COQ is normally agreed to be the sum of conformance and nonconformance costs. The conformance cost is incurred on inspection and quality appraisal to prevent poor quality cost. The non-conformance cost (like wastage of resources and reworks) is faced due to failure of product and service, it is also called "Cost of Poor Quality" (Schiffauerova and Thomson -2006). Juran (1951) has contended that the COQ can be explained with reference to the economics of quality of end-product, or it can be the economics of the conformance to standards.

Crosby (1979) has defined the cost of quality with two key components in his book "*Quality is Free*": (i) the cost of good quality (or the conformance cost that is prevention and appraisal costs) and (ii) the cost of poor quality (or the non-conformance cost comprising Internal and External failure costs). Crosby (1983) stated that no subject has received more attention from quality professionals over the past several years other than COQ. According to Ansari et al. (1979, p-3) the objective of quality costing is to help management maximize the value customers receive from a product. Failure of product performance creates cost for both i.e. customer and producing firm. Improving product performance reduces cost for both of them. Harry et al (2000) states that in the end, poor quality costs companies, customers, consumers, and general society, which is real problem and pretty big money.

Dian et al (2010) contend that working out the cost of quality in monetary terms allows an organization to evaluate the extent of its resources being used to mitigate the adverse effects of its poor processes. Such information can help an organization to determine the potential savings which can be gained by improvement in its process. From the management accounting perspective, economic issues are predominant, "The true language of management is accounting, and money is only the accent" (Dobbins & Brown, 1991, p. 22).

Analysis of Cost of Quality (COQ) makes it possible for organizations to evaluate and control the bad effects of poor quality. The COQ approach can play a major role for improvement of the bottom-line by eradicating cost of poor quality (Mohandas and Sankara-2008). Quality costs are not simple arithmetic sum of factory operations. The support processes like maintenance and human resources are also major contributors. The major quality costs are contributed by incapable support processes. Such costs are hidden in the standards and can be avoided but the problem is that no clear responsibility has been fixed for action to reduce them. COQ, after its recognition can be reduced through structural approaches (Dian et al - 2010).

Abdul-Rahman (1993) and Barber et al (2000) are of the view that to attain knowledge about COQ and to managing construction projects effectively, a project quality information system should be made an essential part of an organization. It would require carrying out collection, measurement, and quality analysis. However, according to Love and Irani (2002) it is not an easy task due to complex problems, as there are numerous activities involved with in the and organizations to carry out procurement. Furthermore, organizations have diverse technological capabilities and sizes, making it a challenging job to manage project information, especially quality costs data. Most of the construction organizations do not have COQ system or they don't even collect quality cost data.

With the addition of quality costing, a project management information system can deliver vital information about quality failure incidents to the project management and stack holders to ensure prevention of their future occurrence. The information can be utilized to initiate quality improvement measures to achieve a noticeable cost saving and quality improvements (Love and Irani -2002).

2.5) Cost of Poor Quality

This cost is generated on providing poor quality product or service, resulting due to failure to conform the quality standards and customer requirements. Harrington (1987, P-5) defines Cost of Poor quality as sum of the costs faced by a company and its customers because its end product/service failed to meet required specifications and/or customer expectations. Crosby (1979, P-1) states that "Quality is free. It's not a gift, but it is free. They are the un-quality things that cost money and failing to do jobs right the first time. According to Raddatz and Klemme (2006) failure costs are incurred to rectify the variation/defects cropped up after execution of a work or rework an unsatisfactory job to achieve the required specifications. This cost has two components internal and external failure costs.

i) Internal Failure Costs

These costs are associated with product failure before its delivery to the external customer, they include total cost of material waste/scrap, overuse/spoilage, time wastage, rework, and labor wastage, overheads associated with production, scrape, failure analysis, re-inspection, supplier rework and, retest, and opportunity cost (Rao et al-1996, Pyzdek -2003, Harrington -1987).

ii) External Failure Costs

These costs crop up after delivery of the project to the customer with in warranty or "defects liability period". Examples include deterioration of executed work, complaints of malfunctioning devices and complaints associated with repair, and replacement of non-conforming defective parts. Warranty costs, customer complaint variations, product recalls, returned merchandize, compensatory allowances and defects liability costs are also external failure costs. They comprise of direct and indirect costs like labor charges and travel expenses for investigation of customer complaints, field inspections for warranty, testing and repair works (Rao et al-1996, Pyzdek-2003, Harrington -1987).

2.5.1) The Extent of existing hidden losses and the required range (The Opportunity)

Mahmood and Kureshi (2014) established that according to ten various researches conducted from 1984 to 2008, COPQ with a standard deviation of 7.02 ranges from 22 to 32% of an organization's annual turnover or operating costs. Mahmood et al. (2014) with the help of twenty researches spanned from 1979 to 2008 have concluded that the COPQ ranges from 22.23 to 32.83 % (average 27.53%) with a standard deviation of 6.46. Mahmood and Kureshi (2015) based on the review of 42 related researched conducted in last 40 years from 1975 to 2014 on COPQ have concluded that COPQ ranges from 16.91% to 26.90% of company's revenue (mean 21.91% Std. Dev. 8.38). The results are almost similar and therefore verify the extent of existing hidden losses on account of COPQ.

Population mean of 21.91% is a very high cost of failure; it means that more than quarter of a project amount is getting wasted without being noticed. According to Hagan-(1985), 90% of said amount is expended on appraisal and failure costs. Dale and Plunkett (1990) conclude that, the quality costs can be brought down to one third of its original value with the implementation of a cost-effective quality management system.

The required range of COPQ has been concluded by Mahmood and Kureshi (2014) with the help of six researches carried out by different researchers from 1987 to 2009 as 3.0 to 4.2% (average 3.6% and Standard Deviation of 1.32) of an organization's annual turnover or operating costs, and Mahmood et al. (2014) have also verified the same range, but Mahmood and Kureshi (2015) with the help of 11 researched conducted from from1987 to 2012 have concluded that COPQ should be 2.81 to 3.85% (mean 3.33% Std. Dev 1.10).

There is a big difference between the existing COQ (21.91%) and the required (3.33%). Therefore, it is a big opportunity of cost reduction on account of COPQ.

2.6) Gaps in Literature

The COPQ cannot be traced or identified from the existing accounting reports and auditing system, (James and William-2005). Barbará et al (2008) contends that COPQ is still a mystery to the vast majority of organizations. It is not only difficult to measure such costs, but also, by the sensitive nature of the subject, it can be termed "politically controversial". Companella (1990) states that most of the quality costs are concealed in accounts and are difficult to identify through traditional accounting systems.

According to Jung et al (2011) research on Information systems (IS) for the construction industry is one of the most frequently discussed fields in the academia and industry. A number of studies have been carried out to explore the IS concepts, technologies, methodologies, and find solutions for specific construction problems. However, formulation of the most appropriate IS for the construction industry is yet to be done, it is a difficult task due to the subjective and comprehensive nature of IS in construction.

However, still only a small number of researches are available in the literature on the application of PMIS that promote the demographics of project management systems in evaluation of particular functions of these systems to achieve specific objectives during project management life cycle, like planning, organizing, communicating and reporting, risk management, estimating costs, scheduling, executing, closing and managing documents (Herroelen, 2005; Love and Irani 2003).

Although it has been recognized that measurement of COPQ is very important and it would improve the work processes along with improving quality, productivity and profits etc. but no procedure has so for been devised for its identification and measurement and most important its presentation to the management in a meaningful manner. COPQ therefore remains hidden and not reflected in the existing accounting and auditing system being used in the construction industry. Accordingly there is no MIS for presenting COPQ or internal failure costs to project management for assessing the gravity and adverse effects of problems/hidden losses. There is a need to design a dynamic dashboard MIS to present and elaborate the adverse effects of internal failure costs on construction projects, so that timely corrective actions could be initiated to check the losses on the account of COPQ.

3) RESEARCH OBJECTIVES

COPQ translates the failure incidents in to monetary value which is the language of management. Presently there is no system to identify and record the hidden costs of poor quality in the accounting system of development/construction projects. COPQ cannot be controlled until its identification and measurement. Furthermore there is no MIS for presenting COPQ to project management. The corrective actions would trigger once the management would know the extent and nature of losses on account of COPQ. Therefore, a dynamic Dashboard Management Information System (DMIS) has been developed for presenting the internal failure costs to project management during execution of project so that management could take timely corrective actions to control their losses.

3.1) Research Significance

The Dashboard Management Information System would be very helpful for the working of construction companies with the following benefits to the stake holders:

i) Project managers during project execution will promptly know the gravity of problems and their respective areas.
ii) It will help in setting priorities and initiate prompt corrective actions.
iii) Wastage and losses on account of resources and reworks would get reduced and thereby reduce the cost of project.
iv) Identification of hidden problem area will make the respective work force to work more responsibly.
v) Quality, productivity, profitability and useful life of the project will increase.
vi) Projects will be completed comparatively in less time due to reduction in reworking.

3.2) Limitations

Pointing out the corrective actions was beyond the scope of this study, it was left to the discretion of project management. The study was also limited to the internal failure costs during project execution; external failure cost is faced after the project completion and is beyond the scope of this research study.

4) RESEARCH METHODOLOGY

4.1) Research Instrument

A COPQ measuring tool or system was developed based on the information available in literature, unstructured interviews with the management accountants, project managers, cost accountants. It comprised of data entry forms to record losses on account of COPQ during execution of work at various activities/tasks on daily basis.

A dashboard reporting system has also been developed using MS Excel spread sheets. The internal failure cost data recorded during the experimental study has been used in dashboard reporting system. The components were recorded for machinery, labor, material and overheads being used at the project and their costing has been carried out on the basis of respective unit rates. The COPQ was recorded for continuous 60 days. Excel spread sheets were used to enter the COPQ data. Separate sheets were used to enter cost data with respective dates and references in each cost category. The output of dashboard has been based on the four independent variable (Manpower, Machinery, Material and Overheads) and one dependent variables (Total COPQ), to show and highlight the cost comparison between bench mark and subsequent periods.

4.2) Research Area

The COPQ (Internal Failure Cost) was measured on a real time public sector infrastructure project. Its internal failure cost data has been used in the Dashboard MIS.

5) EXPERIMENTAL STUDY OF CONSTRUCTION PROJECT

A bridge on a storm water stream was being constructed in the alignment of a road as a public sector project at a budgeted cost of 48.300 million Rupees or 0.600 Million USD. The costing has been carried out in Pakistani currency "Rupee" (Rs.). The project commenced in the month of May and had scheduled completion time of four months. The scope of project included diversion of rain water stream, excavation for foundation, raft foundation, abutment walls, pre-cast pre-stressed concrete girders, deck slab, concrete railing, earth filling along the approaches of bridge and construction of approach road. The monsoon rainy season started in the 1st week of July which not only disrupted the work execution but also damaged some of the executed works. Paucity of allocated funds was also a constraint; "availability of required funds for the project" has been assessed to be the most important success factor for construction companies by Mahmood et al. (2012).

5.1) Method of Internal Failure Cost Measurement

The internal failure cost (the dependent variable) worked out through measurement of four independent variables, i.e., (i) Machinery, (ii) Labor, (iii) Material and (iv) Overheads, in the 1st fortnight have been considered as benchmark. The internal failure cost was not intimated to the project management, in the benchmark period (the first 15 days). The management was apprised of internal failure cost after the benchmark period on fortnightly basis through Dashboard MIS. The charts, graphs summaries, comparisons etc. of all the five variables (four independent and one dependent), were helpful to find out the cost centers with respective reasons for initiating corrective actions.

5.2) Hypothesis

It was presumed that identification, measurement and presenting of hidden internal failure costs will trigger corrective actions, leading to reduction of losses and improvement in Productivity and Profitability. The Hypothesis developed are listed as under:

Hypothesis-1
Null (H0): COPQ recorded in subsequent quarters ≥ the Benchmark COPQ;
Alternate (H1): COPQ recorded in subsequent quarters < the Benchmark COPQ;
Hypothesis-2
Null (H0): Labor Productivity recorded in subsequent quarters ≤ the Benchmark Labor Productivity;
Alternate (H1): Labor Productivity recorded in subsequent quarters > the Benchmark Labor Productivity;
Hypothesis-3
Null (H0): Profitability recorded in subsequent quarters ≤ the Benchmark Profitability;

Alternate (H1): Profitability recorded in subsequent quarters > the Benchmark Profitability.

6) CREATION OF THE DASHBOARD REPORT

The dashboard reports were created as part of Management Information System for presenting the results drawn from the data of experimental study. The M.S Excel (Office-2010) was used to generate dashboard reports with following steps:

i) The internal failure cost data was used, it was recorded on daily basis for all the four independent variables as can be seen in a part of table shown at Annex-B.
ii) The study period of sixty days was divided into four quarters of fifteen days each. The first quarter was considered to be the bench mark.
iii) The data was separated and summarized for each quarter. Summary tables were generated using array formulae as can be seen on calculation sheets at Annexure-C. An "array formula" can perform multiple calculations on one or more of the variables in an array. Array formulas can produce multiple or a single result.
iv) A calculation sheet further generated two tables with drop down menus and list of options as seen in Annexure-D.
v) Another calculation sheet combined the two tables with two drop down menus as shown in Annexure-E. The desired detail can be seen in one table with options available in dropdown menus.
vi) A Dashboard report in tabulated form was generated with query options available in radio buttons, it also shows some graphical presentation of results (Annexure-F). The layout shows the information required for pointing out the problem areas, with the past trend. Future prediction can also be made from the trend analysis.
vii) A complete dashboard report showing all the required detail in figures and graphical presentation was finally generated with all query options available in radio buttons (Annexure-G).

6.1) Data Reliability

As per analysis carried on SPSS (Annexure-A), Cronbach's Alpha value is 0.805, it is more than 0.700, and therefore reliability of data is O.K.

7) RESULTS AND ANALYSIS

Increase/decrease in values of all the variables in subsequent quarters with respect to bench mark can be seen in the dashboard report along with variation in labor productivity and profitability. Exposing of hidden costs of internal failure triggered corrective actions from the management, leading to reduction of losses in all subsequent quarters. A negative trend in failure cost can be seen even in the bench mark period, it is because of Hawthorn effect, the workers after knowing that their performance lapses are being monitored and measured, improved their performance. The percentage reduction in the internal failure losses in all four quarters can be seen in figure-1 below:

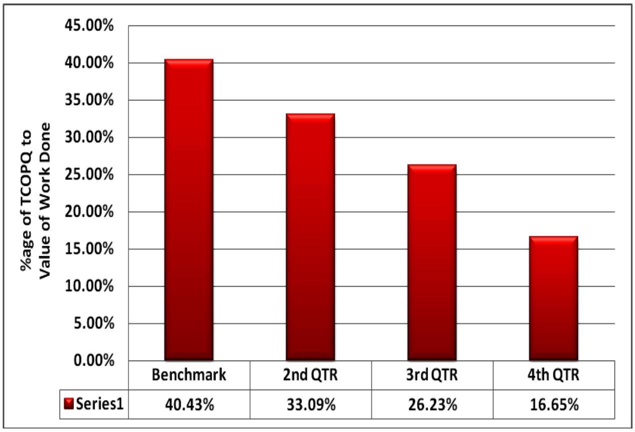


Figure 1: Reduction in Percentage Loss (Total internal failure losses/ Value of Executed Work) in Three Quarters Compared to Benchmark.

The percentage of Total internal failure losses to Work value has been brought down from 40.43% to 16.65% with an improvement of about 59%. Reduction in internal failure losses on account of all variables have been shown in Table-1 below:

Table 1: Detail of reduction achieved in internal failure losses at the end of 60 days study period

Cost in 1000 Rupees

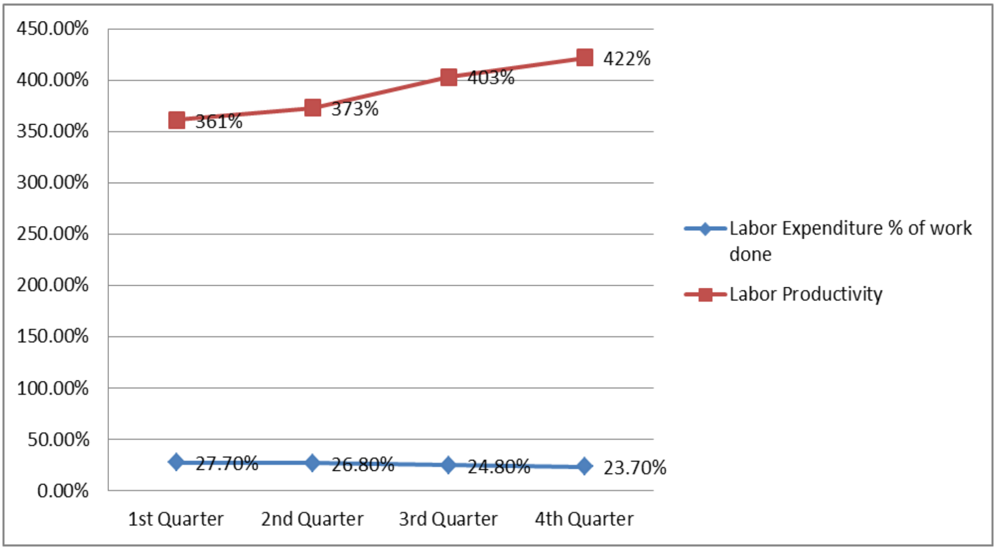
COPQ Components	Benchmark cost	4th and Last Quarter cost	% Reduction
Machinery	1392	722	-48.13%
Labor	477	238	-50.10%
Overheads	240	120	-50.00%
Material	302	185	-38.74%
Total COPQ	2411	1265	-47.53%
% of work value	40.43%	16.65%	-58.82%

Figure-1 and Table-1 show that COPQ has been continuously reducing as compared to bench mark period; COPQ reduced from bench mark of 40.43% to 16.65% at the end of 4th quarter. Therefore, there is sufficient evidence to reject the Nul-Hypothesis-1.

Table 2: Labor Productivity Analysis

Study period		Cost in million Rupees		%age of Labor Expenditure	Productivity = (Amount of executed work/ Expenditure on Labor)	Improvement
		Expenditure on labor	Amount of executed work			
1	Benchmark	1.65	5.96	27.70%	361%	
2	2nd Quarter	1.62	6.06	26.80%	373%	3.36%
3	3rd Quarter	1.71	6.88	24.80%	403%	8.06%
4	4th Quarter	1.80	7.60	23.70%	422%	4.64%

Figure 2: Trend of Labor Expenditure and Labor Productivity



As evident from Table-2 and Figure-2 above that Labor productivity kept improving with a positive trend in every quarter with the reduction of COPQ. The overall improvement is 16.89%. Expenditure on Labor also kept declining with a negative trend in successive quarters due to corrective actions of the management. Therefore, there is enough evidence, to reject the Nul-Hypothesis-2.

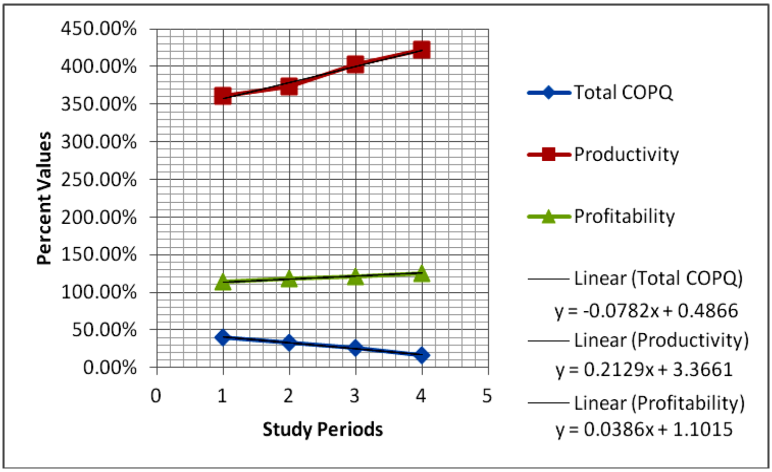
Table 3: Profitability Analysis

Study period		Cost in million Rupees		%age of input expenditure	Profit in Million Rupees	Profitability	Improvement
		Cost of inputs	Amount of executed work				
1	Benchmark	5.23	5.96	87.70%	0.73	114%	
2	2nd Quarter	5.13	6.06	84.60%	0.93	118%	3.66%
3	3rd Quarter	5.68	6.88	82.60%	1.20	121%	2.42%
4	4th Quarter	6.03	7.60	79.40%	1.57	126%	4.03%

Profitablity kept continuosly increasing in the study period of 60 days as seen in Table-3. The cost of inputs has also reduced due to reduction in losses on account of COPQ. Over all improvement in profitability is 10.45%, it is a significant improvement. Therefore, there is enough evidence, to reject the Nul-Hypothesis-3.

Relationship between Total COPQ, Labor Productivity and Profitablity

Figure 3: Comparison of trends between Total COPQ, Productivity and Profitability



From Figure 3, it is observed that Total COPQ has a very high unwanted intercept value of 48.66%, a lower value will be better. Whereas high intercept values are required for the Labor Productivity and Profitability, which are 336.6% and 110.15% respectivly. Total COPQ has a negative slop of 7.82% for its trend line, it means that it is decreasing with every quarter as a continuos improvement process. Labor Productivity and Profitability both have positive gradient in their trend lines i-e 21.29% and 3.86% respectivly. A very consistent, gradual and linear improvement in the performance can be observed from the trend lines shown in Figure.3.

Table 4: Correlation between Total COPQ, Labor Productivity and Profitability

Variables Relationship	Coefficient of Correlation
Total COPQ – Labor Productivity	-0.984
Total COPQ – Profitability	-0.999
Labor Productivity – Profitability	0.975

According to results shown in Table-4, there is a very strong negative correlation between Total COPQ – Labor Productivity and Profitability respectively. Labor Productivity and Profitability will increase with reduction of Total COPQ and vice versa, whereas, there is a strong positive correlation between Labor Productivity and Profitability. Profitability will increase with the improvement in Labor Productivity.

8) CONCLUSIONS

The dashboard reporting proved to be successful in presenting the internal failure losses on account of four independent and one dependent variables, along with pointing out opportunities of improvement. Timly and apprpriate corrective actions from the management triggered as a result of uncovering hidden losses through dashboard reporting. It proved successful in reducing the internal failure losses and improvement in labor productivity and profitability of the company.

COPQ started reducing even in the Benchmark period under the Hawthorn effect, because the project staff also realised lapses on its part. The major contributor in COPQ was “Machinery”. The percentage of COPQ to executed work value has reduced from 40.43% to 16.65% in the 60 days study period with a considerable reduction of 59%. The mean Total COPQ of 16.65% achived at the end of study period is much less than the popultation mean of 21.91%. Therefore there is a significant improvement in reduction of project losses but still there is a big room for improvement to reach the desired level of minimum COPQ of 3.33%.

Analysis of four quarters also show a consistent negative trend of COPQ in each successive quarter for each variable. It has also been observed that in a study period of sixty days the labor productivity improved by 16.88% and profitability increased by 10.45%. Labor Productivity and Profitability get improved with the reduction of COPQ, due to a strong negative correlation inbetween them.

The study has validated the COPQ measuring system and methodology adopted for the dashboard Management Information System, therefore it can be used on future construction projects.

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SPSS DATA ANALYSIS OUTPUT REPORT

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	N of Items
.805	.830	4

Annexure-B

Part of table showing data entry in Excel spread sheet on daily basis

Study Period	Data Recording Days	Account Head	COPQ	Profitability	Productivity	Benefit/Cost Ratio
Bench mark	Day 1	Machinery	109,000.00	1.04	1	1.00
Bench mark	Day 1	labor	55,000.00	1.04	1	1.00
Bench mark	Day 1	Overheads	-	1.03	1	1.00
Bench mark	Day 1	Material	26,000.00	1.03	1	1.00
Bench mark	Day 2	Machinery	101,000.00	1.04	1	1.00
Bench mark	Day 2	labor	40,000.00	1.03	1	1.00
Bench mark	Day 2	Overheads	-	1.05	1	1.00
Bench mark	Day 2	Material	27,000.00	1.04	1	1.00
Bench mark	Day 3	Machinery	100,000.00	1.05	1	1.00
Bench mark	Day 3	labor	37,000.00	1.04	1	1.00
Bench mark	Day 3	Overheads	-	1.03	1	1.00
Bench mark	Day 3	Material	23,000.00	1.05	1	1.00
Bench mark	Day 4	Machinery	98,000.00	1.02	1	1.00
Bench mark	Day 4	labor	32,000.00	1.05	1	1.00
Bench mark	Day 4	Overheads	-	1.04	1	1.00
Bench mark	Day 4	Material	15,000.00	1.02	1	1.00
Bench mark	Day 5	Machinery	87,000.00	1.03	1	1.00
Bench mark	Day 5	labor	35,000.00	1.01	1	1.00
Bench mark	Day 5	Overheads	30,000.00	1.05	1	1.00
Bench mark	Day 5	Material	17,000.00	1.04	1	1.00
Bench mark	Day 6	Machinery	80,000.00	1.02	1	1.00
Bench mark	Day 6	labor	31,000.00	1.03	1	1.00
Bench mark	Day 6	Overheads	-	1.05	1	1.00
Bench mark	Day 6	Material	20,000.00	1.02	1	1.00
Bench mark	Day 7	Machinery	82,000.00	1.03	1	1.00
Bench mark	Day 7	labor	27,000.00	1.04	1	1.00
Bench mark	Day 7	Overheads	60,000.00	1.05	1	1.00
Bench mark	Day 7	Material	23,000.00	1.05	1	1.00

Annexure-C

Calculation sheet showing two summary tables one for the four study period and other for four head of accounts (independent variables)

Study Period	COPQ per day of all head of accounts															Total
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	
Bench mark	190,000	168,000	160,000	145,000	169,000	131,000	192,000	166,000	181,000	146,000	200,000	168,000	155,000	129,000	141,000	2,441,000
2nd fortnight	127,000	134,000	170,000	131,000	183,000	180,000	122,000	158,000	114,000	107,000	114,000	119,000	116,000	114,000	116,000	2,005,000
3rd fortnight	155,000	130,000	200,000	160,000	111,000	126,000	108,000	101,000	147,000	105,000	109,000	102,000	90,000	82,000	79,000	1,805,000
4th fortnight	88,000	133,000	94,000	84,000	78,000	75,000	109,000	100,000	70,000	71,000	67,000	64,000	72,000	62,000	98,000	1,265,000
Total	560,000	565,000	624,000	520,000	541,000	512,000	531,000	525,000	512,000	429,000	490,000	453,000	433,000	387,000	434,000	7,516,000

Account Head	COPQ of all quarters under respective head of account															Total
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	
Machinery	332,000	343000	349000	320000	295000	297000	288000	280000	292000	283000	280000	275000	260000	258000	261000	4,413,000
labor	124000	113000	110000	107000	100000	94000	82000	91000	93000	86000	83000	80000	86000	82000	81000	1412000
Overheads	30000	30000	90000	30000	90000	60000	90000	90000	60000	0	60000	30000	30000	0	30000	720000
Material	74000	79000	75000	63000	56000	61000	71000	64000	67000	60000	67000	68000	57000	47000	62000	971000
Total	560,000	565000	624000	520000	541000	512000	531000	525000	512000	429000	490000	453000	433000	387000	434000	7,516,000

Annexure-D

Calculation sheet interlinking both the tables, by dropdown menus

There are five options
1 means machinery
2 means Labor
3 means Overheads
4 means material
and 5 means all

4
Material

Study Period	COPQ per day															Total
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	
Bench mark	26,000	27,000	23,000	15,000	17,000	20,000	23,000	22,000	19,000	18,000	23,000	17,000	11,000	11,000	30,000	302,000
2nd fortnight	20,000	19,000	23,000	16,000	13,000	12,000	15,000	15,000	14,000	12,000	13,000	18,000	15,000	13,000	12,000	230,000
3rd fortnight	15,000	18,000	16,000	20,000	15,000	17,000	20,000	16,000	20,000	19,000	18,000	21,000	17,000	12,000	10,000	254,000
4th fortnight	13,000	15,000	13,000	12,000	11,000	12,000	13,000	11,000	14,000	11,000	13,000	12,000	14,000	11,000	10,000	185,000
Total	74,000	79,000	75,000	63,000	56,000	61,000	71,000	64,000	67,000	60,000	67,000	68,000	57,000	47,000	62,000	971,000

There are four options
1 means Bench mark
2 means 2nd fortnight
3 means 3rd fortnight
and 4 means 4th fortnight

4
4th fortnight

Account Head	COPQ per day															Total
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	
Machinery	59,000	68,000	62,000	54,000	51,000	47,000	51,000	43,000	40,000	45,000	40,000	38,000	42,000	37,000	45,000	722,000
labor	16,000	20,000	19,000	18,000	16,000	16,000	15,000	16,000	16,000	15,000	14,000	14,000	16,000	14,000	13,000	238,000
Overheads	-	30,000	-	-	-	-	30,000	30,000	-	-	-	-	-	-	30,000	120,000
Material	13,000	15,000	13,000	12,000	11,000	12,000	13,000	11,000	14,000	11,000	13,000	12,000	14,000	11,000	10,000	185,000
Total	88,000	133,000	94,000	84,000	78,000	75,000	109,000	100,000	70,000	71,000	67,000	64,000	72,000	62,000	98,000	1,265,000

Annexure-E

Calculation sheet combining both tables and giving options to see required details.

There are five options
1 means Bench mark
2 means 2nd fortnight
3 means 3rd fortnight
4 means 4th fortnight
and 5 means All

There are four options
1 means COPQ
2 means Proftability
3 means Productivity
and 4 means Benifit-Cost ratio

2		3
2nd fortnight		**Productivity**

Account Head	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Total
Machinery	1.1	1.2	1.3	1.21	1.22	1.02	1.05	1.05	1.07	1.09	1	1	1.02	1.04	1.06	16.43
labor	1.02	1.05	1.05	1.07	1.09	1	1	1.02	1.04	1.06	1.2	1.26	1.025	1.021	1.3	16.206
Overheads	1	1	1.02	1.04	1.06	1.2	1.26	1.025	1.021	1.1	1.2	1.3	1.21	1.22	1.1	16.756
Material	1.2	1.26	1.025	1.021	1.1	1.2	1.3	1.21	1.22	1.02	1.05	1.05	1.07	1.09	1.4	17.216
Total	4.32	4.51	4.395	4.341	4.47	4.42	4.61	4.305	4.351	4.27	4.45	4.61	4.325	4.371	4.86	66.608

Annexure-F

A Dashboard report in tabulated form with options available in radio buttons, also showing some graphical presentation

Select Head of Account: ○ Machinery ◉ labor ○ Overheads ○ Material ○ All

Select Detail Required: ◉ COPQ ○ Profitability ○ Productivity ○ Benefit/Cost Ratio

Study Period	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Total	Average	Trend	COPQ Reduction	Profitability	Productivity	Benefit/Cost Ratio
Bench mark	55000	40000	37000	32000	35000	31000	27000	30000	28000	28000	26000	26000	27000	28000	27000	477000	31800.00			3.27%	1.00	1.00
2nd fortnight	28000	27000	26000	27000	25000	25000	22000	25000	25000	23000	22000	21000	25000	25000	24000	370000	24666.67			6.57%	1.11	185.25
3rd fortnight	25000	26000	28000	30000	24000	22000	18000	20000	24000	20000	21000	19000	18000	15000	17000	327000	21800.00			13.05%	1.91	356.92
4th fortnight	16000	20000	19000	18000	16000	16000	15000	16000	16000	15000	14000	14000	16000	14000	13000	238000	15866.67			18.12%	2.51	1351.88
Total	124000	113000	110000	107000	100000	94000	82000	91000	93000	86000	83000	80000	86000	82000	81000	1412000	94133.3					

Select Study Period: ○ Bench mark ◉ 2nd fortnight ○ 3rd fortnight ○ 4th Fortnight ○ All

Select Detail Required: ◉ COPQ ○ Profitability ○ Productivity ○ Benefit/Cost Ratio

Account Head	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Total	Average	%age contribution
Machinery	79000	88000	91000	88000	85000	83000	85000	88000	75000	72000	79000	80000	76000	76000	80000	1225000	81666.67	61.10%
labor	28000	27000	26000	27000	25000	25000	22000	25000	25000	23000	22000	21000	25000	25000	24000	370000	24666.67	18.45%
Overheads	0	0	30000	0	60000	60000	0	30000	0	0	0	0	0	0	0	180000	12000	8.98%
Material	20000	19000	23000	16000	13000	12000	15000	15000	14000	12000	13000	18000	15000	13000	12000	230000	15333.33	11.47%
Total	127000	134000	170000	131000	183000	180000	122000	158000	114000	107000	114000	119000	116000	114000	116000	2005000	133666.67	100.00%

Annexure-G

A Dashboard Report showing all available Query Options in Radio Buttons and Presenting Results in Figures, Graphs and Charts.