Cost of Poor Quality in Public Sector Projects

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ABSTRACT

Generally every customer's objective is to have defect free product/service at a reasonable cost and almost every company's objective is to remain competitive, satisfy its customers and maximize its profits by producing at a minimum cost.. It can only be achieved by producing efficiently using TQM and keeping the Cost of Poor Quality (COPQ) to minimum level. Built-in quality in products and services is now a prerequisite to remain competitive and thus no longer a differentiator in today's cut throat competitive business climate. The COPQ can substantially increase the cost of production/service including inflicting loss to reputation, good will and business. COPQ is inversely proportional to profits. Conventionally it includes appraisal, prevention and failure costs (internal & external). COPQ remains hidden and cannot be determined or identified from current accounting practices and therefore mostly remains unattended. It is a new concept in the developing countries especially for public sector due to which most of the business persons/managers do not realize the adverse effects of COPQ on their investments and returns. Most of the research so far carried out has mainly focused on the cost of poor quality in private sector born by the client, contractor and customer. This research has established a new dimension of "indirect" COPQ especially in public sector projects of developing nations, in which the general society is also a major stake holder, who bears the indirect cost of poor quality. It has been established in this research paper with the help of a case study of a public sector project, that the COPQ indirectly borne by the general society on account of traveling longer distances due to closure of a major intersection, loss of man hours and health/environmental problems, was more than the project cost. The case study relates to construction of an interchange at one of the existing and busiest intersection of Islamabad, the capital city of Pakistan. The project had a direct link with the public inconvenience because; it disrupted the traffic and created environmental problems along with other issues pertaining to COPC during the construction phase. COPQ is required to be identified measured and eliminated from all phases and processes of construction projects that is from project inception, defining objectives, planning, designing, procurements, execution, controlling and monitoring etc along with minimum disturbance to environment and general public. Results of this research would help the public sector organizations to reduce the COPQ in their future construction projects especially keeping in view the indirect COPQ due to public inconvenience.

Keywords: Cost of poor quality, Appraisal cost, Prevention cost, Failure cost, Public sector project, public inconvenience

INTRODUCTION

A project, irrespective of its size or magnitude, must be completed under three constraints "*cost, time and scope*" often referred to as the "Triple Constraints of Project Management" (Deming-1986). The fourth dimension can be "Quality"; it is arguable whether quality can actually be a constraint of a project. In order to remain competitive "Quality" has to be made a constraint. According to Mohandas and Sankara (2008), Quality is the degree to which a specific product/or service satisfies the wants of a specific consumer. Any change in one constraint is likely to trigger change in others too.

Completion of construction projects within the specified triple constraints and quality are signs of successful project management. It has been generally observed that in most of the public sector projects in developing countries, objectives and deliverables are not clearly defined which adversely affect the project planning, designing and execution, as a result, the projects over run the scheduled triple constraints cost, time and scope. Therefore, the Cost Of Poor Quality (COPQ), starts right from project inception and definition of its objectives/deliverables. Poor project management does not address the causes of induction of COPQ which enhances the project cost.

Cost of poor quality is the cost faced due to production of poor quality products and services. There are four categories of costs; prevention costs (costs incurred to keep failure and appraisal costs to a minimum), appraisal costs (costs incurred to determine the degree of conformance to quality requirements), internal failure costs (costs associated with defects found before the customer receives the product or service), and external failure costs (costs associated with defects found after the customer receives the product or service), (Nat R Brisco and Frank M Gryna; Retnari Dian M, Amrin Rapi and Nilda -2010).

Understanding the concept of COPQ is extremely important in establishing a quality management strategy. It is possible to examine how these costs affect the projects and organizations, only after defining the three major costs of quality and discussing their application. COPQ can be reduced by investing more in preventive measures (Mbinira Munthali http://www.slideshare.net/ahmad1957/cost-of-quality-presentation).

This research is focused on public sector projects of developing countries, where COPQ is a new concept and therefore ignored in project planning and execution. The COPQ cannot be

traced or identified from the existing accounting reports and auditing system (QIMPRO BestPrex; Retnari Dian et al-2010; Michael Cieslinski). The Management only understands the language of numbers and figures especially the financial effect, COPQ cannot be extracted from the traditional accounting system, and therefore gravity of its adverse effects is not realized by most of the project manager.

Causing inconvenience to public and creating environmental problems during project execution can be considered violation of human rights and environmental laws (SRO-2001; Tikun Olam-2009; Public Nuisance), which are not given due priority in developing countries. The implementation and observation of municipal and environmental laws is not very strong as witnessed on the project under study. Due to these reasons, the COPQ on the part of project executing agency is also born by the general public.

A case study has been carried out for a public sector construction project, which was executed in the middle of the capital city of Pakistan, Islamabad. An interchange has been constructed to facilitate the traffic congestion at one of the busiest intersections, where according to CDA's traffic survey the traffic volume was 100,000 vehicles per day at the time of design of the project in 2007. The intersections had to be closed for construction work, which disrupted the traffic flow and construction activities caused environmental problems for the general public and the project completion also got delayed by one year due to various reasons like poorly defined project deliverables, planning, designing, procurement, coordination etc. which have been discussed in the case study part of this paper. This project of significant public importance affected lives of millions of people. This project has therefore been selected to examine the effects of COPQ on its stake holders like employer, contractor and general public.

RESEARCH METHODOLOGY

For the case study, the secondary data has been collected from the project and hospital records. Unstructured interviews were conducted for primary data from the members of the project management teams of the Employer, Consultants, Contractor and general public. A method has been devised to work out COPQ for the project stake holders mentioned above, and its analysis has been carried out.

Structured survey was conducted from randomly selected 128 persons/motorists affected from road closure to find out its effects. A structured survey was also conducted from randomly selected 109 persons living and working around the project site to find out the effect of environmental pollution caused by the project.

Limitation: Case study of one mega project of public importance has been selected and analyzed.

LITERATURE REVIEW

Cost of Quality

Most suitable definition for Quality in the construction industry, according to David L. Goetsch and Stanley B Devis is that, it is a dynamic state associated with products, services, people, processes and environment that meets or exceeds customer expectations and contract requirements/standards or Quality can be defined as conformance to the standards and fitness for purpose. According to Deming (1986) quality is uniformity with respect to a correct target. Quality in the construction industry is evaluated according to design & specifications given in the contract therefore quality would be the ability to meet the requirements as per contract. There can also be some implied requirements like no disturbance to the general public, wild life and environment etc.

Cost of quality is a measure of costs associated with achievement or non-achievement of required outcome of a project, as agreed in contract between a contractor and its employer (Nat R Brisco and Frank M Gryna). Juran (1951) has suggested that the cost of quality can be understood in terms of the economics of the end-product, quality or in terms of the economics of the conformance to standards. Quality and profitability are directly proportional; high quality level in procedures, processes, input materials, human resource and management etc results in lowering of overall cost (no rework, no wastage), it thereby increases profitability. Quality should be built in, as they say "do it right the first time"(Carl Spetzler et al-2006).

Cost of Quality (COQ) analysis enables organizations to identify, measure and control the consequences of poor quality. The major goal of a COQ approach is to improve the bottom-line by eliminating poor quality (Mohandas and Sankara-2008). Understanding the cost of quality concept is extremely important in establishing a quality management strategy. 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 (Retnari Dian et al - 2010).

Costs of quality are defined as the sum of costs over the lifecycle of a product. Customers prefer high quality products or services at a reasonable price. Firms should invest on prevention and appraisal costs to ensure that customers would have value of their money by receiving good quality products or services. It is a tradeoff between the prevention & appraisal costs and the failure costs to achieve a quality output. Thus, quality conformance is inversely proportional to failure costs (Mbinira Munthali).

Retnari 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; Johannes (2004) has also supported this idea. It has made COQ an important factor in quality measurement. It should be an evaluation of problems and defects into monetary value per incident, including cost of operator, material for rework, delay and also opportunity cost etc. COQ measurement can be a very useful way to draw conclusions, evaluate alternatives and form an opinion to improve its processes, with clearer objectives & benefit (Retnari Dian et al-2010). COQ cannot be identified and determined from current accounting practices and therefore it remains hidden. According to William et al the practical measurement of quality costs involves dealing with the attitudes and approaches of management for exactly explaining; what constitutes a quality cost.

Reducing the COQ can potentially save a huge value on account of wastage. Companies can expect to add 10- 15% of the total costs to the bottom line without any capital investment (QIMPRO Bestprax). However, quality-related costs are much higher than are commonly expected. These costs range between 20 to 30% of sales or 25 to 40% of operating expenses for most of the companies (QIMPRO Bestprax). Successful COQ exercise results in reduced cost of defects/errors, improved process capability, reduced customer dissatisfaction/defections, increase in new customers, and so on. Considering the size and range of the benefits, the investment may be required on preventive and appraisal measures like diagnostic and other forms of analysis, training, redesign of products and processes, testing and experimentation, and equipment. It is amazing that, most of the improvement projects require little or no costly equipment or facilities. The investment is mainly required in the analytical work. The aim of minimizing COPQ is to prevent the failure costs and minimize the appraisal costs. It also promotes a 'defect free' philosophy (QIMPRO Bestprax).

Cost of Quality measurement

According to Deming (1986) the objective of "never ending improvement" in TQM could not be achieved without measurement. Osman and Abdul –Razek (1996) have contended that "you won't be able to manage what you cannot measure". It is the measurement which triggers the improvement processes. However, Deming (1986) has stated that cost analysis for quality is not effective and that measuring quality costs to seek optimum defect levels is an evidence of failure to understand the problem. Quality costs need to be measured not for management control, but for the development of quality thinking within the organization. The more popular approach is that of Juran (1951), he advocated the measurement of costs on a periodic basis as a management control tool. Measurement of the COQ proposed by Retnari et al (2010) includes following steps**:**

a. Identify the problems and defects in the output of each process.
b. Identify all activities that exist only because of poor quality. Conduct a brainstorming session with project team members having firsthand knowledge of the process to capture all possible causes and process deficiencies to remedy quality problems.

c. Identify the organizational area where the cost of each activity is being experienced. These costs might appear in one or multiple areas.
d. Determine the method which will be used to calculate the cost of poor quality.
e. Collect the relevant data and estimate the costs.

Use of the total resources method would require identification of the total resources consumed in a category and the percentage of those resources used for activities associated with remediating the effects of poor quality. The unit cost method would require identification of the number of times deficiencies occur and the average cost for correcting the deficiency. Small companies can estimate the cost of poor quality easier than large firms. The smaller number of personnel and fewer lines of communication in small firms make it easier to trace and determine costs of events that lead to poor quality. The optimum level of investment on quality improvement can be determined from the information of quality costs. The cost of quality is not manageable unless it is measured.

The advantages of measuring and classifying quality costs

The benefits which can be drawn from the cost of quality measurement are as follows (Nat and Frank www.qimpro.com; Seapine Software):

a. Quantification of the size of the quality problem in a language which is understood by the upper management has a greater impact: The language of money improves communication between middle and upper managers. Typically, this kind of study surprises the upper level managers by giving information that the quality costs are higher than expected and problems not previously recognized are revealed.
b. It identifies major opportunities for cost reductions: a major benefit of evaluation of cost is, identification of costs of specific problem areas, each creating an opportunity to reduce the quality cost.
c. It identifies opportunities to reduce customer dissatisfaction/defection and associated threats to product salability: Sometimes products due to some defects fail to satisfy the external customers. Analysis of the manufacturing costs, supplemented by marketing research/customer requirement, can identify the vital few areas of high

costs for remedy. Addressing the quality problems can help to improve retention of current customers and creation of new customers.

d. A successful COQ exercise results in reduced cost of errors, improved process capability, reduced customer defections, increase in new customers, and so on
e. It provides a means of measurement and evaluation of the effects of quality improvement activities: Measurement of progress helps to keep a focus and control on improvement activities.
f. It helps to align quality goals with organization goals: Measuring the cost of poor quality is a key factor to assess the current status of quality. Knowing the cost of poor quality enables to develop a quality action plan consistent with overall strategic organizational goals.
g. It reduces the risk of litigation, which may result due to external failure of the product/service. Its cost could be very high.

Cost of poor quality (COPQ):

It is the cost associated with providing poor quality product or service. There are three categories of quality costs: prevention costs (costs incurred to keep failure and appraisal costs to a minimum), appraisal costs (costs incurred to determine the degree of conformance to quality requirements) and failure costs (internal failure costs, associated with defects found before the customer receives the product or service and external failure costs, associated with defects found after the customer receives the product or service) (Nat and Frank www.qimpro.com; Janet R Raddatz and Donna Klemme-2006; Mbinira Munthali). These costs are explained as under:

4.4.1 Prevention costs

Prevention of non-conformity factors plays an important role in construction works. According to Harrington (1987) prevention costs result from activities directed towards prevention of expected variation or defects in quality of work. Examples of such costs are design reviews, training and development, supplier selection, capability reviews, and process re-engineering/improvement. Preventing non-conformity before a product is manufactured or produced is clearly the most appropriate action in reducing appraisal and failure costs. It is the

least cost, less time consuming, and least troublesome approach to achieve high quality output. Prevention activities kill expected problems before they actually appear to affect the quality. Investment in prevention processes yields tremendous savings on account of appraisal and failure costs. Roberts (1991) found that by spending 1% more on prevention efforts, the failure costs of construction can be reduced from 10% to 20%. For example execution of a building work based on poor quality design can lead to loss of life, property & reputation of the builder, along with redoing the whole project.

Appraisal costs

The second low cost process for reducing the COPQ is appraisal of work quality. Appraisal costs include costs associated with measuring, testing and evaluating the product quality to find out, if it conforms to the required standards and specifications? Examples of appraisal costs include inspections of material, processes and executed works, their measuring, testing and evaluating. Appraisal cost is associated with the outcome of project activities, whereas prevention cost is associated with managing the intent. Prevention and appraisal costs are unavoidable, to ensure delivery of a quality product/service within the given time, scope and cost. Providing quality control in construction requires an expenditure ranging from 1% to 5% of total project costs (Janet R Raddatz and Donna Klemme-2006). Campanella (1989) asserted that the appraisal costs gradually diminish as failure costs decrease because there is less need for inspection.

Failure costs

According to Janet and Donna (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 can be divided into internal and external costs. Internal failure costs are those costs associated with product failure before its delivery to the internal or external customer, such as scrap, rework, material, labor wastage, and overheads associated with production. External failure costs are the costs that crop up after delivery of the project to the

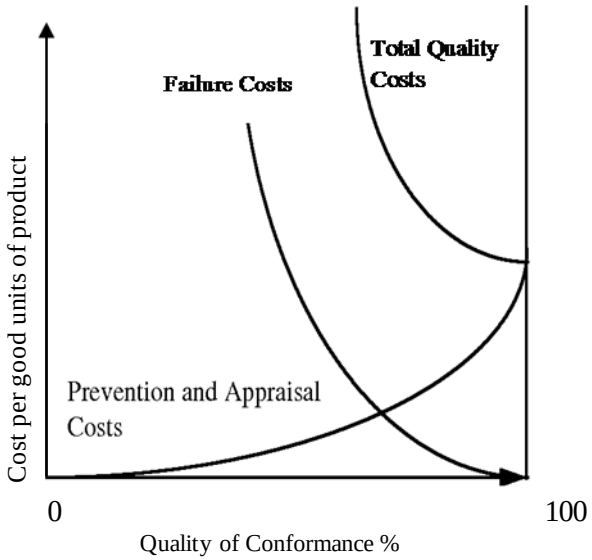
customer with in "defects liability period". Examples include deterioration of executed work, complaints of malfunctioning devices and complaints associated with repair, and replacement of non-conforming defective parts. Warranty charges and product liability costs are also external failure costs. External failures can cause loss of future business through customer dissatisfaction. Customer pay higher maintenance costs due to premature failure of product delivered by the contractor. It not only causes inconvenience, mental stress but also, loss of time and money along with reduction in project life. Failure cost can be very high; it can even be more than the cost of original project. It has been observed during the following case study that construction firm did not measure or keep record of all three cost categories. A balanced investment on prevention and appraisal processes can significantly increase financial gains on project investment. We can expect a significant decrease in failure cost due to increase in prevention and appraisal costs. According to Kazaz et al (2004) most failure costs can be eliminated with little investment in process improvement, prevention and with timely inspection. Identification of causes of deviation can assist in prevention of such failures in similar future activities and projects. Cause & effect or fish bone diagram can be used to identify the problem areas.

The COPQ and its factors can be broken down as follows:

- ✓ Total cost of quality = Prevention cost + Appraisal cost + Failure cost
- ✓ Total cost of failure = Internal failure cost + External failure cost (Indirect COPQ)
- ✓ Cost to client = Total cost of quality + Initial investment cost
- ✓ Total Cost of poor quality = Total cost of quality + indirect COPC
- ✓ Total cost to economy = Total Cost of poor quality + Initial investment cost

Figure 1. Juran's Model for Optimum Quality Costs Emerging Processes

Juran's quality control handbook, fourth edition, (1988)



It can be seen from Juran's model, that with the increase in the costs of improvement (prevention and appraisal costs) there is a sharp decline in the failure costs and the total quality cost.

Reducing COPQ

In any quality improvement exercise, the journey to reduce COPQ should begin by evaluating the extent of the challenge. The recommended process for reducing COPQ includes brainstorming and investigation to identify the problem areas/causes, data collection, analysis, and action plan of an improvement strategy. A major by-product of COPQ evaluation is the identification of those vital few segments, which contributes most to COPQ (QIMPRO BestPrax-2005) The Pareto logic (also known as the 80/20 rule) can be used to identify the vital few causes of problems. According to the Pareto logic, there are 20% causes for 80% problems. Therefore, concentration is required to resolve 20% vital few causes to solve 80% problems (according to Deming (1986), this ratio is 85/15). This results in setting priorities for the effective use of resources. It may be decided depending upon the case that either a complete overhaul of the

existing core/support processes is required or an incremental improvement may be adopted (QIMPRO BestPrax-2005) .

Considering the size and nature of objective, the investment may be required for identification and analysis, training, redesign of products, re-engineering of processes, testing and experimentation, and replacement/improvement of equipment. Surprisingly, most of the improvement projects require little or no costly equipment or facilities. The investment is mostly in the analytical work. The concept of minimizing cost of poor quality includes preventing the failure costs and minimizing the appraisal costs. This concept paves a way to create processes with a 'defect free' philosophy (QIMPRO BestPrax-2005).

4.6 Gaps in the available literature and research material

Most of the public sector infrastructure improvement projects are constructed in populated areas. It has been observed that in developing countries the contractors often do not follow the rules/procedures strictly; as a result the projects during their execution also disturb the life of general public along with creating environmental problems. Although it is a violation of human rights (public nuisance) (Tikun Olam-2009; Public Nuisance) and Environment Protection Agency (EPA) rules (S.R.O (1)/2001) but still the contractors go unchecked due to poor Government controls. Poor quality procedures during the execution of a project on the part contractor put an indirect COPQ on the people not directly linked with the project. This "indirect" COPQ has not yet been identified in the available literature and research work. This study has indentified a new dimension of "indirect cost" in the COPQ and has elaborated its effects with the help of following case study.

CASE STUDY - COPQ IN THE UNDERPASS AND FLYOVER PROJECT AT THE INTERSECTION OF JINNAH AVENUE AND FAISAL AVENUE – ISLAMABAD

Project Back Ground

This case study relates to construction of underpass and flyover at the intersection of Jinnah Avenue and Faisal Avenue, Islamabad Pakistan by the Capital Development Authority (CDA), which is a public sector organization. It is one of the busiest intersections of Islamabad

where according to CDA's survey more than 100,000 vehicles per day used to cross the intersection in 2006 i.e. before construction of this project. The traffic has been facilitated by providing a signal free access which has increased by more than three times after completion of the project.

The Project Details

According to data obtained from project teams and CDA, the project amounting to Rs. 981.000 million was designed by consultants. Only five firms participated in its bidding. The lowest bidder quoted 0.96% below rates on engineer's estimate, whereas 2nd lowest quoted rates 7% above and the difference in costs of 1st and lowest bidder was about Rs. 65.00 million. The project was awarded to the lowest bidder, though his quotation was not of a good quality because of unreasonably low rates. He remained under cash flow problems during the entire project execution period, which reflected a poor quality on the contractor's part in evaluating the project before quoting his bid.

Scope of the project included, construction of 1.1 km long 3 lane underpass with RCC walls on both sides, construction of 3 lane fly over bridge (one on each carriageway) with 11 number of spans each 30 meters long. Construction of eight slip roads, footpaths, drainage system, street lights and road furniture (sign boards, cat eyes and lane marking) along with shifting of water supply lines. It was a steel intensive project having requirement of more than 5000 M. tons of steel. Other services coming in the alignment of project like electricity, telephone, gas and optic fiber lines were required to be shifted by the respective service providers.

The project commenced in March 2007. The design Consultants originally suggested a two years completion time for the project but CDA as employer reduced the completion period to one year without even checking if it is technically possible. It was a poor quality project scheduling. The project could not be completed in one year.

Apart from designing, the Consultants were also responsible to carry out work supervision, monitor the work progress & quality, and verify the quantities of executed work and bills submitted by the contractor.

Project Execution

This busiest intersection is located in the center of city and was required to be closed for taking up the construction of underpasses, therefore the Islamabad Traffic Police (ITP) was hesitant to allow closing of traffic on the intersection. There were no traffic diversion plans and alternate routes were too far away. ITP finally allowed taking up the work in June 2007 when schools of Islamabad were closed for summer holidays and vehicular traffic reduced on the intersection. The project therefore lost three precious dry months. The monsoon rainy season starts in the 1st week of July and ends in 2nd week of September, the monsoon rains started soon after the excavation work. The pits excavated for underpasses did not have drainage outlet therefore got filled with high intensity monsoon rains. The contractor could not do anything other than pumping out the rain water. This was a poor quality planning on the part of CDA and poor coordination between two Government agencies.

Service lines coming in the alignment of project were required to be shifted by outside Government agencies like IESCO, SNGPL and PTCL dealing with electricity, natural gas and landline telephony respectively. They took up to 15 months in processing and awarding the works to their contractors and shifting the utilities. Electrical lines were shifted in August 2007, telephone lines in September 2007 and gas lines in September 2008. This is an example of poor quality coordination and planning on the part of CDA and other agencies, due to which considerable time got lost.

The tenders were invited without complete working drawings. Design of box girders was furnished by the Consultants in September 2007 according to which, 90 meter long box type girders were to be provided over three spans. The contractor objected to the design and contended that one girder spread over three spans is technically not possible. He instead suggested an alternative pre-cast/pre-stressed box girder in November 2007 with a claim that it could save time along with cost and was convenient to construct. His proposal was evaluated and it was observed that it would not only save time but would also save a cost of about Rs. 60.000 million. The proposal was approved in February 2008. This is poor quality design work on the

part of Consultants and poor quality decision making on the part of CDA. It took them four months to decide a variation in design and the advantage of saving in time and cost as a result of new design was lost.

Price of grade-60 steel was Rs. 42000.00 per M. ton and diesel fuel used by construction machinery was 37.50 per liter when the project was awarded to the contractor. Prices of fuel and steel started rising in February 2008 and reached to unprecedented levels. Steel prices rose to Rs. 92000.00 per M. ton and diesel price jumped to Rs. 70.00 per liter. Increase in fuel and electricity prices gave rise to prices of other construction materials like cement, bitumen, sand, crushed stone etc. The newly elected government also raised the minimum labor wages from Rs. 4600.00 per month to Rs. 6000.00 per month. The contract did not contain the provision to allow price adjustment against escalating prices of construction materials. It is an example of poor quality contract documentation. It adversely affected the cash flow of contractor and the work progress. According to extracts of project data, the price impact not covered in contract on various accounts is given in Table-1.

Table-1. List of costs not covered in the contract of the project

Description	Amount (Millions)
Price adjustment on POL	Rs. 49.441
Price adjustment on labor	Rs. 37.500
Price adjustment on steel	Rs. 112.788
Net financial effect	Rs. 199.729

Had the project completed by March 2008 i.e. within one year of scheduled time period, there would have been no price escalation effect. Worsening of law and order situations like incident of Lal Masjid, assassination of former Prime Minister Mrs. Banazir Bhutto, Marriot Hotel bomb blast, political chaos/long march and government elections etc also affected the work progress adversely. The site was not completely closed for traffic which kept running on completed slip roads; the Islamabad Traffic police restricted working of construction machinery

during rush hours. Abnormal rains and weather conditions also affected the work progress. These matters were beyond the control of Employer and the Contractors.

Extension in time was granted to the contractor up to June 2008 due to late handing over of site. The work could not be completed in the extended time period and a 2nd extension was granted up to January 2009.

Due to his low rates and escalated prices of inputs, the contractor faced cash flow problems, which adversely affected the rate of progress and quality of work. He laid off his highly paid Engineers and hired less qualified staff on comparatively low salaries. Instead of new formwork of concrete he used repeatedly old formwork for concreting, which adversely affected the quality of finishing work.

CDA, in order to ease out the cash flow problems and facilitate the contractor to complete the project, extended many facilities to the contractor. About 700 M. ton steel was issued to contractor from CDA stores, an additional financial assistance of 10% of contract price was allowed against bank guarantee, price adjustment on steel was allowed on market rates, water charges already recovered from the contractor were reimbursed and asphalt work was carried out by CDA through its own asphalt plant. This can be termed as good example of damage control and an effort to get the project completed.

The consultants did not specify the design for finishing of the concrete walls of underpass. 1100 meter long unfinished concrete walls on both sides of the underpass approaches are yet to be finished properly. The finishing material and design are still under consideration. It is again poor quality planning and designing.

The project was substantially completed in March 2009. The underpass was opened for traffic in October 2008; both carriageway of Flyover Bridge were opened for traffic in March 2009. The project was completed and opened for traffic in exactly two years time period.

The project remained under harsh criticism of media regarding dust and environmental problems along with delayed completion. General society had to face health problems due to environmental problems created by the contractor. They also had to travel longer distances

consuming extra fuel and man hours. According to survey data the estimated indirect cost paid by the general society on this account is given in table-2 below

Table-2, Estimated Indirect COPQ born by the general Society.

Description	Amount (M)
Cost of fuel of 100,000 vehicles for extra traveling of (Average) 2 Km per day in 2 years and cost of wasted man hours	Rs. 1150.000
Cost of health related problems due to air pollution	Rs. 7.300
Total indirect COPQ paid by the general society	Rs. 1157.300

Table-3, Cost of poor quality (failure cost) born by the Contractor

Description	Amount (M)
Price adjustment not allowed on construction material due to defective contract documents (opportunity cost)	Rs. 199.729
Cost difference as a result of poor bidding	Rs. 65.000
Cost of mismanagement of resources	Rs. 15.500
Cost of reworks/material wastage	Rs. 32.500
Total cost of failure (about 38% of project cost)	Rs. 312.729
Time delay due to various reasons	One year

Out of Rs. 312.792 million, price adjustment of Rs. 112.788 million has been born by the Employer by compensating the contractor for the time delay pertaining to employer's fault.

Table-4, Cost of poor quality born by the employer

Description	Amount (M)
(COQ) Prevention& Appraisal cost	Rs. 6.000
Cost of delay (compensation to contractor)	Rs. 112.788
Total cost of poor quality (about 14.5% of project cost)	Rs, 118.788

5.4 Cost details and comparisons

The estimated Indirect COPQ paid by the general society = Rs. 1157.300 million

COPC (failure cost) born by the Contractor (312.729 – 112.788) = Rs. 199.941 Million

Cost of poor quality born by the employer = Rs. 118.788 Million

- ✓ Total cost of quality = Prevention cost + Appraisal cost + Failure cost

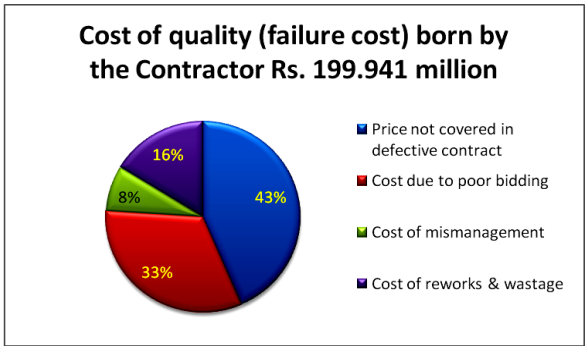
  Total cost of quality = 6.000 + 312.729 = Rs. 318.729 million
- ✓ Total cost of failure = Internal failure cost + External failure cost

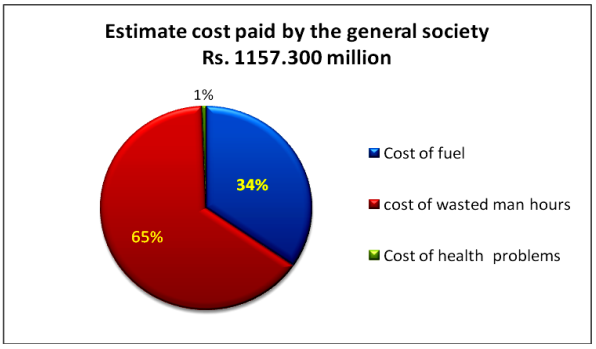
  Total cost of failure = 312.729 + 1157.300 = Rs. 1470.029 million
- ✓ Cost to client = Total cost of quality + Initial investment cost

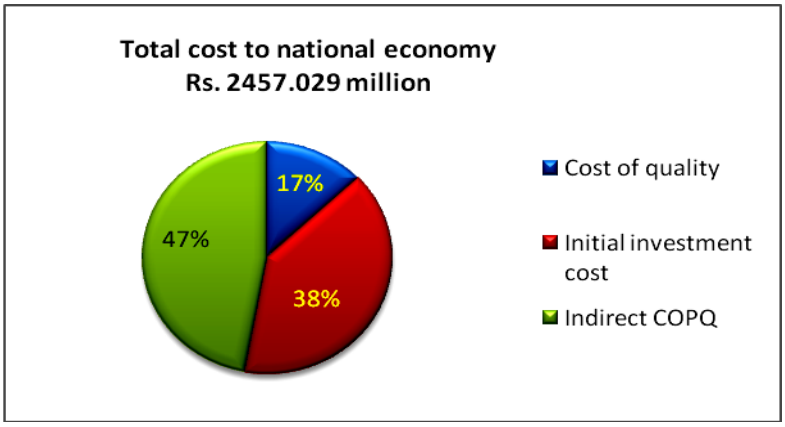
  Cost to client = 6.000 + 112.788 + 981.000 = Rs. 1099.788 million
- ✓ Total Cost of poor quality = cost of quality + indirect COPC

  Total Cost of poor quality = 318.729 + 1157.300 = Rs. 1476.029 million
- ✓ Total cost to national economy = Total cost of poor quality + Initial investment cost

  Total cost to national economy = 1476.029 + 981.000 = Rs. 2457.029 million







FINDINGS AND ANALYSIS

It can be seen from the above details and graphs that a substantial cost of Rs. 1476 million has been incurred on cost of poor quality; especially the external failure cost is more than the original project cost. The national economy had to bear a cost of Rs. 2457 million for a project which was estimated for Rs. 981 million. It is 150 % more than the original cost. It can also be seen that very little investment of Rs. 6.000 million (less than 1% of the project cost) has been made in the improvement costs (prevention and appraisal costs) due to which the failure costs have risen to Rs. 1470 million. These costs did not reflect in the accounting system of the organization and record of project, therefore remained hidden. The management and stake holders therefore are unaware of the consequences of cost of poor quality. The results of this study were shown and discussed with the organization's managers and they were surprised to know the facts of the hidden plant. It is hoped that the lessons learnt in this research would be helpful for the public sector organizations in eliminating the COPQ from their future construction projects.

CONCLUSION

The construction costs are normally worked out from the accounting records of projects, which include costs of inputs like human resource, machinery, material, energy and overheads etc. There are also some failure costs that result due to poor quality of processes, workmanship or material etc, which are also buried in the accounting record and therefore remain hidden from the management. These failure costs not only, eat up the profits of the company but also damage the company reputation, good will and business along with losing the customers.

When we talk of quality, most people take it as quality of finished product/project delivered by a contractor. Providing work quality as per required specifications is one aspect but the quality in other factors like defining project objectives, designing, planning, decision making, team building, selection of contractor, consultants, contract documents, coordination among the major stake holders & agencies is also essential to reduce the COPQ.

In order to improve the quality of output and reduce the failure costs, the cost of poor quality concept has evolved. It comprises of prevention cost, appraisal cost and failure costs

(Internal and external customers). Investment is required in the prevention and appraisal costs to reduce the expensive failure costs. We cannot improve the system unless we are able to measure the failure costs. Identification of customer requirements, causes of failure and problem areas in the work processes and thereby improvement/revision in the product design, project planning and work process would improve the work quality. It would also reduce the wastage, reworks and COPC, along with improving the productivity, business and profits.

Undue Public disturbance and creating environmental problems (air, water, noise pollution) during execution of any project is a chargeable offence under the human rights (Tikun Olam-2009; Public nuisance) and Environment Protection Agency (EPA) rules (S.R.O (1)/2001) but still the contractors go unchecked due to poor Government controls in developing countries and hence a heavy indirect cost is born by the effected segment of general public, wild life and wild flora etc. General public in developing countries is also not aware of its rights, due to which normally no reaction is seen from them on violation of rules by construction contractors except appearance of some media report, which also fail to attract the attention of city managers. The cost born by general society on this account can be termed as an indirect cost which is often ignored in cost of poor quality.

There is another indirect cost paid by the general society and stakeholders of the project, when the project completion is delayed. For example they have to travel long distances consuming extra fuel and waste man hours because the bridge or road leading to their destination was not constructed on schedule. They start getting benefit when the project starts functioning. Therefore calculating the cost of poor quality keeping in view all the factors is a complex process. However, it can be measured for the factors directly related to a project.

This study has identified some other factors which contribute to the cost of poor quality of the projects. This research has quantified the total poor quality cost of a public sector construction project in a developing country. Previous studies in the construction industry have been undertaken in developed countries, having a particular emphasis on estimating failure or nonconformance costs. It has been demonstrated that there is a similarity between the findings of this study and previous research as far as costs of improvement and failure are concerned. However, a new dimension of indirect cost has been added as a result of this research. In order to estimate the real project cost, most studies have referred the total cost to contractor, whereas this study was focused on the cost to stake holders. Researchers

and practitioners can use this research to improve their estimations for total poor quality costs which may also include the cost born by the general society due to adverse effects of project and its quality. It has been established in above case study that indirect poor quality cost born by the general society was more than the project cost.

Area for future research

The area of future research is designing of a process for reporting and recording of COPQ during execution of construction projects. It would support the management for taking timely decisions and remedial actions to check the drain of valuable resources. Re-engineering of accounting process would eliminate the concept of hidden costs of COPQ.

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