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Cost of poor Quality in Construction

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***ABSTRACT*:** *The cost of quality are cost associated with the prevention, discovery, and resolving of defects. These costs can arise whether the product is in design stages, manufacturing plants, or in customer's hand. It is important to identify the cost of quality so that one can determine the expenses associated with producing a quality product.*

The present paper aims at making a review associated with use of quality in construction industry. Data necessary to achieve the objective of the paper is collected from different projects in industry. The paper focus on construction defects on respective projects and poor quality cost measurement. It also shows that defective building construction not only contributes to added construction cost of the project but also the cost of maintenance, which can be substantial.

Keywords: *Building defect, Quality, Cost of quality, Cost of quality model, Optimum cost*

1. INTRODUCTION

Quality has become one of the most important competitive strategic tools which many organizations have realized it as a key to develop products and services in supporting continuing success. Quality system is designed to set a clear view for organization to follow, enabling understanding and involvement of employees proceeding towards common goal. In the cycle of never ending improvement, quality measurement plays an important role. The measurement is considered as a trigger for the improvement .No improvement could be achieved if no measurement is applied and analyzed in order to assist in identifying opportunities for improvement.

Defects within new buildings are areas of non-compliance with the Building Code of India, various Indian Standards and published acceptable tolerances and standards. Defective building construction not only contributes to the final cost of the product but also to the cost of maintenance, which can be substantial. Defective construction may lead to the complete failure of a structure.

2. NEED OF QUALITY IN CONSTRUCTION INDUSTRY

Errors on construction sites occur frequently and can be costly for the contractors and owners of constructed facilities. In fact, 6-15% of construction cost is found to be wasted due to rework of defective components detected late during construction and 5% of construction cost is wasted due to rework of defective components detected during maintenance.[1] The nature of these errors is quit diverse. 20-40% of all site defects have their roots in errors arising during the construction phase [2], 54% of the construction defects can be attributed to human factors like unskilled workers or insufficient supervision of construction work. Furthermore, 12% of the construction defects are based on material and system failures [1].

These observations suggest that a thorough inspection of construction sites is needed and that current site inspection approaches need to be improved in identifying defects on construction sites effectively. Since the main causes of construction errors, e.g. human involvement in the construction process and changing environmental conditions resulting in discrepancies in material behavior are uncontrollable, it is critical to improve the inspection and assessment of the quality of construction projects.

3. BUILDING DEFECTS

Building defect is one of the major components of building that needed attention. When a building fails to perform as it should, we immediately look for answers. Is the problem is the result of someone's failure to assemble it properly? Is the problem an act of nature? Was the proper maintenance of the building not performed as it should have been? The answers often depend upon a number of factors: the age of the affected building component, the exact nature of the problem, the presence or absence of human error, or some combination of all three. [3]

3.1. Construction defect would result from

1. Defective building material or components-materials: i.e., inferior material such as building bricks,

cement, roofing material, poorly manufactured windows
2. A violation of Building Codes at the time of construction.
3. Failure to meet professional standards for design at the time plans were approved Design: i.e., faulty RCC roofing design contributes to water intrusion
4. Failure to build according to accepted trade standards for good and workmanlike construction. Workmanship: i.e., substandard or shoddy work
5. Engineering/Soil: i.e., structural failures and earth movements.

4. COST OF QUALITY (COQ)

The concept of COQ was first mentioned by Juran (1951) as the 'cost of poor quality'. According to Crosby (1979), COQ is the 'price of non-conformance'. The term 'Cost of poor Quality' refers to the costs associated with providing poor quality product or service. COQ is the amount of money a business loses because its product or service was not done right in the first place. It has been suggested that the cost of poor quality can range from 15%-40% of business costs.

4.1 The categories of COQ [4]

4.1.1 Failure cost

4.1.1.1 Internal Failure Costs

Internal failure cost is a cost that would disappear if no defects existed prior to shipment to the customer. These costs include rework, scrap, re-inspection, re-testing, corrective action, redesign, material review, material downgrades, vendor defects, and other like defects.

4.1.1.2 External Failure Costs

External failure cost is a cost that would disappear if no defects existed in the product after shipment to the customer. These costs include processing customer complaints, customer returns, warranty claims and repair costs, product liability and product recalls.

4.1.2 Appraisal Costs

The costs incurred while performing measuring, evaluating, or auditing to assure the quality conformance. These costs include first time inspection, checking, testing, process or service audits, calibration of measuring and test equipment, supplier surveillance, receipt inspection etc.,.

4.1.3 Prevention Costs

The costs related to all activities to prevent defects from occurring and to keep appraisal and failure to a minimum. These costs include new product review, quality planning, supplier surveys, process reviews, quality improvement teams, education and training and other like costs.

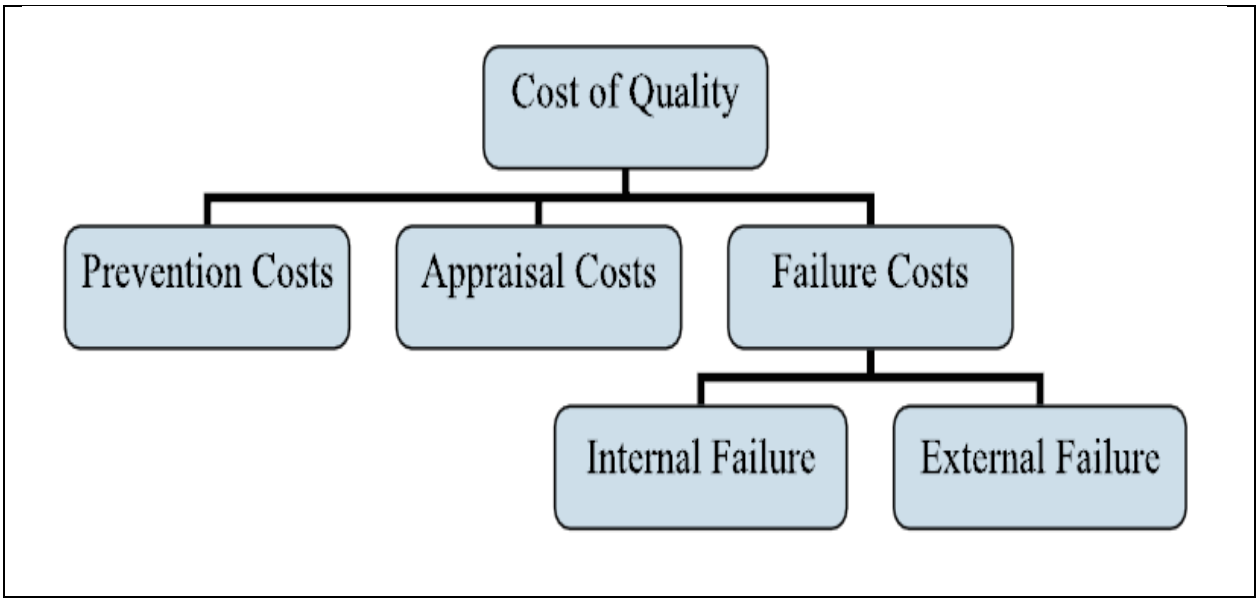


Fig.1. Quality Costs Categories [4]

4.2 The COQ Models

In general, COQ models are classified into four groups [5].

1. P-A-F models: Prevention costs+ Appraisal costs+ Failure costs
2. Crosby's model: Cost of conformance+ Cost of non-conformance
3. Opportunity or intangible cost models: [Prevention costs+ Appraisal costs + Failure costs + Opportunity costs] / [Cost of conformance+ Cost of non-conformance+ Opportunity costs] / [Tangibles + intangibles] / [P-A-F (failure costs includes opportunity costs)]
4. Process cost models: Cost of conformance + Cost of non-conformance

Most COQ models are based on the P-A-F classification and the basic suppositions of the P-A- F model are that investment in prevention and appraisal activities will reduce failure costs, and that further investment in prevention activities will reduce appraisal costs. Opportunity and intangible costs are hidden and can only be estimated as profits not earned (or revenue not earned), because of lost customers. e.g. under-utilization of installed capacity, downtime, insufficient material handling and poor delivery of service.

4.3 Optimum quality cost model

Many economic and mathematical models have been developed to find the optimum COQ. The traditional model detailed by Brown and Kane (1984) has got widespread acceptance [6]. According to this model, shown in Fig. 2, there is an inverse relationship between prevention and appraisal effort and failure cost. The optimum conformance to quality or defect level is where the increasing costs of the prevention and appraisal curve converges with the curve of decreasing failure costs. Total quality costs are minimized to the point where the cost of prevention plus appraisal equals the cost of failure. The total quality cost curve represents the sum of the other two curves, and the location of the minimum point on the total quality cost curve, sometimes referred to as the optimum point [6]

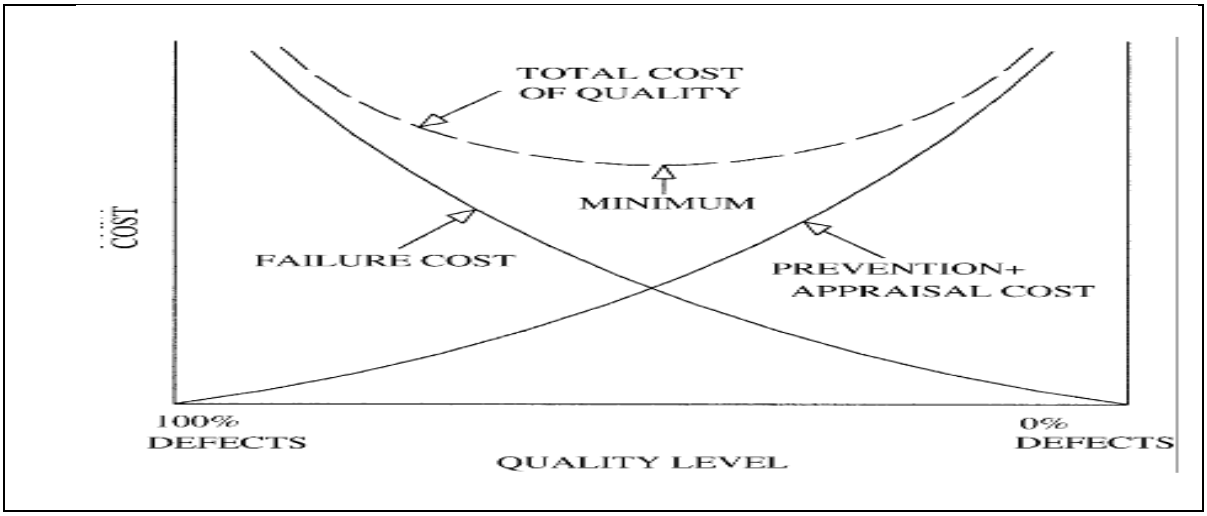


Fig.2. The basic model of optimum quality cost [6]

5. MAJOR FINDINGS FROM STUDY

The data is collected to identify what are construction defects and to understand the Quality Cost Concept. The data collected is from various construction sites from ongoing projects and completed projects. Nature of data collected is defects on construction site and cost of rework done to remove those defects.

5.1 Case 1: (Ongoing project)

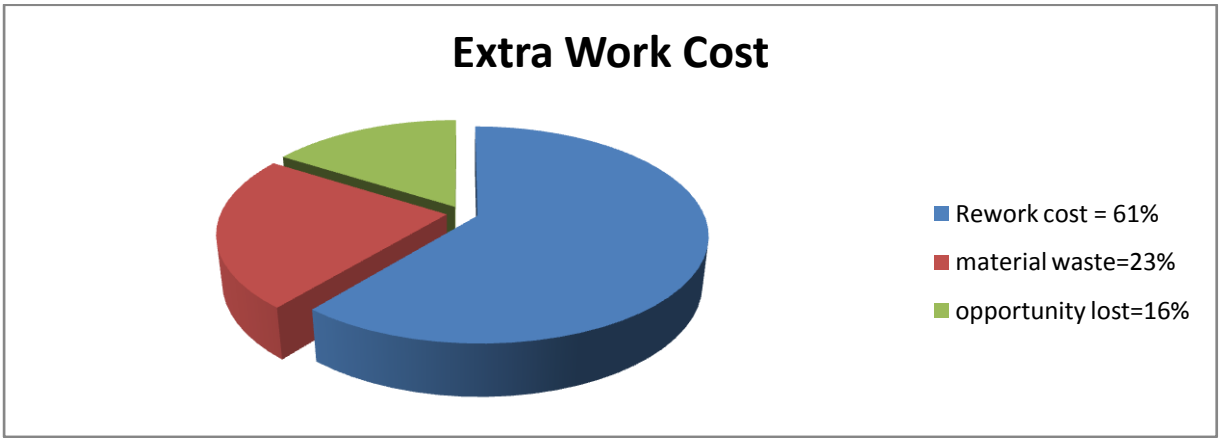
It's a residential building project with P + 10 storied bldg. Total 20 3BHK and 19 2BHK flats, 1 Fire Refusing area on 8th floor. Two auto functioning lifts & amenities like swimming pool, club house podium garden and children play area etc.

The following activities are found defective. The cost of Quality is calculated depending on parameters such as material wastage, labor & opportunity lost.

Table 1: Cost of Poor Quality

Sr. No	Activity	Waste Material Cost in. Rs	Rework cost in. Rs	Opportunity lost cost in. Rs	Poor Quality Cost in Rs.	Item Cost In (lakh) Rs.	% Increase in Cost	% waste Material Cost	% opportunity Lost Cost
1	Lift work	8075	37730	5250	51055	32	1.59	0.25	0.16
2	Wooden door work	17500	23500	6000	47000	6.3	7.46	2.78	0.95
3	Painting Work	11000	19800	2514	33314	8	4.16	1.37	0.31
4	Tile Work	15065	20960	7000	43025	13.47	3.19	1.12	0.52
5	Plaster & Finishes	6575	52080	20250	78905	35	2.25	0.19	0.58
Total		[illegible]	154070	41014	253299 [illegible]	94.77	18.65	5.71	2.52

- From above table pie chart is drawn which gives the break-up of the cost of poor quality % of opportunity lost cost; material waste cost & reworks cost with poor quality cost.



- From above chart Item cost of all elements = Rs 94.75 lack
  Cost of poor quality = Rs. 2.54 lack
  Percentage cost of poor quality = 2.68

5.2 Case- 2 (Defect in completed project)

Selected site is fully completed residential building. This building consists of 18 flats which are handed over to the customers. The defects were found after delivery of the building. As building was in warranty period the defect are rectified by builder.

5.2.1 Defects in building

At the time inspection of building following points were noted.

1. Interruption in power supply and defect in electric fittings.
2. Leakage in taps and defective flushing cisterns.
3. Blockage of sewer line and drains.
4. Leaking roofs.
5. Broken glass panes, non closing doors and windows.
6. Defect in flooring and paints.

Table 2: Defects in Building

Sr. No.	Defects	Total no of flats	Qty. of defect
1	Leakage of taps	8	27 Nos
2	Defective flushing cisterns.	5	8 Nos
3	non closing doors	6	16 Nos
4	non closing windows	7	22 Nos
5	Defects in electric fittings.	4	798 RFT
6	Internal Paint	6	7701 SFT
7	flooring	2	1802 SFT

5.2.2 Defect Rectification Cost

These entire defects are rectified by builder. This case is perfect example of "How Poor Quality in construction increases the external failure cost?" this cost discovered after delivery to customer after failure to meet customer requirements and needs, i.e. cost of repair and replacement.

Table 3: Defect rectification cost

Sr. No.	Agencies	Qty. Of Defects	Rectific Ation Duration in day	Cost of Repairs in Rs.	Total days for Rectific a tion	Cost of (Engineer ½ day) total= 15 day	Cost Of (Supervisor Full day) Total= 30 day	Total Cost of Rectific Tion
1	Plumbing	35 nos.	14	18700	28day	Rs.7000	Rs.6000	Rs. 240937
2	Electrical	798RFT	21	22056				
3	Carpenter	16 nos.	07	18500				
4	Tile Work	1802SFT	12	34050				
5	Painting	7701SFT	19	116721				
6	AI. Window	22 nos.	14	16160				
7	Gardening	3000SFT	05	1750				

- Project cost= Rs. 13060050.00
  Total rectification cost = Rs. 240937.00
  Percentage of rectification cost with project cost= 1.84

In rectification period several family faced problems like disturbance in day to day activity, postponing the important programs, time wasted & more important Privacy disturbed. As these factors are not easy to calculate in cost because every person's time value is different, but an attempt is made to calculate on family income & other assumptions

For example: Nuisance cost calculation

Consider for P0l

- Defect rectification period for Flat P0l was 26 days, so the family has only choice to stay in another place during defect rectification period, flat rent for the period of one moth is Rs. *12000₁* and luggage shifting charges Rs. 3500,
- Family monthly income 76000, i.e. 2500 per day, so loss of one day
- Total Nuisance Cost» Rs 12000 + Rs 3500 + Rs.2500 = Rs 18000

Similar procedure was used for the nuisance cost calculations of other flats.

Table 4: Nuisance Value of Customer

Flat No.	Defect Rectification Duration	Family Income monthly	Persons do the job. (One Person has to stay at the time of rectification)	Flat taken on rent during rectification work. Per month	Total Nuisance Cost in Rs.
P0l	26day	76000	2	12000	18000
P02	08day	34000	2	-----	4533
A01	----	-----	----	----	----
A02	----	----	----	----	----
A03	17day	48000	1	8000	12000
A04	07day	73000	2	----	8516
BOl	----	----	----	----	----
B02	11day	28000	1	----	10266
B03	18day	35000	2	10000	13000
B04	20day	44000	1	----	14666
COl	----	----	----	----	----
CO2	----	----	----	----	----
C03	----	----	----	----	----
C04	1/2 day	26000	2	----	00
DOl	1/2day	38000	1	----	00
002	----	----	----	----	----
003	7day	70000	1	----	4666
D04	7day	45000	1	----	00
				Total = Rs 85647 /-	

- Project cost= Rs. 13060050.00
  Total nuisance cost= Rs. 85647.00
  Percentage nuisance cost with project cost = 0.66

6. CONCLUSION

In above observations Case-1 is an ongoing site, so cost of poor quality associated in this case consists of internal failure cost, prevention cost and appraisal cost. This case does not consist of external failure cost as product is still in manufacturing stage.

Project in case-2 is completed project and as this project is handed over to the customers cost of poor quality in this case consist of external failure cost, prevention cost and appraisal cost. In addition to these costs customer suffer during rectification work. Though this cost is 0.66 % of total project cost it leads to the customer un-satisfaction and lowers the value of company.

The summary of increase in the project cost is as follows

Table 5: summery of cost of poor Quality

Sr. No.	Total worth of items/ project	Cost of poor quality	%
1	Cost of items under construction= Rs. 94.77 lakhs	Rs. 2,53,299	2.68
2	Project cost = Rs. 1,30,60050 .	Rs. 2,40,937	1.85

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