Cost of Quality in the Construction Industry

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December 6, 2009

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ABSTRACT:

The construction industry needs to decrease its costs due to nonconformance by implementing an objective model for analyzing the excessive cost of poor quality and the overall savings realized from good quality. Direct cost estimates from rework in commercial building construction average about 5%. A simple calculation based on U.S. construction industry expenditures of $1.246 trillion in 2007 reveals that $62 billion is wasted just on the direct cost construction rework alone!

The term quality can be applied in many different ways to various aspects of the construction process. This paper proposes a model which helps illustrate how the various elements of the cost of quality (COQ) might be employed by the general contractor within the construction project itself. Several traditional COQ theories are applied, compared, and contrasted as they relate to the construction industry; particularly conforming and nonconforming quality costs.

The study concludes by suggesting possible ways of measuring the costs of construction quality and suggests that the construction industry needs to experience two true paradigm shifts. One which moves the industry from resources spent on quality non-conformance to resources spent on quality conformance; the other moves the construction business perspective from thinking in a quality compliance mode to an actual quality performance mode.

KEYWORDS: Construction, Quality, Cost of Quality, Quality Control, Quality Assurance,

INTRODUCTION:

The capital expended by construction companies as a result of poor quality (or the savings realized from good quality) are, for the most part, being ignored by the industry. Part of the reason for this lack of attention is likely a natural aversion to the unknown or unquantifiable. Failure to face quality cost issues is certainly not due to its lack of importance. The significance of quality costs versus other costs incurred on a construction project is evident from various research studies. Authors such as Crosby (1980), Juran (1999), and Campanella (1999) have postulated that quality costs can soar as high as 20% of construction costs. In industrial construction, the direct costs of rework (termed deviations) can be as high as 12% of total costs (Burati and Farrington, 1987). Direct cost estimates from rework on commercial building construction are more conservative, averaging about 5% (CII, 2005). Based on this more conservative estimate, a simple calculation based on U.S. construction industry expenditures of $1.246 trillion in 2007 (Bureau of Economic Analysis, 2009), reveals that $62 billion is wasted on the direct cost of rework alone. Rework is only one relatively simplistic aspect of nonconformance cost of quality (COQ). This study, among other things, attempts to provide the reader a comprehensive view of all the COQ categories and subcategories as they relate to the construction industry.

QUALITY DEFINED

The construction industry continually struggles with the term quality, partially due to its inability to properly define it. Construction management is traditionally broken down into four primary categories: cost, schedule, safety and quality. The first three are well understood and clearly defined by the construction industry, but the term “quality” continues to be treated like a mystery. When a project’s costs go over budget, when the schedule is delayed, or when someone gets injured on the jobsite, these concepts are simply understood and their cost can easily be quantified. However, when a project experiences poor quality, the term is less explicit and can be understood in a variety of ways depending on one’s perspective. Quality for a construction project can denote several different meanings and elicit numerous responses. Webster’s Dictionary (Guralnik, 1984) has four definitions of quality; two relate to characteristics and two refer to a degree of excellence or goodness. From this it can be presumed that “high quality” goes hand-in-hand with high material costs, esthetically pleasing design, or a high degree of functionality. These are nebulous and subjective concepts which are not easily quantifiable and depend on the person’s point of view.

The American Society of Quality Control (ASQC) once defined quality as “The totality of features and characteristics of a product or service that bears on its ability to satisfy given needs” (Freund, 1995, p.51). Applying this definition of quality to the construction of a building requires identifying what the “needs” are and how they are ”satisfied”. From a general contractor’s perspective, the quality “needs” are simply defined in the contract documents as issued by the architect and owner. The quality criteria are “satisfied” when the contractor complies, at a minimum, with said contract documents. This is in line with Crosby (1980) whose definition of quality is succinctly stated as the “conformance to established requirements.” No longer are we looking at nebulous terms such as “excellence” and “goodness” but now quality can be viewed objectively and more importantly, easily measured.

To remain this simplistic in our definition of quality, some ancillary issues need to be acknowledged yet put aside for the purpose of this study. If the project delivery method is integrated (IPD – Integrated Project Delivery), then the contractor is involved as either a CM-at-risk or Design-Build (DB) contractor. If this is the case, the contractor has now increased his responsibility for the project beyond simply building to a predetermined set of contract documents. This larger responsibility of design and construction quality for the entire project is not addressed here. The other acknowledgement is the assumption that the quality requirements listed in the contract documents are completely specified and not open to interpretation. While the intent of the architect may be to provide the contractor with a "complete" set of contract documents, this rarely occurs. If a project is documented properly, the cost of quality (COQ) issues due to design errors can be easily separated as they are typically well identified and segregated in the change order process.

QUALITY BACKGROUND

Any study that focuses on quality and modern management practices must start with the two names which are synonymous with the topic, Edward Deming and Joseph Juran. Deming (1986) was an advocate of continuous quality improvement known as "The Deming Cycle." Plan-Do-Check-Act (PDCA) helps focus a company's attention and resources on continually meeting a client's needs. Deming's main concern was reducing variability to achieve conformance to the specifications. Higher quality leads to higher productivity which leads to lower costs which results in a competitive advantage. This discussion leads us back to what type of quality management system should be employed by the construction industry, which is outside the scope of this study. Juran (1999) believed it was important to directly link quality issues with bottom line costs. Linking quality, conformance and defects to dollars and profits was the only way to drive true change, thus unifying workers and senior management. It is often said that you can not manage what you can not measure. The concept of identifying, evaluating, measuring, and analyzing the cost of quality for the construction industry is a core concept of this study.

QUALITY MEASUREMENT

Quality is measured by the construction industry in many different ways. McGeorge and Palmer (1997) described seven dimensions of quality as it applies to construction performance, reliability, conformance, durability, serviceability, aesthetics and perceived quality. This is a very practical definition of quality measurement and useful if one were to grade or measure levels of quality against one another. Newton and Christian (2006) looked at quantifying quality from a building life cycle cost (LCC) perspective, taking into account the effects of quality design, materials used and workmanship. This measurement of quality is more holistic and emphasizes the effects of quality on operation and maintenance costs as opposed to being construction focused. Kuprenas (2008) conducted a study on the correlation between quality measurement and project costs. This was a comparative study measuring quality relative to other factors instead of the actual cost of quality itself. All of these approaches to measuring quality are very complex and take into account, in addition to the contractor, the COQ caused by the owner, the designer and facility maintenance. The COQ by participants other than the contractor are outside the scope of this study.

To help focus our attention on the general contractor, Campanella (1999) wrote a definition of quality cost as “those which are incurred from investing in preventing noncompliance with requirements, evaluating compliance with the requirements of a product or service and failure to meet requirements.” This definition leads directly to a simplified equation of COQ which makes it equal to cost of conformance (management prevention and management appraisal) plus the cost of non-conformance (internal and external failure). This perspective is further supported by Cokins (2007) whose COQ classification scheme identifies work activities as either error-free (stable), in conformance (unstable), or non-conformance (defective).

QUALITY CONTEXT

As we have seen, applying the term "quality" to the construction industry is an extremely difficult task. Quality is a vast and multiple-meaning term which can be applied in many different ways to various aspects of the construction process. Figure 1 graphically outlines the contents of this study and shows the various facets of the construction process where the COQ might be analyzed, discussed and applied.

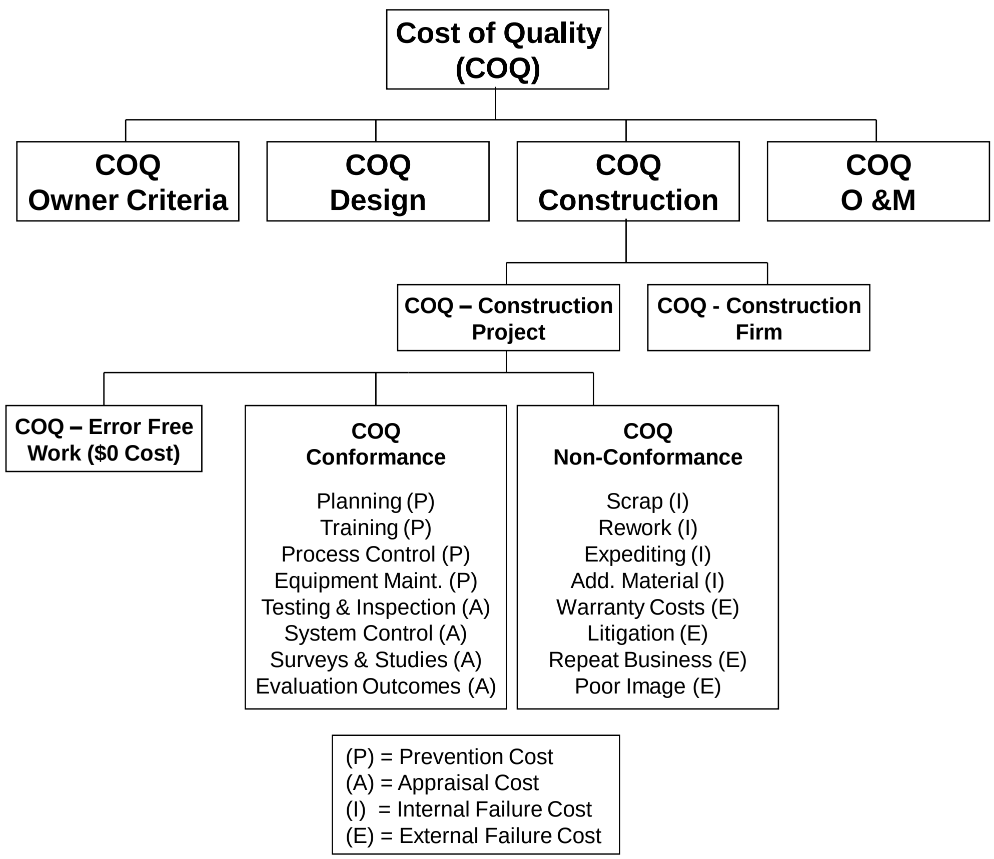

Figure 1: Cost of Quality (COQ) for the Construction Process.

To expedite how this study defines the COQ, it is easiest to first describe what it is not going to include. This study will not specifically address the COQ associated with the owner's criteria, the architect's design process, or the facility management (O&M) of the building. It is critical for the owner to precisely relate the design criteria and parameters of the project to the architect. If the quality of the criteria given by the owner is poor or unclear, it will certainly mean additional redesign costs for the project. Clearly the decisions made during the design process inevitably have a tremendous impact on the final quality of the building. Extensive COQ research has been done relating to the construction design process. One example among many explores the adaptation of Quality Function Deployment (QFD) for the process of project development and design (Arditi & Lee, 2003; Lee & Arditi, 2006). Poor quality operation and maintenance decisions made by the facility management team (either done cheaply or less often) will also likely result in more expensive repair costs down the road. Facility management is just another form of COQ applied to a building which has been completed and is occupied. It is acknowledged that there are significant COQ issues associated with each of these phases of the construction process and should be addressed independently from this paper.

Continuing down to the next level of Figure 1, this study does not address the COQ as it relates to the inner workings of the construction firm itself. That is not to say that there is not a major conformance COQ element within the management of a construction company. This aspect of COQ relates to the internal processes and procedures of any firm (construction or not) which occur regardless of the COQ in the field. Examples of these types of COQ include internal efficiency and accuracy issues involving documentation, management structure, safety, tracking, and scheduling systems. A firm's poor quality performance in these areas can result in significant additional expenses which are another form of COQ. For example, the quality of a firm's safety program might be very poor. As a result, the firm's accident rates will likely increase. This is a COQ to the firm which occurs separately from the project's quality costs and is not considered in this study.

It would be remiss not to pause and make a salient point at this juncture about total quality management systems. Notice the pervasiveness with which the issue of quality is entrenched in all aspects of the construction industry. Clearly the quality management efforts put forth by a construction company will have a significant COQ effect on all aspects of the construction process. While the type of quality management system employed by a construction company is not addressed here, the impacts of any system are undoubtedly far reaching. Briefly, the types of quality management systems (or techniques) which have been applied to the construction industry include Total Quality Management (TQM), Process Cost Model (PCM), Lean Principals and, more recently, Six Sigma.

The integration of a quality management system into the management structure of a construction company is an interesting subject, one about which much research has been done and many articles written. One commonality of most quality management systems is their goal of being embraced and implemented by everyone in the company. The importance of achieving this goal becomes clear when you view it from the perspective of COQ and its widespread implications to the entire construction process. This notion is confirmed by the findings of Yasamis et al. (2002) who developed Figure 2 which identifies construction quality and contractor quality performance (CQP) related to client satisfaction. Figure 2 is similar to Figure 1 and it reinforces the entrenchment of quality in the entire construction process and identifies the importance of quality in the delivery of the construction project and in its planning, administration and culture.

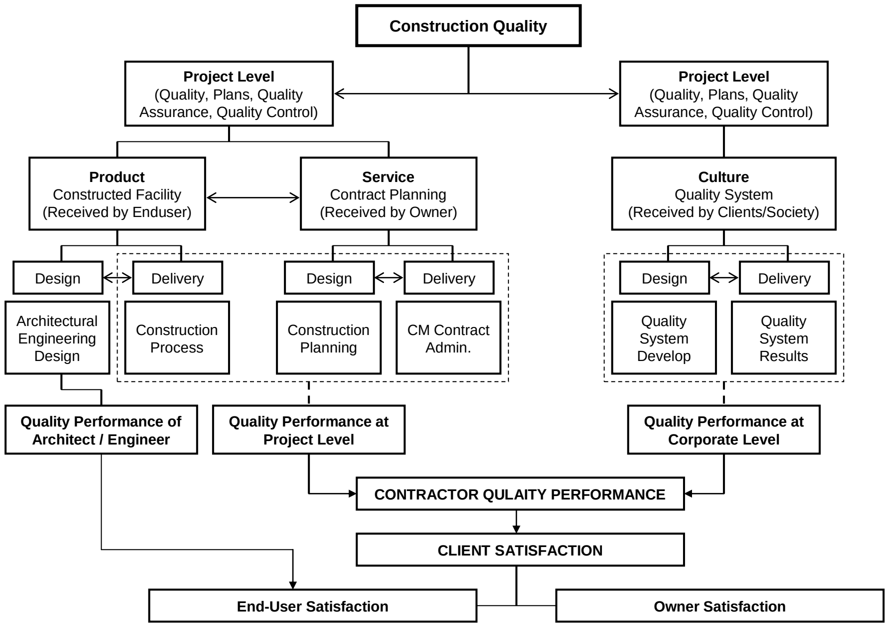

Figure 2: Construction Quality Performance (Adapted Yasamis et al. 2001)

Yasamis et al. (2001) takes a broader view of the COQ by relating it to all aspects of the building construction process. Again, Figure 1 focuses our discussion on the COQ relating directly to construction project and divides the COQ into two subcategories: COQ - Conformance which involves proactive management functions such as prevention and appraisal and COQ - Nonconformance which involves reactive responses which can manifest themselves in the form of internal or external failures. Next a more thorough discussion of the sub-categories relating to a construction project's COQ is presented.

QUALITY ACTIVITIES

Table 1 is a more detailed explanation of COQ for a construction project as referenced in Figure 1. This is by no means a complete list of COQ issues relating to construction projects but is an attempt to summarize the major issues.

Table 1 – Cost of Conformance / Nonconformance. (Adapted from Ireland 1991 and Crosby 1980)

COST OF CONFORMANCE:	COST OF NONCONFORMANCE:
(P) Planning – pre-construction quality management	(I) Scrap – wasted material due to inefficient use
(P) Training- of management and field personnel	(I) Rework – direct cost of poor techniques or management
(P) Process System – construction quality management system	(I) Expediting – crashing a schedule to make-up for lost time
(P) Equipment Maintenance – proper tool maintenance ensures quality	(I) Additional Material – needed due to damage or transportation
(A) Testing & Inspections – in-house and third party testing and inspections	(E) Warranty Costs – call-backs during one year warranty (defects)
(A) System Process Control – cost engineer analysis and reporting work	(E) Litigation – arbitration and/or litigation cost
(A) Surveys & Studies – process of measuring quality success or failure	(E) Repeat Business – loss of additional profitable work
(A) Evaluation of Outcomes – post-construction quality management	(E) Poor Image – loss of potential jobs not considered

(P) = Prevention Cost
(A) = Appraisal Cost
(I) = Internal Failure Cost
(E) = External Failure Cost

The COQ is often broken down into the four main categories as shown in Table 1. The definitions for which are tailored for the building construction industry:

- Prevention costs are incurred by the contractor for activities which are undertaken to prevent internal or external non-conformance issues.
- Appraisal costs are incurred by the contractor in the process of conducting inspections, making evaluations and collecting data.
- Internal Failure costs are incurred upon the contractor due to unsatisfactory results prior to the owner's acceptance of the building (failure).
- External Failure costs incur upon the contractor when poor quality is discovered after the owner accepts the building (defect).

Defects and failures are often used interchangeably. Atkinson (1987) clears up the confusion when he defines the two terms: “A failure is a departure from good practice, which may or may not be corrected before the building is handed over. A defect, on the other hand, is a shortfall in performance which manifests itself once the building is operational.”

COST OF QUALITY

When reviewing Table 1, short of writing a detailed evaluation or appraisal of each item, it becomes clear that the construction industry’s solutions to measuring the COQ for each subcategory will vary greatly. A solution example may be as simplistic as time cards filled out by management personnel identifying the time spent on quality prevention and appraisal issues. These could provide the information needed to accurately measure the cost of many of the COQ conformance categories included under planning, training, control, measuring and evaluation costs. Another solution might be to add a couple of cost categories to existing time cards filled out by field personnel. This would assist in collecting cost data for many COQ nonconformance categories such as testing, inspections, rework, expediting, additional materials and warranty costs. There have even been attempts made by researchers to quantify the COQ for items which seem too nebulous to measure. The COQ from the loss of repeat business or poor company image leading to customer dissatisfaction is a kind of “hidden cost.” Over the past several years, studies have been conducted using “probabilistic theory”, “Taguchi’s quality loss function”, and “fuzzy logic” to quantify these types of hidden costs (Selles et al. 2008) with varying degrees of success.

Rosenfeld (2009) does an excellent job of listing in more detail some additional subcategories which might be considered in Table 1. Rosenfeld makes the distinction between COQ conformance as a “quality” expenses and COQ nonconformance as a “non-quality” expense. The more you invest in “quality” the less you can expect to waste on the cost of “non-quality”. In his discussions, he emphasizes that prevention and appraisal are voluntary expenditures which can be managed by the construction company. Internal and external failures costs are involuntary expenditures and consequences which are imposed on it.

There have been many attempts to graphically depict the COQ in terms of the definitions listed above. An example of one such graph was developed by Schneiderman (1986) as shown Figure 3. Figure 3 compares quality (specifically defects) to cost.

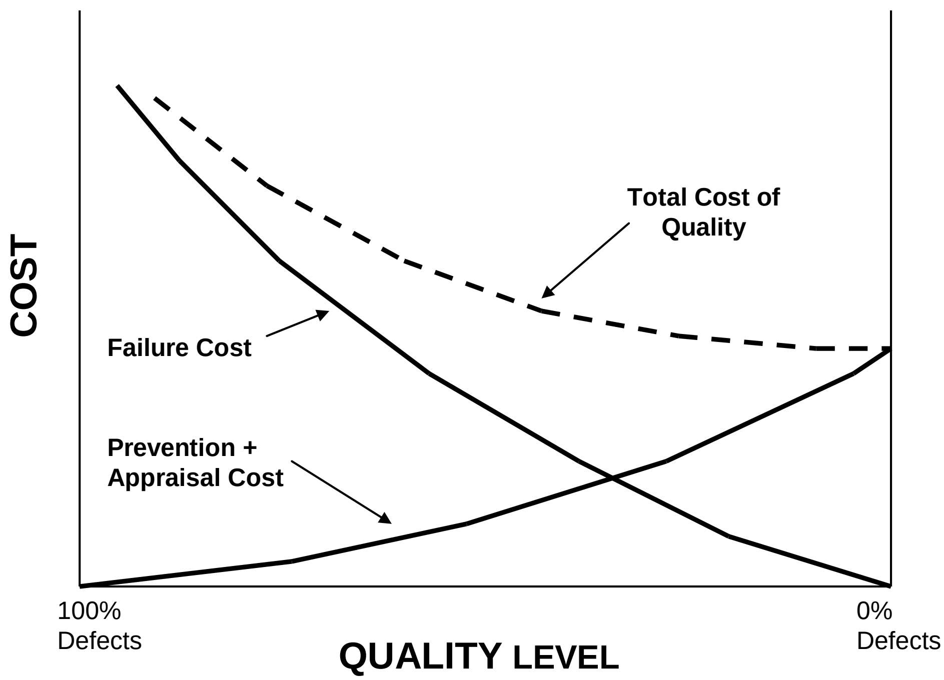

Figure 3: Quality Level – Cost Versus Quality Level (Adapted from Schneiderman 1986)

While not perfect, this graph does clearly show how increasing resources put toward prevention and appraisal (conforming costs) not only decreases the failure cost (nonconforming costs) but also decreases the total cost of quality. Of concern in this graph is the presumed ability (in real life) to actually reach zero defects, thus eliminating all failure costs. It is improbable that a construction company would want to actually allocate enough resources to obtain zero defects.

This subject matter is addressed by Rosenfeld (2009), who believes there is a crucial balance in construction between COQ and cost of non-quality (CONQ).

QUALITY IMPLEMENTATION

Throughout this study, the importance of being able to measure the cost of quality in the construction industry and that quality is achieved by the contractor's ability to meet the customer's requirements set out in the contract documents has been emphasized. While COQ measurement is difficult, it is not impossible. Quality is not an island unto itself. There is an explicit cost and causal relationship in the construction industry between quality, schedule and cost. McConachy (1996) takes the COQ into a broader context and defines "conventional project quality (CVPQ) as meeting the customer's requirements set out in the technical specifications, the budget and the schedule" thus cementing the link between these three parameters when measuring the success of a construction project.

Finding new and inventive ways of measuring and collecting COQ data will need to be continually refined by the construction industry, customized to the needs of a particular construction company, and the goal of further construction research. While the answer to the question of "how" to measure the COQ may be uncertain," who" should attempt to answer these questions in the construction industry is easier to envision. The most cost efficient answer to who should analyze, report, and implement a COQ program for the construction contractor should be the cost engineer (McConachy, 1996). Using the existing project controls and organization of a construction company is inherently cost effective. It is also in line with a cost engineer's current duties including cost estimating, scheduling, value analysis, and earned value calculations. Utilizing a cost engineer for this task is synergistic because he/she is already involved in measuring and reporting performance related to costs and schedules; adding the cost of quality simply completes the picture of total quality management.

CONCLUSIONS

The construction industry needs to experience two true paradigm shifts; one moves the industry from resources spent on quality non-conformance to resources spent on quality conformance, and one moves the construction business perspective from thinking in quality compliance mode to actual quality performance mode.

Rosenfeld's (2009) research concluded, as reasonably expected, that "the more you invest in prevention and appraisal, the less you will have to spend on internal and external failures." Additionally his findings "demonstrate that there is a balance to be struck between the proactive cost of quality and the resulting cost of non-quality." It is generally believed that the COQ in the construction industry is currently incurred or expended by percentage in the following order: [External failure -- Internal Failure -- Appraisal – Prevention] The idea, of course, is the inherent benefits of flipping this order around.

The quality cost of conformance (prevention and appraisal) is a known amount which is manageable and limited. The quality costs of nonconformance (internal and external failure) are not manageable and are involuntarily imposed on the contractor. In addition, the consensus among many is the definable cost of nonconformance is just the tip of the iceberg (Rosenfeld, 2009) representing only a small portion of all hidden costs. Indefinable external failure costs such as the loss of repeat business and poor image are steep. This is particularly true for the construction industry as it is a community which is infinitely small and which has a memory that is particularly long.

One of the unique aspects of quality costs, unlike many other construction costs, is that management has the ability to significantly impact or nearly eliminate the nonconformance COQ if properly managed and controlled. Crosby says, "Quality is free, it's not a gift but free. What costs money are the un-quality things – all the actions that involve not doing jobs right the first time" (Crosby, 1980, p.1).

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