IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SUPPLIER QUALITY MANAGEMENT: WHAT IS IT, 5 KEY METRICS TO KNOW AND A 4 STEP SUPPLIER EVELAUTION PROCESS

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ABSTRACT

The study focuses on quality management of supplier through five key metrics and four steps supplier evaluation process. Supplier's selection as per the core competencies and work culture of the supplier organization should be matching with the requirement of the clients processes, products and services is the key for considering for the selection process and performances as per the service level agreement. Overall the company's performance, products and customer services quality are heavily depends upon these suppliers matching the product and service performances in the market and customer responses.

Based on the enormity of project size and life cycle of the construction industry Supplier Quality Management (SQM) is comparative complex in nature of different construction projects The supply chain through suppliers that backed these projects constantly is really wide and deep in nature that makes

distinctive challenges with management of a network of hundreds and even thousands of separate independent suppliers and subcontracting of supply also. It covers across the globe in same ways and constantly challenges to ensure that the projects needs like equipment, products, materials and manpower that delivered, perform and be more productive without any rework. The varied methods for SQM in the construction industry and also from other industries such as healthcare, manufacturing, services, food and restaurant etc. have been included for making it working, productive and successful. Further while doing so it is always better to recognize the methods and initiatives that could be valuable to the construction industry such as improving supplier partnerships, category captain management and product and service life cycle management etc. Also to determine how these methods may be modified as per the requirements of the construction industry. Management and Engineers are always facing challenge to improve SQM constantly within the limited available resources. By exploring an effective ways of SQM within and outside the construction industry, respective management, process owners, site engineer can leverage and apply these practices. This work includes probing and recognizing various practices for assuring the quality of supplier. These practices can be applied by engineering practitioners to improve the current management systems so that poor quality problems can be prevented. This study also summarizes the findings from the several literature of the varied methods of SQM in the construction industry with comparison of these methods from other sector like healthcare, manufacturing and food etc. The key objective to identify the most suitable methods may be beneficial to the construction industry beyond Safety Quality and Services (SQS) such as supplier partnerships, vertical integration, category

captain management and product life cycle management etc. with conclusion that how these ways might be best improved for the construction industry.

KEYWORDS

QMS, PMS, SMP, SQS, Supply Chain, Rework, Cost Quality and Delivery

1. Introduction

The construction enterprises comprises of the supply of amazing number of building items such as bulk materials and fabricated components etc. to a construction site and there designated stores where either they store or mounted in their final places. Each project has a unique project needs and sustained by an extensive supply chain involving multiple independent contractors, sub-contractors and suppliers. Due to involvement of number of establishments with their different level needs and complexity, it is always become difficult during the execution of the construction project to ensure that the essential equipment, products and materials are procured, produced, supplied and delivered to the project site without any delay and rework. This study defines conclusions from an ongoing research project and led by a cross functional team of academic researchers from Industrial and Civil Engineering and industry members on behalf of construction owners, contractors, and suppliers. The primary study is Supplier Quality (SQ) process, identifying effective SQM practices within and outside of the construction industry and supplier evaluation process and then determining how these SQM and evaluation performances would be utmost effective if incorporated into the SQ & evaluation process within the construction industry.

2. LITERATURE REVIEW

The best practices in SQM were obtained using both academic and industrial researches. Fletcher (1992) provides a range of reportedly successful supplier quality management practices of leading companies which involves supplier recognition/supplier certification, quality and process audits, and two-way relationship between buyer and supplier through training, communication and involvement in product development. Carter and Ellram (1994) investigated practices for improving SQ with empirical data from suppliers of machined parts for various industries and see quality improvement as two-dimensional approach that includes modification of product and implementation of process analyses techniques like SPC. Forker (1996) examined the results of a survey of 348 aerospace component manufacturers and found management leadership and quality policy, quality department, training, product/service design, supplier quality management, process management, quality data and reporting, and employee relations as factors that affect supplier quality performance. The results show that process management, transaction-specific investments and buyer–SR hold great promise.

Nwankwo and Aiyeku (2000) studied expert systems that can help organisations co-ordinate and connect potentially diverse sources of input resources in supplier quality management. González-Benito and Dale (2001) used empirical observations for the Spanish auto components industry in implementing supplier quality and reliability practices. They pointed out that suppliers more advanced in the use of quality practices achieve better operational performance in terms of quality, reliability, cost, flexibility and design. Rodriguez, Hemsworth, and Lorente (2005) analysed and classified quality management practices in purchasing

and assessed the relationships of these practices with a firm's purchasing operational performance (POP), internal customer satisfaction and business performance. Their study shows that a purchasing management, committed to quality, will place human resource initiatives at the top of its agenda and place a high priority on coordination with other functional areas, including the management of its suppliers.

3. RESEARCH METHODOLOGY

Articles were obtained from the ABI/Inform Global Proquest scholastic data set. The point of the survey was to catch a preview of the variety of exploration being directed in the SQM. As needs be, all of ABI/Inform Global Proquest's diaries were remembered for the hunt. An underlying watchword look for articles containing any of the provisions of the expression "Supplier Quality Management" (restricted to references and edited compositions of periodicals) uncovered that there were in excess of 10,000 articles present in the data set. The watchword search was consequently restricted to the specific expression. This search uncovered 3000 articles. Command over quality was accomplished by restricting the hunt to peer-surveyed distributions as it were. With this extra limitation, the number was diminished to 882. Preludes, publication notes, book surveys and meetings, notwithstanding any articles from magazines or industry distributions, were avoided from this set, leaving 614 usable articles. An exhaustive methodology would expect that each of the 614 articles be looked into. This was considered wasteful. All things being equal, factual strategies were utilized to produce an agent irregular example. To be 90% certain of being right to inside ^0.1 of the genuine extent, everything being equal, a base example size of 61 articles was required (Berenson and Levine, 1989, p. 327). This example was expanded to 100 to decrease the

likelihood of Type II blunder. Full bibliographic subtleties of the 100 articles chose for examination are displayed in the Appendix to make our exploration processes straightforward, and permit free evaluation of our grouping and investigation. Survey process and between rater dependability Eleven key aspects connecting with SCM conceptualization and exploration systemic issues were characterized, and every one of the articles were then ordered inside these aspects. The three writers, who all have reasonable and scholastic involvement with the area, went about as commentators and characterized dispensed parts of the example of articles. Measures were taken to guarantee an elevated degree of between rater dependability. Starter estimates included commentators ordering a few articles, and afterward contrasting these with guarantee agreement. After the arrangement cycle, the entire gathering talked about articles which individual analysts were unsure of, until understanding was reached. Order structure The 11 aspects along which the articles were dissected were incorporated into a structure what broke into four unmistakable, yet sensibly requested, groupings initiating with the most un-complex ideas and logically managing to all the more thoughtfully progressed research issues. Table I sums up the system. the order system is organized to empower an all encompassing applied and research strategic investigation of the field. In particular, gathering 1 gives an investigation of the example of articles utilized and analyzes patterns in the writing. Gathering 2 arranges the region covered by SCM from a scope of viewpoints utilizing either reason fabricated or existing grouping plans. Gathering 3 additionally orders the writing, however manages issues around hypothetical bases. At last, gathering 4 analyzes issues related with research strategy. While any grouping framework can be tested for levels of thoroughness, it was

felt that the broadness of viewpoints covered by the 11 aspects was satisfactory to foster a sound comprehension of SCM. Additionally, the arrangement classifications for a portion of the 11 aspects were a possible wellspring of dispute. To conquer this, where conceivable, existing reasonable and taxonomical structures that have been broadly utilized in comparable examination were utilized. For aspects where no current system was accessible, we fostered our own. The 11 components of the structure were intended to help with laying out a reasonable "view" from data sources to definitional matters, and afterward through to hypothetical worries and examination approaches utilized. Together, these cover applied and research systemic worries. The system, in this way, gives a technique to check to intelligent connections and associations with confirm consistency (or the deficiency in that department) among the different examination exercises inside SQM. The information created from assessment of the connections between the system's 11 components then, at that point, illuminate a meta-examination on the way of thinking of information in the SQM.

4.The Construction Industry and Supplier Quality Management

SQM and Evaluation process in the construction industry is complex due to the specific requirements and uniqueness of every project in terms of its scope of work and life cycle. Fig.1 depicts a high-level process map of the SQ process. The map contains five major processes beginning with Planning and Selection (of the Suppliers). Execution (of the Supplier Quality Plan) follows with subsequent processes depicting Release (Packages) from Shop, Received (Packages) at Site, and Mechanical Completion. Feedback loops are embedded at each step within the process, however, the feedback is often not systematic, and suppliers are informed of non-conformities

and deviations when these are identified. Additionally, suppliers' performance is usually evaluated and taken into account by procurement in future acquisitions. Details of this SQ process can be found in Alves et al. (2013).

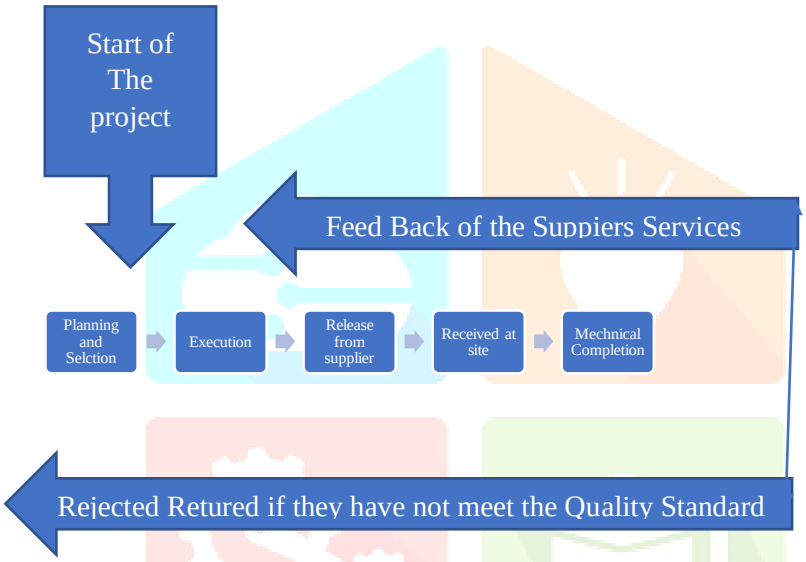


Fig.1 SQ Process Map

According to the study and scrutiny the typical nature of the construction industry as it relates to SQM has been observed. Based on the identical nature of construction industry the following important facts summarize from the findings from the review of literature of SQM with respect of the construction industry:

- The construction product supplies are extremely integrated and required the coordination management and collaboration of several independent small and firms /organizations hence quality cannot be incorporated and handled by the separate functions, departments and organizations but relatively it must be inbuilt designed through the entire system (Sullivan, 2011).
- Considering the construction projects are dynamic and extremely asymmetrical in nature, the systematic planning and execution planning useful from relying on having past on hand experiences and lessons-learned from those experiences. (Jongwoo, 2009).
- The ultimate role of the construction industry is to provide services, facilities, and delivery of scope of work as per

agreements which meet the needs of the customers' (Burati Jr., Mathews, & Kalidindi, 1992).

- The ability to produce a quality products and services in the construction process depends on the relationship management among the various parties involved for supply, delivery and completion of site work within a timeline (Burati Jr., Mathews, & Kalidindi, 1992).
- The major challenges of the construction industry is considered by the cost and duration overruns, serious problems in quality standards and safety measures, poor time and work management and an increased number of claims, counterclaims, and litigation due to these challenges. Moreover, the peculiarity of construction is that no two projects are identical in terms of site conditions, requirements of sites design, use of construction materials, labor and other skill set requirement requirements, plants, equipment and tools requirements, construction methods, technical complexity and level of varied management skill required." (Singh & Tiong, 2005, pg. 62).
- Due to lack of robust coordination and clarity of the supply and service delivery there are occurrence of higher cases of repeated rework disturb the sequence of works and schedule targets, wastage of materials and manpower, reduce productivity, increase cost & time period and affect quality(Rogge, Cogliser, Alaman, & McCormack, 2001). Altogether these factors makes construction management more complex and difficult.
- The major area in construction industry that extend inferior contributes to derail the organization and project overall performance is **rework** which happens all the time during the construction cycle of project and impact negatively on project

completion and overall delivery to the customers. (Love, 2002, Love & Sohal 2002).

5. Supplier Quality Management inside the Construction Industry

In order to addressing the primary concern of the construction industry, the relevant literature has been studied to learn more about supplier quality organizations, supplier quality systems, the role of management in SQM and assessment of supplier quality.

Areas with further details are as under:

Area	Details
Supplier Quality Organizations	Supplier quality organizations, Supplier quality personnel training
Supplier Quality Systems	Partnership decisions with suppliers, Supplier support, Supplier Quality Surveillance
Management's Role	Top management role in SQM
Supplier Quality Assessment	Challenges to effectively assess supplier quality

5.1 Supplier Quality Organizations

Construction companies understand the importance of documenting and implementing Quality Management Systems (QMSs) in their work. A study done by Lo (2002) ranks the benefits of QMS from a number of construction companies' perspective. The top five benefits of QMS according to the participating companies in the study are: increased business, reduced project cost, reduced rework and scrap, improved quality of work, and smoother business operations. The education

background and training of quality personnel is critical for any construction organization. One of the important considerations related to education and training for the quality function in organizations as determined by Arditi & Gunaydin (1997) is that the organization must determine the root causes of rework and then design training programs aimed at reducing or eliminating the causes. By having a complete understanding of their internal quality systems, organizations can better ensure successful external relationships with their contractors, suppliers and other stakeholders involved in any project. QMSs are important for all construction companies to manage their internal quality processes and to manage the quality of their suppliers.

5.2 Supplier Quality Systems

Arditi & Gunaydin (1998) study factors that affect process quality of building projects. They report that the capability to produce a quality product is highly dependent on the strength of the relationship among the parties involved in the construction process, in particular the relationship between the organization and supplier. Additional factors within the supplier quality system found in the literature focus on building supplier partnerships, providing support to suppliers, managing the supplier hierarchy and utilization of proper supplier quality tools.

5.2.1 Partnership with Suppliers

Peter (1987) recommends that organizations reduce their supplier base and develop mutually beneficial partnerships with their suppliers. Healthy supplier partnerships are important to succeed in the construction industry (Arditi & Gunaydin, 1998). Lazar (1997) describes the importance of building healthy partnerships between owners and contractors. Thomson, Crane, & Sanders (1996) identify that the organization should establish a collaborative relationship with a “preferred” supplier, especially when this relationship will span multiple construction

projects over a long period of time. Working together in a cooperative environment under mutual goals of successful project completion avoids future problems of dissatisfactions, claims, and litigations. However, partnership disadvantages may include: ineffective cooperation due to conflicting objectives and lack of trust between the organization and supplier. Also, the organization could face difficulties in setting performance measures of the partnership effectiveness. When left unchecked these disadvantages may lead the organization to fulfill a long term commitment with a possibly inadequate supplier. Crane & Felder (1999) state that the partnering process should include partnering objectives and measures. Partnering objectives are strategic criteria for the entire relationship, and partnering measures are management tools to ensure progress toward objectives and desired results. If a partnership involves conflicting goals and lack of trust, it will not achieve effective results. Harper & Bernold (2005) investigate a number of companies in the capital project market and identify what they describe as the key barriers to supplier partnership. These barriers are: conflicting goals that prevent common vision and a win-win working relationship; and resistance to change by the organization and supplier that affect the improvement of their relationship. Tommelein et al. (2003) examine the construction supply chain and identify examples of partnerships between owners, suppliers, and contractors aiming at improving product quality, delivery lead times, reliability of delivery, and reduced levels of inventory to meet demand. Some of these partnerships require early supplier involvement in product design and fabrication, vendor management of site inventories, definition of preferred supplier agreements, and constant assessment of supplier performance and feedback.

5.2.2 Supplier Support

Needy and Ries (2010) study organizations with effective quality management systems. They conclude that successful construction organizations are proactive concerning their suppliers' QMS and develop their suppliers through training. These construction organizations offer their QMS to be used by the supplier organizations for completing project quality objectives in the absence of a supplier QMS.

5.2.3 Supplier Quality Surveillance

One of the challenging tasks for any construction project is to ensure supplier quality, especially if there are multiple tiers of suppliers. Supplier quality surveillance (SQS) is one of the common methods used to ensure supplier quality. This method has both advantages and disadvantages. Singer, Churchill, & Dale (1989) in their study of the construction projects of nuclear power stations, analyze surveillance as a method to ensure supplier quality and cite making the supplier accountable for quality and preventing construction delays to be important advantages of this method. However their research indicates that the surveillance method may lead to unexpected errors unless the supplier is closely supervised. Also, communication can be a challenge when there are many tiers of suppliers involved in the project. They conclude that despite it being difficult to estimate the required degree of surveillance needed in a project, this process can be effective in producing quality results when properly implemented. Other methods may be found in the literature for ensuring supplier quality, such as partnership with suppliers (as mentioned earlier in this paper), and supplier support and development training (Tommelein et al., 2003). Organizations should identify the pros and cons of each method before implementation to avoid any future problems of rework. In general, any chosen method to ensure

supplier quality requires consistent feedback between the parties involved, as well as clear objectives and technical specifications.

5.3 Management's Role

Lo (2002) identifies a number of difficulties with properly implementing a QMS such as: lack of involvement from top management, and inconsistency in inspection procedures. Research conducted by Needy and Ries (2010) finds that effective quality management in the capital facilities delivery industry requires:

1. Consistent and demonstrable management commitment.
2. Capable and consistent quality management processes.
3. Integrating and aligning quality management and project execution processes.
4. Providing frequent and relevant quality management training opportunities for employees in order to maintain the required level of competence.
5. Cultivating partnerships with suppliers and contractors across the project life.
6. Establishing, communicating and using quality metrics across the project life cycle.

These findings highlight the importance of management commitment to quality objectives in current and future projects.

5.4 Supplier Quality Assessment

Harper & Bernold (2005) rank the top five performance measures to assess supplier performance, based on surveying a number of contractors. The top five performance measures that arose from this survey are: quality of work, delivery delays, past working relationships, cost competitiveness, and technological capability. Supplier quality assessment may involve several challenges. Songhori et al (2011) identify that globalization has brought several challenges to designing an effective supplier selection strategy and selecting the right suppliers which are to become part of the organization's supply chain. The authors,

Songhori et al (2011), conclude that effective supplier selection and evaluation processes can directly impact the supply chain performance, resulting in improved outcomes to the organizations. Risk management is a major component of project management due to the complex, dynamic, and difficult nature of construction projects. Consequently, supplier selection and assessment is also part of managing risks in construction projects. According to Isik et al. (2010), risk in a construction project is unavoidable and significantly affects the project performance, quality, and budget. However, risk can be minimized by proper risk management to reduce its undesirable affects. Ford et al. (2005) identify that many managers are more concerned with making quick fixes to current problems rather than implementing long-term solutions for improving organizational performance. Top management must mitigate the risks associated with myopic and short-term solutions and commit to decisions resulting in long-term benefits for the organization.

6. Supplier Quality Outside the Construction Industry

After examination of supplier quality management practices from diverse industries outside the construction industry to identify relevant practices which may be able to be adapted and successfully applied to the construction industry. These practices are also linked to the process presented to indicate where they could be applied in the construction industry SQM process.

The Examined Industry	The Chosen Practice	Location within SQ Process Map	Comments
Healthcare	Suppliers partnership	1. Planning and Selection of Suppliers	The supplier (partner) should have high qualifications
Healthcare	Category Captain Management (CCM)	1. Planning and Selection of Suppliers	The level of package criticality is low
Manufacturing Quality Management's Role in Global Sourcing	Evaluate cultural barriers	1. Planning and Selection of Suppliers	Part of the supplier qualification assessment
Electronic Systems and Equipment Manufacturing	Quality focus (versus price or schedule) in the selection of suppliers	1. Planning and Selection of Suppliers	Part of the supplier qualification assessment
Multiple industries	Vertical integration	2. Execution of the Supplier Quality Plan	A clear integration with appropriate information access should be defined
Electronic Systems and Equipment Manufacturing	Regular performance feedback to the firm's	2. Execution of the Supplier Quality Plan	Observe and document the supplier work. Types of documents

	suppliers (monthly and yearly solicitations to suppliers to rate their conduct as business partners)		may involve: Nonconformance Report (NCR), & Corrective Action Report (CAR)
Aerospace Industry: Boeing®	Supplier quality surveillance (SQS)	2. Execution of the Supplier Quality Plan & 3.1. Release Packages from Suppliers' Shops	Similarities with the construction industry, i.e., product is fixed, bulky, expensive, thousands of parts
Food Industry: Starbucks®	Supplier management system (alliance, training and support)	1. Planning and Selection of Suppliers & 2. Execution of the Supplier	Quality Plan Part of the supplier qualification assessment and development
Food Industry: Chipotle®	Long-term relationship with suppliers	1. Planning and Selection of Suppliers & 2. Execution of the Supplier Quality Plan	Develop mutually beneficial long-term relationships with reliable suppliers
Shipbuilding Industry: Siemens	Product life cycle managem	2. Execution of the Supplier	

PLM Software®	ent platform	Quality Plan, 3.1. Release Packages from Supplier's' Shops, 3.2. Receive Packages at Site, & 3.3. Mechanical Completion	

Table.1 Suggested Practices from Other Industries

6.1 Healthcare Suppliers Partnership & Category Captain Management

Equipment supplied to hospitals may include bulk materials containing sophisticated components that may be installed inside the hospital. Trombetta (2007a) reports findings from a study indicating that supplies represent the second highest expense for hospitals after labor cost. This study goes on to report that a common practice for healthcare manufacturers and suppliers to hospitals is to send representatives to hospitals to meet with representatives of hospitals' purchasing departments. A modified approach is to establish a partnership between hospitals and suppliers, thereby becoming a value-added partner, contributing to the customer's (hospital) efficiency and profitability. Trombetta (2007b) proposes the Category Captain Management (CCM) method to define the supplier/manufacturer as a true, legitimate business partner with the buyer. Desroches, Gundlach, & Foer (2003) define CCM as an arrangement where a supplier, often the category (product type) leader, takes on a significant role in the management of the category, including brands of competitors. CCM is widely used in the health and

pharmaceutical industries, especially when the product uniqueness is not significantly important. In other words, if the hospital/pharmacy products do not have unique features among the other competitors, the CCM approach is usually applied. The key organizational principle for the CCM as determined by Trombetta (2007b) is to develop a strong relationship in which the supplier takes the effort to know how to operate the buyer's (hospital/pharmacy) business and to effectively face any coming challenges.

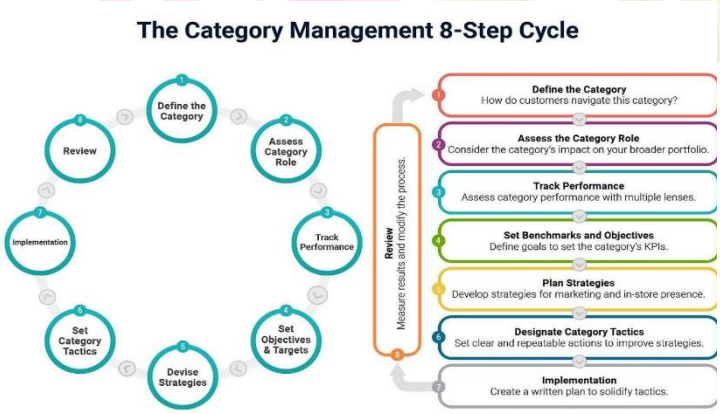


Fig.2 Category Management Cycle

6.2 Manufacturing Quality Management's Role in Global Sourcing

Most of the items/raw materials delivered to manufacturing sites are large in number and from various suppliers and sub-suppliers from different locations globally. Watkins (2005) observed various manufacturing companies from across the world and has developed a collection of observations and recommendations for assessing the operational management of a supplier as shown below:

- ❖ Assess the overall capabilities and limitations of a supplier, such as performance metrics, financial metrics, and certifications.
- ❖ Describe the effectiveness of the management system based on clear objectives.
- ❖ Conduct a detailed review of current and historical concerns. The review may include assessing what the organization considers normal vs. unexpected failure.
- ❖ Evaluate approaches to operational planning, with particular focus on manufacturing product and process metrics and the use of superior quality

planning, and methods to protective actions. The article suggests the following practices for quality management:

- Potential suppliers should be assessed carefully by identifying and evaluating cultural barriers, technical capabilities, as well as financial resources.
- Analyze the end user (customer) satisfaction measures by surveys or performance benchmarking.
- The supplier personnel capabilities must be assessed to determine if they will be adaptive to the customer requirements.

6.3 Electronic Systems and Equipment Manufacturing

Electronics manufacturing often involves several suppliers and sub-suppliers in the supply chain. This process is further complicated when these suppliers are global. Forker & Hershauer (2000) conducted a study that examines the effect of suppliers' internal quality management practices and buyers' supplier development practices on customer satisfaction, supplier satisfaction, and supplier quality performance. The authors survey the population of direct materials suppliers for a common customer manufacturer of electronic systems and equipment. The sample size was 181 pairs of matched survey replies from both buyers and suppliers. Recommendations from the study include:

- Regular performance feedback to the firm's suppliers, also monthly and yearly solicitations to suppliers to rate its conduct as a business partner.
- Quality focus (versus price or schedule) in the selection of suppliers.
- Trust of a few loyal suppliers.
- Involvement in the suppliers' product development process.
- Extension of long-term contracts to the suppliers by the customer.

❖ Clarity of specifications provided to suppliers.

The authors concluded that clarity, transparency, and control of quality management and supplier development programs are the key factors that lead to mutual satisfaction between buyers and suppliers.

6.4 Vertical Integration

Vertical integration is a merger of firms at diverse stages of production and/or distribution in the same industry. There are multiple types of vertical integrations the company can undertake. Backward integration occurs when the company acquires its input supplier, while forward integration involves acquiring companies within the distribution chain (Business Dictionary, 2012). Weiss (1998) summarizes key aspects of supplier quality in multiple types of industries. One of the important aspects is to define a clear integration with the chosen suppliers, in which the supplier has access to the customer's product information, designs, and delivery requirements. Also, the customer should have access to the supplier's manufacturing facilities and should be aware of the supplier's capabilities. The author indicated that there must be a supplier site audit to assess the quality of the supplier's performance, prior to selecting a supplier. The audit may include the examination of the production processes, or experience of the technical staff. Weiss indicates that reducing the number of suppliers and purchasing the same type of parts/materials from one supplier are key requirement of the supplier quality management. Srinivasan & Brush (2006) study the supplier performance in vertical alliances. The authors report that the advantages of vertical integration, with respect to cost and quality, can be obtained if the supplier shares information regarding production parameters and undertakes innovative efforts for the benefit of the buyer.

6.5 Aerospace Industry: Boeing

High quality standards are critical within the Aerospace industry due to the important safety regulations, and high consequences for failure resulting in potential litigations. As one of the world's largest aerospace manufacturers, Boeing is a company to examine. At Boeing, suppliers are managed throughout the product life cycle. Successful partnership with their suppliers through a supplier quality surveillance (SQS) system builds a proactive approach to improve suppliers' quality. Boeing's SQS tools include: Product Assessment (PA), Quality Process Assessment (QPA), and Manufacturing Process Assessment (MPA) (Boeing supplier Quality surveillance, 2012). SQS activities are executed by supplier quality representatives from Boeing, and are conducted at the supplier's facility or the supplier subcontractor's facility under the agreed provisions that address Boeing's right of surveillance and review of goods, procedures, and practices (Boeing supplier Quality surveillance, 2012). Prior to Boeing performing its own assessment, the following actions have to be performed by the supplier in advance:

- Review the checklist(s) prior to the on-site visit by the Boeing supplier quality representative
- Provide admission to the applicable process documentations, and training records Prepare the relative process performance data for the processes under assessment
- Inform knowledgeable personnel to be available during assessment, and
- Provide contact information for the local regulatory agency representative when requested (Boeing SQS Supplier Presentation, 2010). The major benefits of this system are:
- Support monitoring the suppliers without hindering the production process, and help improving the supplier's procedures.

- ❖ Provide information regarding the supplier's processes to the supplier, Boeing, and the other parties involved including Boeing's customers and regulatory agencies (Boeing SQS Supplier Presentation, 2010).

6.6 Shipbuilding Industry: Siemens PLM Software

Ensuring high quality in the shipbuilding industry is critical, and challenging to achieve given the product complexity, high degree of customization and stringent safety requirements. Like the construction industry, the ship building industry depends on a global supply chain of partners and suppliers to help develop and manufacture new ships. Proper communication and information exchange between the primary parties during the product life cycle is important to avoid missing any valuable information that may impact the quality of the final product. One successful example of a technological tool is Siemens PLM Software® which is a leading product lifecycle management (PLM) platform for the shipbuilding industry (Siemens PLM software, 2013). The purpose of this software/platform is to minimize miscommunication and rework complexities. This is particularly important to facilitate collaboration among all partners and suppliers in the shipbuilding supply chain. The idea behind the software is to create an integrated and synchronized environment linking designers, production team, and suppliers to improve the shipbuilding productivity (SIEMENS, 2012).

The benefits of creating a common platform among the involved parties in shipbuilding are:

- ○ Enabling companies to securely share the relative project information with partners and suppliers.

- Updating partners and suppliers with any changes.
- Providing access to the production technical information.

6.7 Food Industry: Starbucks

Ensuring the quality of the supplied coffee beans for Starbucks requires a supplier management system. Austin & Reavis (2004) identify that specialty coffee comes from mid-sized farms (suppliers), and farm owners don't have sufficient business and communication skills to provide coffee beans within the quality standards for Starbucks. So, Starbucks conducted an alliance with Conservation International, a non-profit organization, to provide training and support to farmers in order to maintain the quality and environmental standards of coffee tree growing and production. In addition, farmer (the supplier) selection includes several criteria to be met in order to become a preferred coffee supplier with priority for future purchasing. As a result, Starbucks maintains the reputation of providing high quality coffee and social responsibility through its supplier management system. As described by Austin & Reavis (2004), Starbuck's preferred supplier criteria uses a point system as follows:

- Environmental impact: soil management, water reduction, clean water, use of shade, waste management (Scale of 50 points)
- Social conditions: health and safety, living conditions (Scale 30 points)
- Economic issues: long terms relationships, economic transparency throughout the supply chain (Scale 30 points).

6.8 Restaurant Industry: Chipotle

The supplied materials (food) should have high quality standards to ensure the final product (meals) offered to the customers meet their standards. The competition in the restaurant industry forces many restaurants to focus on the quality of the supplied food and define new concepts for their supplier

management practices. Chipotle's 2012 annual report suggests the following practices for supplier quality:

- **Supplier Relationship**: Chipotle works closely with its suppliers to make sure that it sources consistent and low-cost inputs from sustainable sources." We have established close relationships with some of the top suppliers in the industry, and we actively maintain a limited list of approved suppliers from whom our distributors must purchase." (Chipotle, 2012, pg. 5).
- **Supply chain:** "Maintaining the high levels of quality we expect in our restaurants depends in part on our ability to acquire high-quality, fresh ingredients and other necessary supplies that meet our specifications from reliable suppliers. Our distribution centers purchase from various suppliers we carefully select based on quality and their understanding of our mission, and we seek to develop mutually beneficial long-term relationships with suppliers." (Chipotle, 2012, pg. 6).

7. Supplier Selection Management

The Purchase function is expected to lead the process of assessing the competitive offers and selecting the supplier for any particular contract or job. The methods used for selection are some of the most important elements of the purchase professional's skill set.

The supplier is the fundamental resource employed by the organization to meet its seasonal or perennial requirements. If select is not correctly done, there will never be achieved satisfactory results.

Therefore, proper supplier selection, despite requiring a strong measure of distinctly human insight, must be performed systematically and to the most objective criteria and needs of the products and services.

Hence following stage to be adhered while selecting the suppliers:

7.1 Evaluating Offers

Before selecting an offer, every buyer should employ some process of evaluation to ensure adequate consideration that all aspects of the organization's needs are being covered and optimized.

Evaluating a supplier's offer includes not only evaluating its bit but also checking out the supplier's ability to perform to the required level of speed and quality. Evaluate offers in terms of both: potential risk and benefits. Try to assess three key criteria before reaching a decision to award the contract to a specific supplier: **responsiveness, capability and competitive value.**

7.2 Operational Capacity Analysis

One of the primary considerations in award determination will be the supplier's physical capacity to meet your needs as promised. Obviously, you don't want to select a supplier that could have difficulty meeting the required volume due to capacity constraints or conflicts with the scheduling of other jobs. A simple ratio of current output to capacity can provide a valuable indication of this ability.

Another good idea is to ensure that the potential supplier has the ability to properly schedule orders and keep track of current production operations to meet its customer's commitments. Be able to benchmark all these criteria through the customer references the supplier provides.

7.3 Technical Capability Determination

Another important key capability to be evaluated is the supplier's technology and technical ability. Make sure that your potential supplier has all the necessary equipment, tools, and talent to meet your requirements. You can determine this

through historical performance records and active participation in industry events.

Check how many patents the company holds in comparison to its competition. Examine how often does it lead the market with the introduction of new products and to what extent it is funding its research and development efforts. Don't forget to consider all the necessary licenses, insurance, and supplier certifications.

7.4 Financial Analysis

Recently, financial performance analysis has become increasingly important among most CEOs and CFOs. Financial analysis helps to assess overall supply base risk factors and is often required in order to meet audit compliance requirements. Financial ratios help select and qualify suppliers on the basis of their financial strength, leverage and competitive advantage.

To properly evaluate individual financial ratios, it is crucial that they are viewed with respect to the historical performance of the supplier or the ratios of similar firms in the industry. It's also a good idea to periodically view financial trends.

Effective sourcing management begins with establishing the proper initial selection criteria and ensuring that the right supplier gets chosen.

It often happens that inadequate preparation and effort go into this process with predictably disastrous results: the wrong supplier was chosen or unsatisfactory supplier performance. That's why you should clearly understand the methods available in supplier selection and employ them professionally.

8. Key Factors while Conducting a Supplier Evaluation

Although successful selection process is very important fundamental aspect of supplier performances and continue a supplier. While supplier evaluation can be based on a number

of factors, there are several considerations that every company should address, regardless of the specific industry and their nature work or contract. Some of these elements include:

8.1 Production Capacity

All supplier evaluations should thoroughly appraise the supplier's abilities and limitations. A supplier that cannot scale production in response to the production cycles of the function and organization will not fare well in any review.

8.2 Quality

While it can be difficult to quantify the quality of a product, this should always be a central component of a supplier evaluation. ISO BS/EN ISO 9001:2000 certification remains the industry standard which indicates that the supplier excels in management responsibility, resource management, product realization, and measurement, analysis, and improvement.

Many company adopt to "Just-in-Time" (JIT) Inventory process to reduce the cost of ''waste". Supplier need to make the delivery on-time based on company request. Supplier that perform excellent delivery ability can provide additional value to the company by reduce the risks of material running out, saving on unnecessary transportation costs, reduce the need to storage and cost inventory related cost. Hence, Quality, Cost, and Delivery (QCD) are the most important criteria in construction industry is material quality, delivery dependability, and cost. The most important factor of supplier selection should be the quality level of the procurement items. Product quality should consistently meet specified requirements since it can directly affect the quality of the finished goods. Not only product quality reliability, supplier characteristics like delivery lead time shall be consider carefully.

Unit price should not be the only criteria in supplier evaluation. Total cost of ownership

is an important factor. Total cost of ownership includes the unit price of the material, payment terms, cash discount, ordering and carrying cost, logistics and maintenance costs, and other more qualitative costs that may not be easy to assess.

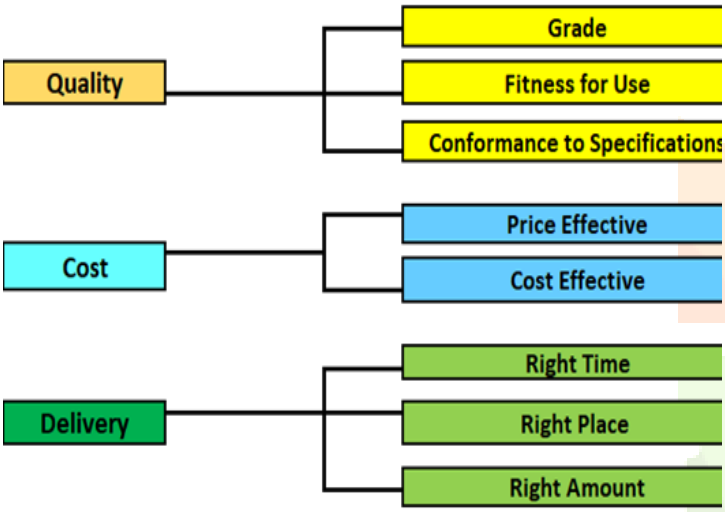


Fig. 3 Quality, Cost and Delivery

8.3 Performance

A company should ask as many questions as needed to determine whether a supplier can handle your typical functions. Previous experiences with similar companies, relevant recent projects, and possible advances on current products or processes are all valid subjects for discussion.

8.4 Risk

Every business invariably confronts some risks, but its suppliers should actively work to minimize them throughout the supply chain. Reviewing performance metrics such as overall delays, average response time, and corrective actions can help you develop a reliable quantitative assessment of the risks posed by a particular supplier.

8.5 Environmental Impact

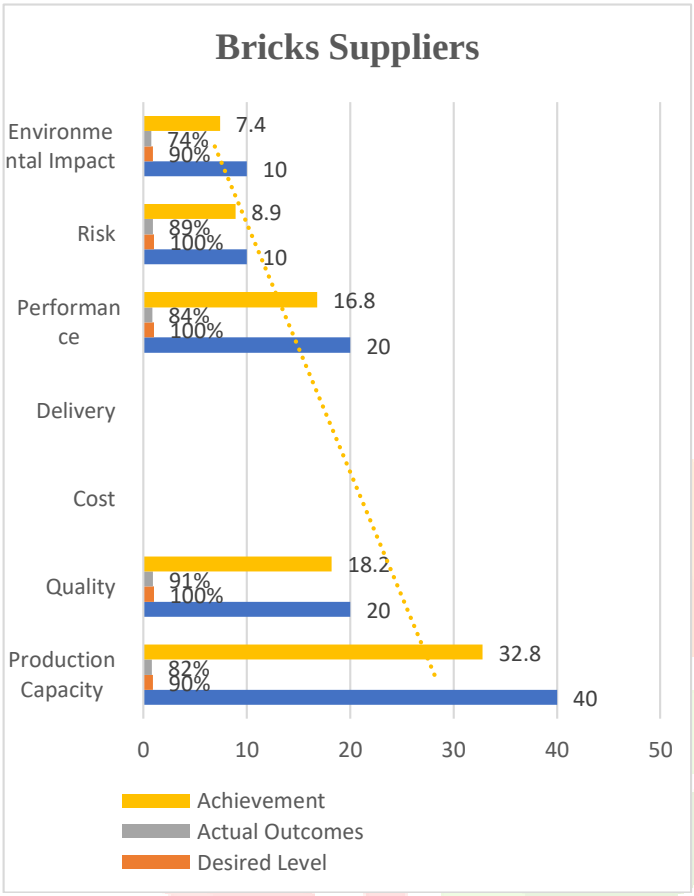
Sustainability is an essential element of a successful business for both financial and ethical reasons. An evaluation should cover a supplier's waste management strategies, waste reduction practices, and material procurement procedures, as well as efforts to achieve energy efficiency and any protocols employed when handling harmful materials.

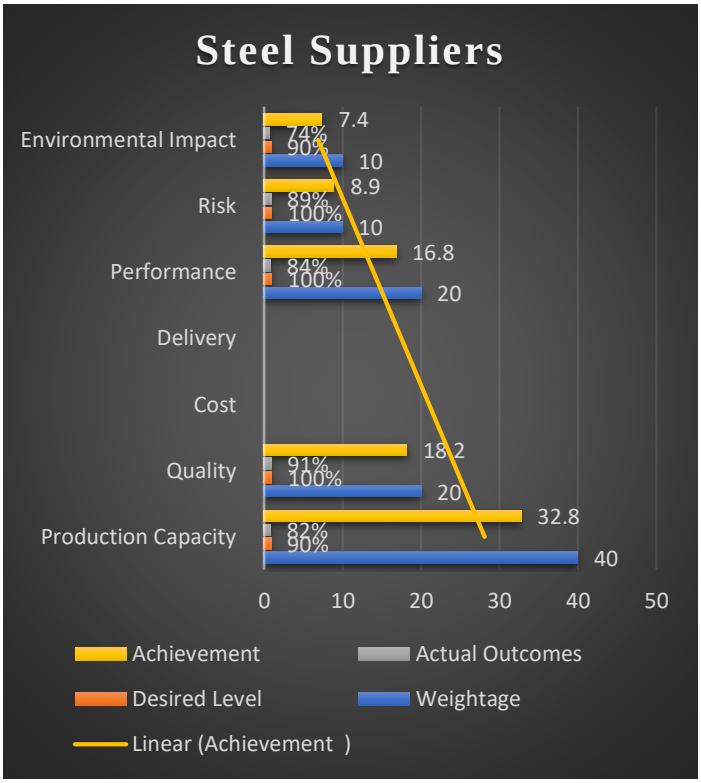
Based on the evaluation criteria following weightage and targets may be fixed for the supplier's evaluation in construction industries:

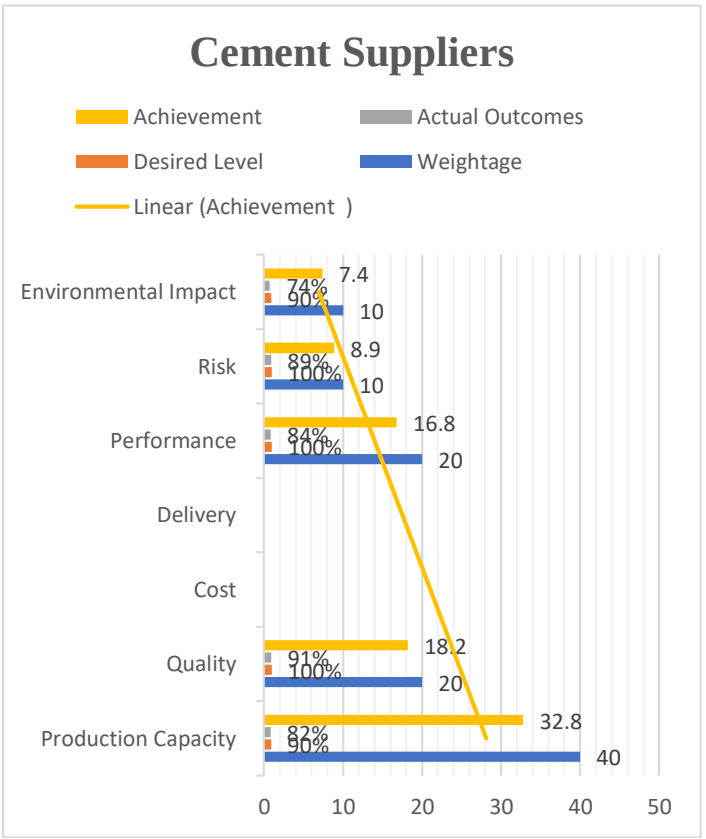
Evaluation Criteria	Weightage	Level	Outcomes
Production Capacity	40	95 %	
Quality	20	100 %	
Cost			
Delivery			
Performance	20	100 %	
Risk	10	100 %	
Environmental Impact	10	100 %	

Table.2 Supplier Evaluation Criteria and Weightage

Based on above matrix outcome of construction suppliers performance outcomes are as under:







9. CONCLUSION AND SUGGESTIONS

The construction industry consists of diverse projects that use different types of supplied bulk materials and equipment that have to be fabricated and delivered to the project site with high level of quality. Supplier quality management in the construction industry is challenging due to project diversity in terms of size and life cycle, and the supply chain being both broad and deep. This paper examines supplier quality in the construction industry and suggests some efficient practices of supplier quality management outside the construction industry, such as manufacturing, aerospace, and food industries. The objective is to recognize methods that can be useful to the construction industry such as supplier partnerships, vertical integration, category captain management, and product life cycle management, and determine how these methods can be implemented in the construction industry. The primary lessons learned from this paper with regard to improving supplier quality are:

- ✓ Close relationship (partnership) with suppliers.
- ✓ Involvement of fewer, dependable suppliers.
- ✓ Feedback system between the buyer and supplier with supplier improvement opportunities based on measurable objectives.
- ✓ Careful supplier selection process focusing on quality aspects.

The approach used in this research is to study what other industries were doing outside of the construction industry and adopt their best practices. It is desirable to incorporate these practices onto the developed Supplier Quality Process map.

So far, we have found that the documented process in the construction industry is quite similar to those that we have studied outside of the construction industry. This raises the question, what is different? Why is the SQS model so persistent in construction, even when it has largely been replaced outside the construction industry? Thoughts are that complexity may be greater in the construction industry, and perhaps the implementation of many of these practices may be different in nature. Hence while adopting such changes the requirements of different construction industry must be in consideration and change in overall selection and evaluation processes of the suppliers should be customized as per respective construction site and project requirements.

10. ABBREVIATIONS

SQM	Supplier Quality Management
SQS	Safety Quality Services
QMSs	Quality Management Systems
NCR	Nonconformance Report
CAR	Corrective Action Report
CCM	Category Captain Management
SQS	Supplier Quality Surveillance
PA	Product Assessment
QPA	Quality Process Assessment
MPA	Manufacturing Process Assessment
PLM	Product Lifecycle Management
QCD	Quality Cost and Delivery

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