QUALITY MANAGEMENT ORGANIZATIONS AND TECHNIQUES

By James L. Burati Jr.,[1] Member, ASCE, Michael F. Matthews,[2] and Satyanarayana N. Kalidindi,[3] Student Members, ASCE

ABSTRACT: To address quality problems and associated costs, the construction industry must pursue and implement innovative quality management organization and techniques. The need for quality management in the construction industry is discussed in the initial sections. Customer satisfaction and continuous improvement, which are the fundamental goals of total quality management (TQM) and thereby the principles on which it is based, are then discussed. Customers can be either external or internal. Internal customers must be satisfied if the final external customer is to be satisfied. Seven fundamental elements that form the framework that support TQM principles are presented. They include: management commitment and leadership, training, teamwork, statistical methods, cost of quality, supplier involvement, and customer service. Commitment and leadership from top management is essential to TQM implementation. The process for implementing TQM in an organization is discussed. Finally, some of the problems related to implementing TQM in the construction industry, such as the transient work force and the competitive bidding environment, are discussed, along with possible solutions.

INTRODUCTION

Increasing numbers of professionals, researchers, professional societies, and publications associated with the U.S. construction industry have, in recent years, expressed great concern over the problems facing the industry. These various participants in the construction process are calling for massive reforms in an industry that is known for its unwillingness, or perhaps inability, to change ("Japanese Bring" 1988; *Quality* 1988; Paulson 1988; Peters 1987; Tatum 1988; Tucker 1988; Wiggins 1988). However, the industry now has no choice; it must change. Some experts predict that, unless steps are taken immediately, the industry may suffer the same fate as the U.S. automobile, textile, electronic, and steel industries (Flanagan 1988; "Japanese Bring" 1988; Paulson 1988).

U.S. construction is not the first industry to be forced to confront its problems. Other industries, both foreign and domestic, have faced remarkably similar dilemmas and succeeded in transforming their cultures and rectifying their situation. The Japanese manufacturing industry after World War II, the Japanese construction industry during the 1970s, the U.S. manufacturing industry during the 1980s, and more recently the European manufacturing and U.S. service industries all required drastic changes to improve. Their vehicle for initiating change was, and still is, a management style that fosters innovation and teamwork while focusing on continuous process improvement and long-range planning. The experiences of other industries provide construction with a pool of proven strategies for improvement.

[1]Prof., Civ. Engrg. Dept., Clemson Univ., Clemson, SC 29634-0911.
[2]Grad. Res. Asst., Civ. Engrg. Dept., Clemson Univ., Clemson, SC.
[3]Grad. Res. Asst., Civ. Engrg. Dept., Clemson Univ., Clemson, SC.

Note. Discussion open until August 1, 1992. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on January 10, 1990. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 118, No. 1, March, 1992. ©ASCE, ISSN 0733-9364/92/0001-0112/$1.00 + $.15 per page. Paper No. 26576.

Objective

The purpose of this paper is to present the basic principles and essential elements of total quality management (TQM) in construction terms, to demonstrate their applicability to the construction industry, and to outline the implementation of the TQM process. The information presented is a compilation of ideas adapted from an extensive range of material dealing with quality management.

Total Quality Management

Total quality management is a company-wide effort that involves everyone in the organization in the effort to improve performance. It permeates every aspect of a company and makes quality a strategic objective. TQM is achieved through an integrated effort among personnel at all levels to increase customer satisfaction by continuously improving performance. TQM focuses on process improvement, customer and supplier involvement, teamwork, and training and education in an effort to achieve customer satisfaction, cost effectiveness, and defect-free work. TQM provides the culture and climate essential for innovation and for construction technology advancement.

TQM is an effective, comprehensive management technique that has proven successful both overseas and in the United States, in manufacturing and service. Japanese construction companies, benefiting from the experiences of Japanese manufacturers, began implementing TQM during the 1970s. Even though construction is a creative, one-time process, the Japanese construction industry embraced the TQM concepts that some argued could only apply to mass production. Since the mid-1970s, three Japanese contractors have been awarded the coveted Deming Prize for quality improvement (Deming 1986). Recent research indicates that TQM is being effectively applied by both owners and contractors in the U.S. private construction arena (Matthews and Burati 1989).

Principles of TQM

Customer satisfaction and continuous improvement are the fundamental goals of TQM and are thereby the principles on which it is based. All efforts undertaken in TQM are directed to satisfy the customer by continuously improving the methods and procedures that govern the work.

Customer Satisfaction

The function of the construction industry is to provide customers with facilities that meet their needs. For a company to remain in business this service must be provided at a competitive cost. TQM is a management philosophy that effectively determines the needs of the customer and provides the framework, environment, and culture for meeting those needs at the lowest possible cost. By ensuring quality at each stage in the construction process, and thereby minimizing costly rework, the quality of the final product should satisfy the final customer.

A strong customer orientation is made possible by using the "market-in" concept, which recognizes that each work process consists of stages. There is a product, market, and customer for each stage. During each process

J. Constr. Eng. Manage., 1992, 118(1): 112-128

stage, customer feedback is obtained to determine what changes should be made to better meet the customer's needs.

Customers may be either internal or external. External customers are not part of the company producing the product or service. For example, for engineering the products are plans and specifications, and the customers are the owner and the construction organization responsible for the construction. For construction, the product is the completed facility, and the customer is the final user of the facility.

There are also customers within the construction organization. These internal customers receive products and information from other groups or individuals within their organization. Satisfying the needs of these internal customers is an essential part of the process of supplying the final external customer with a quality product. For example, for a carpenter preparing formwork, the final external customer may be the owner, but the primary (internal) customer is the crew that will use the forms when placing the concrete. This is the customer that the carpenter must seek to satisfy, by determining the placing crew's needs and expectations with regard to the forms.

Every party in a process has three roles: supplier, processor, and customer. Juran (1988) defines this as the "triple role" concept. These three roles are carried out at every level of the construction process—corporate, division, department, and individual. This concept is illustrated in Fig. 1. The designer is a customer of the owner. The former processes the design and supplies plans and specifications to the constructor. The constructor is the designer's customer, who uses the designer's plans and specifications, processes the construction, and supplies the completed facility to the owner. The owner supplies the requirements to the designer, receives the facility from the constructor, and processes the facility's operation. The roles of the three parties have not traditionally been viewed this way, but this clearly illustrates that construction is a process, and that TQM principles that have been applied to other processes are potentially adaptable to the construction industry.

Continuous Improvement

In the words of Tom Peters, "Excellent firms don't believe in excellence—only in constant improvement and constant change" (Peters 1987). It is management's responsibility to instill these beliefs in a company. Under TQM, management has two functions: (1) To maintain and incrementally improve current methods and procedures through process control; and (2) to direct efforts to achieve, through innovation, major technological advances in construction processes (Imai 1986).

The incremental improvement and maintenance functions are achieved through process improvement and control. In every construction organization there are processes by which all work is accomplished. Similarly, there are innumerable parts to the construction process. Through the use of flow diagrams, every process—whether it be the placing of concrete or the development of welding procedures—can be broken down into stages where work flows in, changes state, and moves on to the next stage. Within each stage, input changes to output, and the methods and procedures directing the change of state (i.e., the construction procedures) can be constantly improved to better satisfy the customer at the next stage. During each stage the employees communicate closely with their supplier and customer to optimize the work process for that stage. This requires each em-

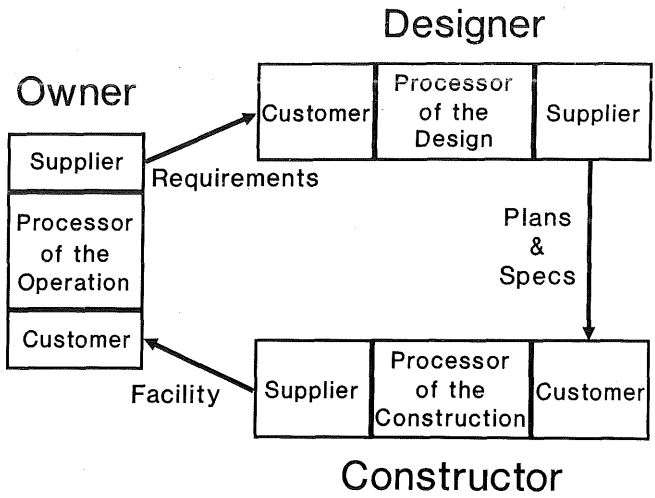

FIG. 1. Juran's Triple Role Concept Applied to Construction

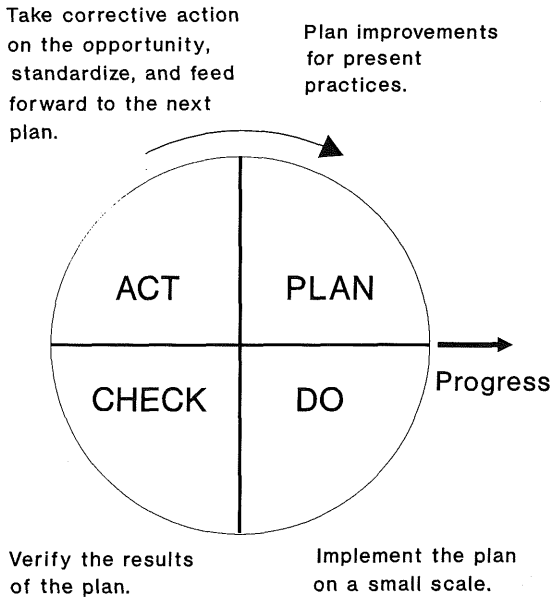

FIG. 2. PDCA Cycle (Deming 1986; Imai 1986)

ployee (foreman, carpenter, etc.) to recognize his or her place in the process and their respective supplier and customer.

Deming's plan-do-check-act (PDCA) cycle, shown in Fig. 2, symbolizes problem analysis steps for narrowing the gap between customer needs and present performance (Scherkenbach 1988). It is a systematic procedure for incrementally improving methods and procedures by focusing on correcting and preventing defects. This is accomplished by removing the root causes of problems and continually establishing and revising new standards. Improving the process and thereby avoiding defects is usually less costly than the typical construction approach of attempting after the fact to "inspect out" defects.

The second primary function of management under TQM is to support the advancement of technology and management techniques. Through innovation, major shifts in present levels of construction performance can be achieved. An example of a major shift in technology might be the use of concrete pumps rather than a crane and bucket, or the use of a laser-controlled screed. The construction industry has always been concerned with process improvement. The driving force in the past has been cost reduction. By adopting a TQM philosophy, the construction industry has the opportunity to acknowledge that improved quality performance leads to reduced costs.

Once established, these new levels of performance must be maintained by the PDCA cycle in order to prevent deterioration. Without any effort to stabilize and upgrade the newly established system, its decline is inevitable (Imai 1986). The relationship between incremental improvements, maintenance, and innovation is illustrated in Fig. 3.

Elements of TQM

Management Commitment and Leadership

TQM is not another management program to be replaced when the next "new" management technique is developed. It is a culture and philosophy that must permeate an organization as *the* method of management. It can thrive only under a senior management that is genuinely concerned with the long-term health of the company and that establishes TQM as a top priority. This commitment must be coupled with a thorough understanding of TQM that will enable senior management to lead the company in a quality revolution. Supported by commitment and understanding, senior management can personally establish new goals and directions for the company and then lead the management team toward the realization of those goals and directions.

The first step for management is to recognize that there is a problem. Deming's statement that "it would be a mistake to export American management to a friendly country" is a sad commentary on the present state of management in the United States (Deming 1986). Construction industry management cannot be excluded from his proclamation. The Business Roundtable construction industry cost effectiveness study concluded that the primary causes for the decline of the construction industry directly or indirectly involve poor management practices ("More Construction" 1983).

The prominent method of management practiced in the United States today, including the construction industry, is management by control, not by participation. Forced by international competitive pressures and increasing demands for quality products and services, industries are reevaluating

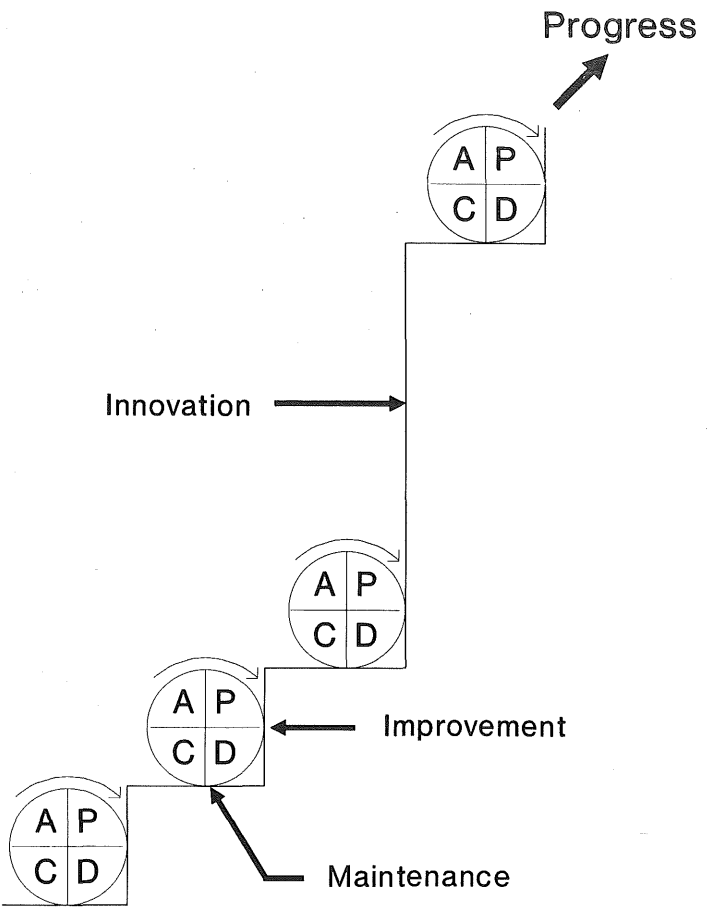

FIG. 3. Two-sided Effort of Continual Improvement

the effectiveness of management by control. According to Joiner and Scholtes (1986):

> In this style of management, the emphasis is on the organizational chart and the key control points within the structure. All managers, beginning at the top, are given certain goals for the next year. They, in turn, set goals and impose controls on each of their subordinates.

In construction terms, cost, schedule, and possibly quality goals are established for each project. Project managers are rewarded on the basis of meeting these goals. This method has been somewhat successful. It is simple, logical, and consistent. But there are problems when the work gets displaced by the controls themselves.

Since it is a system of controls, the rewarded accomplishments must be short-term and easily measurable. Without a long-term, larger purpose, the short-term goals of the various units within the company may be contra-

dictory and lead to internal conflict. Competition to meet short-term goals can lead to adversarial relationships, reduced communication, accusations when goals are not achieved, and even to fabricated reports of conformity. Management by control encourages an organization to look inward rather than outward to the customer and the customer's needs (Deming 1986; Joiner and Scholtes 1986; Juran 1988).

Once it acknowledges that there is a problem, the second step for management is to develop a clear understanding of the underlying principles and elements of TQM. Management can then demonstrate its commitment to quality through action. Without this understanding, management's action will most likely contradict TQM, confirming the doubts of the labor force and dooming the effort to failure.

Training

There is a Japanese axiom that quality begins with training and ends with training (Imai 1986). The importance of training is recognized by every quality expert and by CEOs who have successfully implemented TQM in their companies (Imai 1986; Smith 1988). Under TQM, quality becomes everyone's responsibility and the training plan must be targeted for every level of the company. There should be customized training plans for management, engineers, technicians, home and field office staff, support personnel, and field labor.

It can be argued that the transient construction work force is quite different from the relatively stable manufacturing work force. This transient nature may make it more difficult to train workers, particularly craft labor, for the construction industry. However, there are many aspects, such as training and awareness, that are similar between the safety consciousness of construction firms and the implementation of TQM concepts. Many construction companies that had safety forced upon them with the formation of the Occupational Safety and Health Administration have proven the cost effectiveness of their safety programs and now use their safety records as a marketing tool. Some of the same techniques used to instill a safety awareness in craft labor may be adaptable to instill a similar quality awareness. It is easy to envision using a good quality performance record as a strong marketing tool.

In the future, the transient nature of the construction work force may not be as major an obstacle as it now seems. As TQM concepts become widely accepted throughout the construction industry, the general principles and concepts will be applicable as workers switch from one company to another. The company-specific TQM information should require less training effort once all workers have received basic quality awareness and TQM training.

The training effort should include instruction in the basics of TQM, cause-and-effect analysis, team problem solving, interpersonal communication and interaction, rudimentary statistical methods and cost of quality measurement. An orientation to the basic concepts and procedures of TQM provides employees with a fundamental knowledge that can be linked to the instruction of the more technical topics.

A recent study of TQM implementation in more than 200 companies found that skills in human interaction, leadership, and initiative are instrumental to the success of any quality improvement effort (Dumas 1989). The demands on these interpersonal skills increase as the complexity and sophistication of the technical systems increase. These skills should be de-

veloped before, or at least in conjunction with, the development of the foundation skills of TQM.

The following elements are common to successful training efforts (Aubrey and Felkins 1988; Crocker et al. 1984; Peters 1987):

1. Training is not limited to the technical issues and concepts taught by the quality experts. The training effort must also address the human behavioral issues.
2. Training is a job requirement and everyone is involved in the training effort.
3. The training should be carried out by the managers and peers of those being trained.
4. The training effort should be tailored to the group being trained. The subject matter and examples should be relevant to their particular job function.
5. Follow-up training is essential, and should be part of the overall training plan and a job requirement for each individual.
6. Management demonstrates their commitment to the training program through their active participation and support.
7. Training effort is not decreased during a crisis situation.
8. Methods and techniques taught through the training effort should be applied to the job as quickly as possible.
9. The training effort follows a specific plan, and its implementation and effectiveness are carefully tracked. It is initiated in a limited number of pilot teams that have been carefully selected by the planning group. The success stories of the pilot teams are then used to fuel the remaining training effort.

Teamwork

Quality teams provide companies with the structured environment necessary for successfully implementing and continuous applying the TQM process. Quality training is conducted and the continuous improvement process executed through a well-planned team structure. The ultimate goal of the team approach is to get everyone, including vendors, subcontractors, and customers involved with the TQM process.

The focal point of the quality team organization is the advisory committee responsible for establishing the team structure and developing the policies and procedures for the implementation process and team formation. Once the teams are established, the advisory committee continues to provide direction for maintaining the TQM process. Committee membership depends on the needs of the company and is generally determined by the senior management supporting the TQM implementation. The initial training of the advisory committee is generally an orientation to TQM concepts. Members must develop an understanding of basic TQM concepts and their benefits, how to adapt the management philosophy, the policies and procedures used by the quality teams, and their roles as policy makers.

An internal quality consultant or, depending on the size of the organization, a group of quality consultants supports the advisory committee. The consultants are a resource to the whole organization and are responsible for (Aubrey and Felkins 1988; Crocker et al. 1984):

1. Assisting in establishing the TQM systems and structures.
2. Assisting in developing the training materials.

3. Providing expertise on the tools and techniques needed for the TQM process on a gradually decreasing basis, until the groups become self-sufficient.
4. Training the team leaders and assisting the leaders in training the team members.
5. Helping the teams communicate their results to management and the whole organization.
6. Directing and documenting the TQM implementation process.
7. Promoting TQM to both the management and the employees.
8. Acting as a liaison between all levels of management and the employees and coordinating all team activities.

Team meetings are chaired by a team leader, who is usually a supervisor or manager. Within the team meetings the leader is not in an authority role but rather acts as discussion moderator, who facilitates problem solving. The leaders are key to the teams just as the quality consultants are key to the TQM movement. The leader's role is to assist and coach the team members in the TQM process. To do so effectively, team leaders must possess certain skills that are quite different from the traditional style of being "bosses." The training for the team leaders includes: communication skills, group dynamics, statistical methods, presentation skills, problem-solving methods and techniques, and group leadership skills (Crocker et al. 1984; Imai 1986).

Team membership is voluntary and ranges from 3–15 members, with an average of about 8–10. The members work together to continuously study their particular work process and uncover and solve work related problems. The results of their efforts are communicated through the "QC story" (Imai 1986). The first step of the QC story is to explain the nature of the problem; e.g., high weld-reject rates, delays waiting for inspector sign-offs, etc., and the reasons the team selected a particular theme for the improvement process. Next, the team identifies factors contributing to the problem and prioritizes them in order of importance. Once this is completed, the team determines a specific goal for improvement.

After selecting an improvement opportunity, the team identifies and verifies the causes of the problem and then develops solutions to the most significant root causes. The solutions are implemented, their effectiveness checked, and any necessary modifications made. Steps are then taken to ensure that any recurrence of the problem is prevented, and the result is standardized. Finally, as a follow-up measure, the effectiveness of the new standard is continuously tracked and the team begins to look for ways to improve on the improvement (Imai 1986).

Usually, the teams meet for about an hour a week, and it is best that meetings are held during working hours to demonstrate management's support and commitment. As time passes, the team meetings should be accepted as a normal part of the job requirements. Initially, the meeting agenda is divided equally between training and the improvement process. The members are trained in planning and controlling projects, brainstorming, flow charting, graphing, statistics, public relations, presentation techniques, and cost-benefit analysis. The training is tailored to the composition and needs of the team.

Statistical Methods

Statistical methods provide essential problem-solving tools to the TQM process. They provide teams with the tools to (Perisco 1989):

1. Identify and separate causes of quality problems.
2. Communicate in a precise language that can be understood by all team members.
3. Verify, repeat, and reproduce measurements based on data.
4. Determine the past, present, and to a lesser degree, the future status of a work process.
5. Discuss and make decisions on facts that are based on data rather than the opinions and preferences of individuals or groups.

The most commonly used statistical methods in the TQM problem-solving process are known as the "seven statistical tools" (Imai 1986). These tools include histograms, cause-and-effect diagrams, check sheets, Pareto diagrams, graphs, control charts, and scatter diagrams (Imai 1986; Ishikawa 1982; Kume 1985). Flowcharts are another excellent problem-solving tool. Specific discussion of these tools is beyond the scope of this paper.

Cost of Quality

The cost of quality is considered by both Crosby (1979) and Juran (1988) as the primary quality measurement tool. In their approaches, it is used to track the effectiveness of the TQM process, select quality improvement projects, and to provide cost justification to doubters. By bringing together these easily assembled costs of review, inspection, testing, scrap, and rework, one can demonstrate expense accumulation to convince management and others of the need for quality improvement (Ledbetter 1989). The concept of cost of quality is particularly appealing to the cost-conscious construction industry, and it has already been applied to a number of construction projects (Ledbetter 1989, 1990).

Quality costs are broken down into two categories: costs of prevention and appraisal, and costs of deviations. The breakdown of these costs is shown below (Ledbetter 1989):

$$\text{quality costs} = \text{quality management costs} + \text{deviation costs} \quad \ldots\ldots\ldots (1)$$

$$\text{quality management costs} = \text{prevention costs} + \text{appraisal costs} \quad \ldots\ldots (2)$$

In terms of construction, prevention costs are those resulting from quality activities used to avoid deviations or errors, while appraisal costs consist of costs incurred from quality activities used to determine whether a product, process, or service conforms to established requirements (Burati and Farrington 1987). Design or constructability reviews might be considered prevention costs, while inspection is an example of an appraisal cost. Deviation costs are those resulting from not meeting the requirements. Some deviation costs are incurred on the project site due to scrap, rework, failure analysis, reinspection, supplier error, or price reduction due to nonconformity. Other deviation costs are incurred once the client has the project. These include costs for adjustment of complaints, repair costs, costs for handling and replacing rejected material, workmanship, or equipment, costs for correcting errors, and litigation costs.

Cost of quality has received increasing attention in recent years. It is effective in its intended purpose of raising awareness about quality and communicating to management the benefits of TQM in terms of dollars. However, it is only one element of the TQM process. The limitation of cost of quality systems lies in the fact that costs include visible and invisible amounts. Deming addresses these invisible amounts as "unknown and un-

knowable" and stresses that management must take them into consideration if a company is to remain successful (Deming 1986). For example, in construction it is difficult to assess all of the impact costs associated with a rework activity. In addition to the direct costs associated with the rework, the cost impact of the delay on other activities and the project in general may be difficult to determine. Examples of "unknown and unknowable" benefits include:

1. The return business of a happy customer and the lost business of an unhappy customer.
2. The improved productivity of a satisfied employee and the lost productivity of a dissatisfied employee.
3. The improved quality and productivity resulting from using the teamwork concept both internally and externally.
4. The improved quality and productivity resulting from management's commitment and support of TQM.
5. The improved quality and productivity resulting from training, and using the quality improvement process.
6. The improved quality and productivity in one work group resulting from quality improvement from a prior work group.
7. The improved quality and productivity resulting from removing barriers and obstacles to pride of workmanship.

Supplier Involvement

The concept of continually improving work processes is one of the fundamental principles of TQM. The ability to produce a quality product largely depends on the relationship among the parties involved in the process; the supplier, the processor, and the customer. The quality of any stage in a process is contingent upon the quality of the previous stages. This concept applies to both internal and external customers. The quality of the project built by the constructor is directly related to the quality of the plans and specifications of the designer, the quality of the materials and equipment supplied by the vendors, and the quality of the work performed by the subcontractors. Close and long-term relationships with these suppliers to the construction process are required if the constructor is to achieve the best economy and quality.

Traditionally, in the construction industry, contractors, subcontractors, and vendors are all pitted against one another to compete on the basis of low-bid contracts. The fourth of Deming's 14 points stresses that companies must:

> End the practice of awarding business on the basis of price tag alone. We can no longer leave quality, service, and price to the forces of competition for price alone . . . without adequate measures of quality, business drifts to the lowest bidder, low quality and high cost being the inevitable result. American industry and the U.S. government, civil and military, are being rooked by rules that award business to the lowest bidder (Deming 1986).

Successful projects in the future are likely to be decided based on quality (lifetime cost of the product and not the initial cost) and supplier responsiveness, which can only be achieved through partnership relationships.

These relationships will involve fewer suppliers, and they will be based on mutual trust (Peters 1987). This is already being proven true in certain areas of the industrial construction market. Long-term partnering agreements have been formed between a number of owners and contractors. Some owners are requiring their contractors to have formal TQM programs, and both owners and contractors are requiring their vendors to implement TQM if they wish to be considered for future work (Matthews and Burati 1989).

Customer Service

TQM is a process that requires universal involvement to be successful. This includes customer involvement. As more and more companies become involved in the TQM process and demands for improved quality increase, this concept will become increasingly important. This has proven to be true for the manufacturing and service industries, and an increasing number of firms in the construction industry are adopting TQM approaches. A recent Construction Industry Institute (CII) study of 16 large firms involved in the construction industry (eight owners, with engineering and construction staffs, and eight contractors) found that 12 of them were in various stages of implementing TQM (Matthews and Burati 1989). CII is currently sponsoring research to identify the most effective techniques for implementing TQM in the construction industry.

Extending the TQM concept to the customer in the form of joint teams achieves customer satisfaction. These joint teams are responsible for establishing joint goals, plans, and controls. The teams provide a mechanism for listening to and communicating with the customer and for measuring the level of customer satisfaction. The organizational machinery, methods, and tools needed for establishing these joint teams are similar to those used for internal customers. Two obstacles to establishing joint teams are the state of legal independence between companies and their traditional methods of working together (Juran 1988).

These obstacles can be overcome, however, if the owner is dedicated to doing so. At the 1990 CII annual meeting, several case studies of successful partnering arrangements were presented, and one of these was a U.S. Army Corps of Engineers project. Additionally, on a large refinery project that is under way, the owner's project manager has decided that TQM will be applied on a project team basis. Representatives of the owner and the two major contractors on the project serve on the project quality steering committee. While this is truly a new concept, early progress is encouraging.

IMPLEMENTATION

For many companies, TQM is a significant shift away from the standards of management previously practiced. The task of bringing about such a change throughout an entire organization is a tremendous undertaking that requires the patient support and leadership of management. Deciding where to begin can be the most difficult step in the process (Smith 1988). Although there are no set procedures for implementing quality improvement, there are some common steps among companies that have been successful, and these are discussed in the following sections. As noted previously, the CII is currently sponsoring research to identify the most effective techniques for implementing TQM in the construction industry.

Preparation and Planning

Senior management should first familiarize itself with the concepts, tools, and methods of TQM. This can be accomplished by visiting companies that have successfully implemented TQM, watching the videotapes, attending the seminars, reading the books developed by the quality experts, and reading the numerous articles that are published on quality management.

As senior management becomes familiar with TQM, it should begin to assemble the supporting structure for implementing TQM on selected pilot projects. The quality support structure includes an advisory committee comprised of leaders from different areas and levels of the company, a quality consultant group comprised of quality managers versed in TQM, and steering teams at the department level for directing the implementation effort down into the departments.

The advisory committee, together with the assistance of the quality management consultants, should then begin formulating the quality approach for the company. The formulation of a "customized" quality approach is important to the success of the implementation effort. Management should not simply purchase a "program" and blindly apply it to their company. The concepts from all of the available approaches are solid in their own right, but some companies have difficulty implementing them into their own operations. They should work to tailor an approach that best suits the culture and requirements of their particular company. This can be accomplished by either adapting a program provided by one of the quality experts or studying all of the different concepts and developing a customized approach that will best suit the company's needs (Matthews and Burati 1989).

Implementation of TQM Plan

The implementation process should begin with carefully selected pilot projects, and as the momentum of the process increases, the effort should be extended to the rest of the company. Control points and measures of the implementation effort should be included in the implementation plan to track its effectiveness and make any necessary improvements. The next step is announcing to the employees management's commitment to implementing TQM, the reasons for the decision, and perceived future benefits. This is followed by forming steering teams at the department level for directing the quality improvement efforts in each of the departments in the company.

The quality consultant group assists the steering teams in getting the TQM process down into the quality teams within the department. Training is carried out as the quality teams begin to form and is applied to real problems as soon as possible. The team structure is also used to communicate the company's new quality policy and goals throughout the organization to unify the improvement efforts. As the implementation effort gains momentum, the success stories from the pilot projects are used to sell TQM to the rest of the company.

Measuring and Verifying the Implementation

The implementation effort is a planned and controlled process. As the process progresses, its effectiveness should be compared against the control points and measures established at the preparation and planning stage. These measures should be carefully monitored and their conformity to the initial plan should be verified. Any deviations from the established plan should be investigated and removed through the PDCA problem-solving process.

Reflect to the Next Preparation and Planning Stage

This stage of the implementation process ensures the continued enthusiasm and commitment to TQM. The achievement of annual goals is evaluated and new goals set. The midterm goals are reevaluated in light of the progress and adjustments are made accordingly. Outstanding teams should be recognized based on criteria established during the preparation and planning stage.

Will TQM Work in U.S. Construction?

Many arguments can be and have been put forth as to why TQM will not work in the U.S. construction industry. Many of the same arguments were advanced in the past as reasons why TQM would not work in the U.S. manufacturing industry. A common argument is that the cultural differences between Japan and the U.S. are such that TQM works there but not in the U.S. To counter this argument, Juran noted "you still hear experts saying that the better quality in Japan comes from their culture. But 35 years ago they had the same culture and made junk" (Rohan 1987). The manufacturing industry has proven the fallacy of the belief that TQM will not work in the U.S.

As noted previously, three Japanese contractors have won the Deming Prize for quality improvement. This indicates that the Japanese construction industry has been able to successfully embrace the concepts of TQM. While the Japanese and U.S. construction markets certainly differ, it would be shortsighted to believe that TQM concepts cannot be successfully applied to U.S. construction.

The private construction sector should be able to adopt TQM principles relatively easily. Just as U.S. manufacturing argued that TQM would work in Japan, but not in the United States, the private U.S. construction industry argued that TQM will work in manufacturing but not in construction. As found in CII research (Matthews and Burati 1989), many owners and contractors in the industrial construction area are in the process of implementing TQM. Some owners are requiring their contractors and suppliers to have formal TQM programs. It is no longer a question of whether TQM can and will be implemented in this industry; it is now a question of how long it will be before all owners, contractors, and vendors in the industrial construction market have formal TQM programs.

Many questions about the implementation of TQM in the construction industry do remain. The public construction sector and the transient craft labor force are factors to be addressed. However, this should not discourage efforts to adopt TQM. Establishing long-term owner-contractor relationships and avoiding low bid contracts are typically goals of the TQM philosophy. These are contrary to the currently accepted and allowable public sector contracting strategies. There have, however, been some efforts to promote contracting strategies for public projects other than accepting the low bidder. The U.S. Transportation Research Board (TRB), in Washington, D.C., has proposed projects in which the contractor will be selected based not only on low bid, but also on estimated project duration. TRB has also proposed awarding design-build contracts, requiring warranties from contractors, and awarding contracts with incentives for quality ("FHWA" 1991). Other innovative contracting approaches, such as negotiated competitive bidding, have also been proposed (Harp 1990).

Even if competitive bidding requirements cannot be overcome, TQM

philosophies can still be implemented within government agencies and contracting firms. The federal government is very interested in implementing TQM applications. The Federal Quality Institute has been established to assist with TQM implementation within the government (*Total Quality* 1989). The Federal Highway Administration is currently considering funding a demonstration project in the area of quality management. TQM is one area under consideration for this project. Some state transportation agencies have also investigated the application of TQM concepts (Hughes 1990; Holt 1990). Once contracts are awarded, the TQM philosophies of the contracting parties should allow for a more team oriented, less adversarial relationship on the project. At the 1990 CII annual conference there was a presentation regarding how team building and partnering concepts were used to improve relationships among the parties on a Corps of Engineers project.

The question of the transient craft work force must be addressed before TQM can reach its fullest potential in the construction industry. Of 19 companies interviewed in a CII study of TQM in the construction industry (Matthews and Burati 1989), none had yet reached the point of bringing their TQM training to the craft level. However, many contractors have succeeded in conveying a safety awareness to their transient craft labor. Some of the same techniques may be successful in instilling an equivalent quality awareness to the crafts. Orientation videos and weekly meetings with foremen or other supervisors may be a way to instill the necessary quality awareness. It will also be necessary to prove through management's actions that quality is of equal or greater importance when compared to cost and schedule considerations. It may be possible for labor unions to provide training in basic TQM concepts to their members. It is also possible that as the supply of construction craft workers dwindles, the work force will not be as transient, with longer-term employment with single contractors. Research and study are needed to determine the best way to train craft workers in TQM concepts, but this should not be used as an excuse for not moving ahead with implementation in the construction industry.

Conclusion

Based on the experience of the Japanese manufacturing and construction industries and the U.S. manufacturing industry, TQM is an effective, comprehensive management process that helps in achieving the goals of customer satisfaction and continuous improvement. As discussed herein, the construction industry can successfully implement TQM by adapting the techniques that have been successful in the manufacturing industry. Further study is necessary regarding how best to train craft workers in TQM concepts and how TQM can best be employed in the public construction arena.

It might be wise to close with the conclusion drawn by the CII quality management task force at the end of its research into quality management in the private construction industry (Burati 1990): "Companies must institute total quality management (TQM) or become noncompetitive in the national and international construction and engineering markets within the next five to ten years."

Acknowledgments

The writers gratefully acknowledge the Construction Industry Institute for providing funding to support this research effort, and they also extend

their gratitude to the members of the CII quality management task force for their guidance, support, and contributions.

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