King Fahd University of Petroleum and Minerals

College of Industrial Management

Master of Business Administration Program

CEM520: CONSTRUCTION ENGINEERING

TERM PROJECT

Submitted to

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Introduction:

Due to the increasing competition between organizations and the growing satisfaction demands of the customers many organizations redefined their management principles to ensure their survival. The emergence and the recent importance being given to the principle of Quality Management (QM) has led to serious rethinking by organizations looking for ways to stay competitive.

Quality in construction is defined as the conformance to requirements, as defined by the owner, A/E, contractor, and the regulatory agencies. The A/E and contractor organizations are responsible of meeting these requirements. There can be no doubt that the A/E organizations bears the greater burden of ensuring quality as it defines the requirements of the owner in the form of drawings and specifications to the contractor. Any deviations in defining the owner requirements at this stage can lead to increased costs in their rectification. Studies (Ransom 1987; Burati et al 1992) show that design deviations account for about sixty percent or more of construction project deviations. The costs due to poor quality in design and engineering have been estimated at about twelve percent and eight percent (Trainer 1953) of the total project cost.

Thus to ensure quality in the constructed project it is vital to concentrate on the area. i.e. the A/E organization, where quality management practices can bring about the greatest beneficial affect. This investigation will determine the prevalence of quality management practices among the local A/E organizations, and hence assess the quality of the services provided by the local A/E organizations.

Significance of the study:

The increasing competition and growing quality awareness in the construction industry has prompted a lot of research into determining the ways to improve the quality of construction. These researches revealed the lack quality by the A/E as the major reason of lack of quality in the finished product.

The importance of determining the QM practices among the A/E organizations cannot be more stressed. This study by increasing the awareness of quality management practices among the local A/E organizations can increase the service quality of the A/E. With organization seeking ways to reduce wasteful costs this study could be used as an aid to build a framework for implementing a QM system as per the local organizational characteristics. This study can also be used as an aid by competing A/E organizations seeking ways to improve their services by making them aware of their deficiencies.

Objective:

Towards this purpose this study sets out to investigate the quality management (QM) practices prevalent among the A/E organizations in the Eastern Province of Saudi Arabia. The objective of this study is to seek the answers to the following questions:

1. What are the QM practices prevalent among the A/E organizations?
2. What areas of the QM system, e.g. Organizational quality policy, design control, design review, document control, working relationship, audit, etc. are practiced?
3. To what extent are the different areas of the QM system developed?
4. What is the quality of service provided by the A/E organizations?

Scope and limitations:

The study is limited to the A/E consulting organizations in the Eastern Province of Saudi Arabia. The organizations are those so classified by the Chamber of Commerce.

Literature review:

Taking the quality improvement programs of Philip B. Crosby, W. Edwards Deming, and Joseph M. Juran as guidelines that should help to improve quality.

Crosby's (1979) fourteen steps quality improvement program is as follows:

1. Management Commitment
2. Quality Improvement Team
3. Quality Measurement
4. Cost of Quality Evaluation
5. Quality Awareness
6. Corrective Action
7. Establish an Ad Hoc Committee for the Zero Detects Program
8. Supervisor Training
9. Zero Defects Day
10. Goal Setting
11. Error cause Removal
12. Recognition
13. Quality Councils
14. Do it over again.

Deming's fourteen points is simply a list, unlike Crosby's fourteen points which are in chronological order, and as such they have evolved over time and have been restated (Fox 1993). Deming’s fourteen steps as stated by March (1996) are as follows:

1. Create constancy of purpose for improvement of product and service
2. Adopt the new philosophy
3. Cease dependence on mass production
4. End the practice of awarding business on price tag alone
5. constantly and forever improve the system of production and service
6. Institute modern methods of training on the job
7. Institute modern methods of supervising
8. Drive out fear
9. Break down barriers between departments
10. Eliminate numerical goals for the work force
11. Eliminate work standards and numerical goals
12. Remove barriers that hinder tile hourly workers
13. institute a vigorous program of education and training
14. Create a structure in top management that will push every day on the above thirteen points.

The ten steps in the quality improvement process as perceived by Juran are (Fox t993):

1. Build awareness of the need and opportunity for improvement
2. Set goals for improvement
3. Organize so as to reach the goals
4. Provide training
5. Carry out projects to solve problems
6. Report progress
7. Give recognition
8. Communicate results
9. Keep score
10. Maintain momentum by making annual improvement part of the regular systems and procedures of the company.

Quality management:

The importance of a quality management in any organization is evident from the emphasis given by Crosby, Deming, and Juran, and cannot be more stressed. Crosby (1979) states that “quality management is systematic way of guaranteeing that organized activities happen the way they are planned. It is a management discipline concerned with preventing problems from occurring by creating the attitudes and controls that make prevention possible”.

The ten features that determine the extent of quality culture in an organization, and thus vital for any QM implementation program, stated by Johnson (1993) are:

1. **Top-down leadership**. Leaders know where they are going, and they are taking their people with them.
2. **Vision**. A clear image is provided depicting exactly where the organization is going, what plans, objectives, and goals are required to get there, and the benefits employees Carl expect when goals are achieved.
3. **Customer focus**, Satisfying both internal & and external customers is a primary part of all mission considerations.
4. **Employee well-being**. Employee well-being is considered in the decision making processes and efforts are made to strike a positive balance between this and other important factors.
5. **Performance management system**. Employees are selected for quality, trained, appraised against a standard, and recognized for their achievements.
6. **Reward system**. Employees are rewarded based on accomplishments rather than seniority, longevity, or a subjective standard.
7. **Communications system**. Communications are open and employees know what is occurring and why.
8. **Roles and relationships**. Roles are supportive rather than directive, where possible, and relationships up and down the chain are designed to encourage teamwork rather than conflict.

9. **Structure**. The structure is discretionary allowing mare employee input into operations and process input.

10. **Teamwork**. Lone Rangers are out and teams are in. The rewards system supports team efforts.

From the above discussion it can be understood that any successful implementation of a QM practice consists of two aspects the people and the process. While the people aspect of QM is vital for the success of any QM practice it is beyond the scope of this study. The process management aspect is the most appealing end easily understandable to the A/E professionals. The A/E professionals are quick to grasp and implement quality management techniques in varying levels although many do not term such practices as a part of quality management.

Quality in the design process:

The A/E consulting organization act as the middleman through whom the owner states his/her requirements and objectives to the contractor. Thus the consulting organization has the triple task of ensuring that it has collected all the information necessary for meeting the owner's requirements, has understood the said information and processed it correctly into the form of drawings and specifications, and that the contractor is able to clearly understand and implement the owner's requirements through the drawings and specifications.

Any shortfall in fulfilling these tasks can lead to quality deviations in the complete project due to faulty design. Ransom (1987) reported a study by the Building Research Service (BRE) in which the causes of failures were analyzed to indicate whether they were due to faulty design, poor execution, the use of poor materials, or unexpected user requirements. Faulty design was taken to include all cases where the failure could be attributed to not following the established design criteria; the percentage of failures, with some overlap between these categories, was found to be 58%, 35%, 12%, and 1% respectively.

Burati et al (1992) collected quality deviation data from nine construction projects. The data was collected after the construction phase of the projects to identify the direct costs associated with work redesign, repair, and replacement. The data indicated that deviations on the project accounted for an average of 12.4 percent of the total project costs. Furthermore, design deviations averaged 78% of the total number of deviations, 79% of the total deviation costs, and 95°/a of the total project cost. The construction deviations averaged 16% of the total number of deviations, 17% of the total deviation costs, and 2.5% of the total project cost. These values are conservative as they considered only the direct costs, but they are indications of the impact of design quality on the project. Other studies (Kirby et al 1988, Morgen 1986) have identified the three major causes of the contract modifications as deficiencies, user requested changes, and unknown site conditions. These studies have also revealed that 56 percent all contract modifications are to correct design deficiencies.

Previous Studies:

A study by Al-Shiha (1993), into the effects of faulty design and construction on building maintenance, revealed that nine of the top fifteen affecting the maintenance work fell under the responsibility of the A/E organization. In a study by Bubshait and Al-Abdulrazzek (1996), a survey was conducted to assess the extent of eleven major design quality management activities utilized by the local engineering consulting offices. It was determined that job training, peer review, and establishment of an incentive system were the most neglected QM activities in the A/E organizations.

A study by Al-Musaid (1990), determining the influence of owner involvement on certain tasks during construction on project quality, suggests that A/E, as the representative of the owner, should solve tasks requiring owner input by bringing them to the owners notice and/or striving to determine the owner's input so as improve the project quality.

All these researches recognized the importance of the design professional or the A/E organization in ensuring the quality of the project. Thus this research intends to determine directly the QM activities used in the design process of the A/E organizations to determine the quality of service provided by these organizations.

Design Quality Management Areas:

During Literature review fifteen Quality Management Areas were identified, by the author, as having a bearing on the quality of service provided by A/E consulting organizations.

The following sections introduce the reader to these fifteen quality management areas, so as to understand their role in ensuring the organizational service quality of A/E consulting organizations. The fifteen quality management areas are as follows:

Organizational Quality Policy:

This area addresses the organizational policy towards establishment of a quality program and definition of organizational objectives and individual responsibilities. The establishment of a quality program in an organization communicates the importance given by the organization for ensuring quality of its service. The defining of organizational objectives and individual responsibilities outlines the details of how the organization intends to proceed towards achieving a high standard of service.

This area also covers the presence and the updating process of the quality manual. The quality manual contains information regarding the organizational objectives, quality policy statement, and extent of application of the quality management program documents, organizational objectives and responsibilities. Organizational procedures regarding quality are also addressed in the quality manual and it is openly available to the

employees (McLaughlin1995). As part of its organizational policy the organization also needs to specify the methodology it intends to follow to achieve quality in its service.

Design Qualification:

For an A/E consulting organization the design professional is the essence of its being. This quality management area covers the organizations hiring practices and working guidelines with respect to its design professionals.

Employee Training and Education:

This quality management area is the one of the most widely recognizes quality area by quality experts. Employees should be given job training, provided with facilities to improve their general skills, and provided with courses to enable them to handle special tasks.

Design Planning:

This area covers A/E consulting organization's process with regards to how it ensures the planning of its design process, and identification of inputs and interfaces. The project design plan is usually in the form of a flow chart identifying various activities required to deliver the project to the client. The design plan identifies the relationships among the various activities promoting the completion of the project, and notes the responsibilities and assignments with regards to each activity.

Design Inputs:

This area covers the organizational policy in the identification, transmission, and agreeing upon of design inputs. Design inputs include codes/standards, project functions, design criteria, technical data (and their sources), and drawing arrangement and layout.

Design Process:

This quality management area covers general practices followed by the origination in ensuring quality in the design process. Factors like assignment of project to a single team, efficiency of preliminary design, design procedures, investigation documents, and specification of special treatments are intended to be measured in this quality management area.

Interface Control:

This quality management area covers aspects of how the organizational procedures ensure the integration of work done by different entities, both internal and external. The transmission of information, the how and when, is also covered in this quality management area.

Design Review:

The most effective means of identifying deficiencies and incorporating improvements into the construction documents is the establishment of a design review program (Kirby et al 1988). Design reviews are conducted in addition to the ongoing checking process required by design professionals in the course of their work. The design review is an

internal quality control process carried out by members of the design team and/or by employees selected for their expertise.

Such reviews are undertaken by the organization for detection and correction of errors, and technical deficiencies. These measures are undertaken by the organization as way of increasing the quality of its services and limiting exposure to liabilities.

Design Changes:

Changes are an inevitable part of any construction project. Change of circumstances, equipment becoming obsolete, emergence of a better doing work, client changing his/her mind, and other varied reasons may account for design changes. Whatever reasons for change, it is vital that procedures for managing design changes should be followed, so that only the correct design documents are used for the project.

Subcontractor Control:

Lack of expertise or the client's insistence may prompt the design organization to subcontract part of their work. The well known principles of control in other industries need to be modified to be applied in this case.

Subcontracted design professionals should be informed of the organization's quality program and monitored to ensure that their work dove-tails the main project works.

Document Control:

A quality conscious organization has a sound policy regarding the storage, filing, and transmission of documents. Any construction activity involves specifications, regulations,

changes, checks, revisions, and the like, all these bring into being their own respective documents that need to be regularly updated to ensure work is conducted through out the project with the same and latest information. This quality management area is widely recognized as a major factor in increasing organizational efficiency.

Design Maintainability:

This quality management area involves principles from material selection and space allocation. The A/E consulting organizations need to ensure that materials specified by it can be easily maintained/replaced by the client. Proper allocation of space needs to provision to provide for easy accessibility in any future maintenance works. Assaf et al (1996) revealed that owner's ranked `design defects in maintenance practicality and adequacy' as number one terms of severity.

Thus the proper practice of this quality management area assumes a role in determining the service quality of the A/E consulting organizations.

Computer Usage:

Computers have nowadays become an integral part of any organization. The proper use of computers can lead to a decrease in the amount of doing work/rework, thus increasing the productivity of the organization. The increasing availability of design related soft wares also increase the responsibility of the organization for proper selection.

Working Relationship:

The proper working relationship of an organization takes into account the cooperation with and the satisfaction of its customers. The reason behind naming this quality management area 'working Relationship' and not 'Customer Satisfaction' is the posing of the question by some as to who is the real customer?

A customer can also be defined as any entity that in some way derives some benefit from the project. In increasing order of receiving benefit, from the work of the A/E consulting organization, customers can be enumerated as society, project users, maintenance contractors, construction contractors, and owners. This study measures, in this quality management area, the relationship of the design organization only with those entities that it comes into direct contact with, i.e., the project Owner, and to a lesser extent the construction contractor. This quality management area covers the A/E organization's interaction with the client and the construction contractor in working out ways to improve the quality of the project.

Performance Quality Audit:

Auditing can be defined as a methodical study and review of one or more quality practices, and the checking for compliance and effectiveness; for the purpose of verification and improvement (Hutchins 1993; Mirams and McElheron 1995). This quality management area assesses the A/E consulting organizations process in auditing its quality performance by self examination and customer feedback.

RESEARCH METHODOLOGY:

The research, being of the exploratory type, consisted of a questionnaire survey among the local A/E organizations of the Eastern Province. The questionnaire is designed to evaluate the prevalence of the outlined activities among the A/E organizations. The questionnaire survey will be conducted mostly by mailing the questionnaire and partly by the conducting an interview with willing organizations. This method while obviously providing the information regarding the prevalence of QM activities among the A/E organizations will also provide more details for assessing the reasons for the presence/lack of these QM activities among the A/E organizations.

QUESTIONNAIRE DESIGN:

The questionnaire consists of seventy questions grouped into the following QM areas and are displayed in the below table:

S. NO	QUALITY MANAGEMENT AREAS	QUESTION NUMBER
1	Organizational Quality Policy	1-4
2	Designer Qualification	5-6
3	Employee Training and Education	7-9
4	Design Planning	10-12
5	Design Inputs	13-14
6	Design Process	15-20
7	Interface Control	21-24
8	Design Review	25-32
9	Design Changes	33-35
10	Subcontractor Control	36-37
11	Document Control	38-41
12	Design Maintainability	42-43
13	Computer Usage	44-45
14	Working Relationship	46-66
15	Performance Quality Audit	67-70

The questions inquire about the extent of practice of the QM practices, in the above areas, in the A/E consulting organization. The respondents are requested to record their opinion regarding the extent of these QM practices as ‘Always, Mostly, Sometimes, Rarely, and Never. The responses will be quantified as follows:

- ‘Always' equal to one hundred percent
- ‘Mostly’ equal to seventy five percent
- ‘Sometimes’ equal to fifty percent
- ‘Rarely’ equal to twenty five percent
- Never' equal to zero percent.

The respondent’s answers will be utilized to fulfill the objectives of this study. The average prevalence of quality management practices will be determined by the equation:

Average Prévalence = (100x1 + 75x2 = 50x3 + 25x4 + 0x5) / (x1 + x2+ x3 + x4 + x5)

X1 = number of respondents answering ‘Always’

X2 = number of respondents answering ‘Mostly’

X3 = number of respondents answering ‘Sometimes’

X4 = number of respondents answering ‘Rarely’

X5 = number of respondents answering ‘Never’.

RESULTS AND DISCUSSION:

This part of the study discusses the results and analysis of the survey on prevalent management practices in the local construction industry. The fifteen quality management areas (QMA) are analyzed first, and then an analysis of the prevalence and importance given to these quality management areas is undertaken. A method for evaluating the service quality of the design organization is also being introduced in this part.

As mentioned before the statements in the questionnaire were designed to measure the fifteen quality management areas mentioned in the above Table. The percentage frequency of responses to the seventy statements measuring the quality management practices is given in Table 4.1 in the research but since I am summarizing I thought it is not applicable to display it in this summarized study.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary:

The growing awareness in the local construction industry of quality management has led many organizations to adopt practices aimed at providing the customer the best service possible and staying competitive. The most important phase of any construction process is the design process, and as thus it is vital for the A/E consulting organization to ensure the quality of its services.

In the beginning the author introduced the topic of quality in construction, and the vital importance of quality in the design process. The importance of determining the prevalent

quality management practices and increasing their awareness among the A/E consulting organizations were identified as significant parts of the study. The objectives of the study formulated as determining the following:

1. What are the quality management practices prevalent among the A/E organization?
2. What areas of the quality management system are practiced?
3. To what extent are the different areas of the quality management system developed?
4. What is the quality of service provided by the A/E consulting organizations?

The study was limited to the A/E consulting organizations in the Eastern Province of Saudi Arabia.

Part two stressed the importance of quality management through literature review. Studies highlighting the need for quality in the design process were presented. Previous researches related to A/E organizations in Saudi Arabia and their findings were also presented. Fifteen quality management areas, identified as having bearing on the quality of service provided by the A/E consulting organizations are also discussed in this part.

In part three, the methodology of conducting the research was defined. Allocation of the seventy statements (See below Table), designed to measure the quality management practices of the A/E consulting organizations, and the determination of the sample size is also presented in this part.

S. NO	QUALITY MANAGEMENT AREAS	IMPORTANT CONCLUSIONS
1	Organizational Quality Policy	Need for more efforts for establishing and updating the quality manual
2	Designer Qualification	Strong need for establishment of a design code for Saudi Arabia
3	Employee Training and Education	Second least prevalent QMA. High need for more job training.
4	Design Planning	Need for more emphasis towards identifying design interfaces in preliminary design
5	Design Inputs	Need for defining responsibilities of transmission of design inputs
6	Design Process	Need for more assignment of project work to a single team. Need for more trust and cooperation with contractor
7	Interface Control	Need for greater interface control, and confirmation in writing of informally transmitted information between interfacing entities.
8	Design Review	The most prevalent QMA. A slight increase in the prevalence of review is recommended
9	Design Changes	The second most prevalent QMA
10	Subcontractor Control	Slight need for ensuring ease of maintainability while specifying material in design documents
11	Document Control	The third most prevalent QMA
12	Design Maintainability	Slight need for ensuring ease of maintainability while specifying material in design documents
13	Computer Usage	Need for more frequent use of CAD tools
14	Working Relationship	Need for encouraging more client interaction and building up more trust and cooperation with contractors
15	Performance Quality Audit	High need for end of the project studies for future reference. Need for evaluations from client and contractor at the end of projects.

The surveyed quality management practices (QMP) were grouped into fifteen quality management areas (QMA) for classification. This classification ensured that the service quality of that quality management area was dependent on the practice of multiple quality management practice instead of one. This also gives the study a greater degree of accuracy and understanding in the determination of the true state of the local A/E consulting organizations, than if each quality management area was measured by a tone statement.

In part four, the results of the survey responses were presented. The results of the fifteen quality management areas were analyzed and the prevalence of each quality management area presented. The agreement level in the ranking between the prevalence of quality management areas and the importance given to these quality management areas was also determined. This analysis highlighted the need for organizations to put an extra effort to improve their quality of service in certain quality management areas, so as to be in concordance with the importance given by them to these quality management areas.

The average service quality of the local A/E consulting organizations was also presented in part four. The average service quality of the local consulting organizations was determined by taking the overall average of the quality management areas.

Conclusions:

The most prevalent quality Management areas are design review, design changes, document control, and design planning. While the lowest prevalent areas are performance quality audit, employee training and education, working relationship, and interface control.

The areas given the highest importance ratings are design review, design changes, designer qualification, and design inputs. While employee training and education, working relationship, performance quality audit, and interface control are given the lowest rankings.

The highest degree of agreement between the prevalence rates and the importance rates is among the following quality management areas:

Design changes, design review, interface control, and design maintainability. While the lowest agreements between prevalence rates and importance ratings are among the following quality management areas: design planning, subcontractor control, designer qualification, and design inputs.

The comparison of the ranking between the prevalence and importance given to the quality management area indicated the extra effort being put by the organizations in certain areas and a lack of effort in others, to be consistent with the importance given to those areas. The areas were an extra effort is being put in as compared to the importance given to them are design planning, subcontractor control, organizational quality policy,

document control, working relationship, employee training and education, and design maintainability. This indicates a healthy attitude towards these quality management areas. The practice of two quality management areas, design review and design changes, was consistent with importance ranking of these two areas. On the other side of the spectrum designer qualification, design inputs, computer usage, performance quality audit, design process, and interface control revealed a lack of effort in the practice of these quality management areas in concordance with the importance given to them. This indicates a possible potential for complacency and needs to be monitored as a check against it

A summary of important conclusions reached in each of the fifteen quality management areas is given in the pervious table. Some other important conclusions reached after discussions with some of the respondents are as follows:

- Need for ways to define and ensure the quality of service provided by the A/E consulting organizations (preferably by regulatory bodies).
- Development of a method for defining A/E consulting organization, on the basis of their service quality, in different grades, on the lines of grades applied to contractors.