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## STUDYING THE EFFECTS OF USING TOTAL QUALITY MANAGEMENT (TQM) IN CONSTRUCTION SITES (CASE STUDY: STEEL STRUCTURE BUILDING)

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**Resumen:** La gestión de la calidad total (TQM) es uno de los métodos más útiles y efectivos utilizados en sistemas de gestión que efectivamente incluyen los temas de calidad. En este estudio, los efectos del uso de TQM se examinan en talleres de construcción y en un caso de estudio sobre un conjunto de edificios metálicos y se explican todos sus pasos desde el inicio hasta la realización del edificio. En este estudio, para identificar las debilidades y los problemas de los enfoques de gestión derivados de la falta de una gestión adecuada en los edificios de metal, el modo de aplicación de la GCT en otros países. Por lo tanto, al identificar las debilidades de la gestión de los ejemplos anteriores, se puede dar un paso significativo para mejorar y mejorar el sistema de gestión y la calidad de la construcción del país.

**Palabras Clave:** gestión de la calidad total (TQM), sistema de gestión, construcción metálica, calidad del edificio

**Abstract:** Total quality management (TQM) is one of the most useful and effective methods used in management systems that effectively include the topics of quality. In this study, the effects of use of TQM is examined in construction workshops and in a case study manner on a set of metal buildings and all of its steps from the beginning to the accomplishment of the building is explained. In this study, for identifying the weaknesses and problems of management approaches derived from lack of proper management in the metal buildings, manner of implementation of TQM in other countries, are examined. Therefore, by identifying the weaknesses of management of previous examples, one can take a significant step for improving and enhancing the management system and quality of construction of the country.

**Keywords:** total quality management (TQM), management system, metal building, building quality

## 1. INTRODUCTION

Given the continuous expansion of industrial, administrative organization and sensitivity of proper use of limited facilities for supplying ever increasing needs of society, guiding of production, industrial and governmental organization in realization of organizational objectives and accomplishing the duty calls for developed industrial and administrative managements relying on scientific principles and use of new technics in managements is essential (TQM, 2016). Meanwhile, present-day environment of organizations faces managers with new challenges and it becomes increasingly more dynamic. Global competition and expectations of developing expectations put forward new managerial needs. Concepts of participation, empowering, group work, flexibility and so on are raised as mainstream issues of organizations. Meanwhile, TQM is one of the most useful and effective methods used in managerial systems that effectively include topics of quality. In this study, given the abovementioned points which shed light on the importance of adopting TQM in construction projects, one examines the effects of use of TQM in increase of productivity of constructions sites of steel structure. Therefore, at first we introduce the TQM and we deal with obstacles in the way of its implementation, then the operational strategies and solutions of establishing of TQM are expressed, and then are expressed and through civil industries simulation that its final product of this process is construction of a civil plan one deals with implementing a pattern of TQM in the process of construction.

## 2. INTRODUCING TQM

TQM is used in recent years in the field of trade. TQM is considered as the improvement of traditional methods of accomplishing work and trade and a proved technic for ensuring the survival in competitive world. TQM is a systematic structure which stresses on the continuous improvement of all internal activities of an organization. The final goal of TQM is improvement of quality of products and services through improvement of human resource (HR), process and equipment and decrease of costs of operational area. TQM is expansion of philosophical concept stating that services and productions are delivered always with a better quality to internal and external customers of organization, and through receiving feedback from

these customers the qualitative features of any production or service can be determined (Rabiei, 2014).

### 2.1. TQM history

The cornerstone of quality management is founded by Edward Deming American scientist which is established during the years after WWII in Japan. Residence of Deming at the beginning was based on statistical technics of quality control which has been presented by Walder Shohart that Deming was working under his supervision in Bell laboratories in New York. After world war, the attention shifted from quality to production and as a consequent, use of statistical control approach decreased. Similarly, the Japanese workers have acquired the simple statistical technics, so that they could use these technics in processes of continuous improvement for increasing the quality and efficiency. Later, the TQM prevailed in other regions of the world especially in United States and Western Europe (Rabiei, 2014).

### 2.2. Use of TQM in improvement of qualitative performance of construction projects

The problems of quality control in construction industries such as low quality of implementation, lack of attention to work environment and HR and costs of re-working give rise to attention to establishing quality management system in these industries. Construction industries, given the assigning a great part of countries budget to itself is of high importance and applying management of quality on them for continuous empowerment, meeting needs of requesters, decrease of re-working, increase of employees engagement and collective work results in considerable profitability. From near one hundred years ago, quality supervises all parts of activities of fabrication and production in Europe and America. Meanwhile, numerous concepts of quality are alternatively appeared and disappeared. Activities of quality control are placed in a wide range which leads to from one hand, failure of doing any activity, and from other hand heavy activities that results in rapid progress of qualitative activities. At the beginning of the development process, not only the quality wasn't an important issue, but also even it hasn't been measured (Lilrant and Noriaki 2014).

### 2.3. Obstacles on the way of applying the TQM

As applying the TQM calls for extensive changes in all fields, doubtlessly it faces with resistance:

- A lot of employees may consider the TQM as a fad innovation.
- In this system, employees may consider the management only involved in production of product and its quality and feel that the needs of employees are not important for management.
- Employees may assume that their current products and services are placed at high level, consequently there is no need to paying attention to the quality.
- Establishing this conviction that by establishing the TQM the only outcome is paper working and waste of time and there is no improvement.
- Traditional employees have no tendency to use numerical statistics and data in their work.
- Resistance of management against employees empowerment process based of this conviction that in case of if employees participate more in decision making, the role of management would be decreased.
- The crisis of fragmentation, that is, each unit consider itself as a separate part with no relation with other parts and there is no need to their collaboration, however, it can be the case if the TQM fails to be accomplished properly.
- Lack of tendency of a lot of people to participate while there is need to participation of all employees in all levels.
- Lack of sense of commitment with regard to quality among many employees and doing the work only for gaining income.
- Negligence of subsidiary contractors with regard to quality.
- The feeling that work of employees become harder and their latitude is decreased (Lilrant and Noriaky 2014).

#### **2.4. Strategy of establishing TQM system**

TQM is an evolutionary system as it evolves with regard to success of firms for continuous improvement of commodities and services for increased satisfaction of customer in a world that is changing rapidly.

For attaining the ideals of TQM and tackling the obstacles, following solutions are considered for establishing TQM (Lilrant and Noriaky 2014).

1. Stating what is accomplishing.
2. Determining, defining, describing and writing what is being stated.
3. Matching what is being written with requirements specified in standard.
4. Continuous accomplishment of what is written.
5. Attracting and preserving the participation of all employees for attaining the quality.

6. Converting the customer satisfaction into customer trust.

Converting the thinking to quality into believing the quality and believing the quality into culture of quality.

Establishing a transparent and common view, integrating and stability of objectives.

Establishing motivation in employees by encouraging the factors that play along the accepted principles of management of quality.

Pointing out the approaches and tools of attaining the quality in works through a set of purposeful didactic workshops.

Establishing and development a relational system for full-fledged communication the messages of TQM.

### **3. EXAMINING THE CURRENT STATUS OF CONSTRUCTION FIRMS IN TERMS OF QUALITY MANAGEMENT**

Examining the current status of qualitative parameters of construction firms through field study has been done based on devising a questionnaire among firms. Near forty construction firms working in the field of design and consultancy and construction are selected for conducting field study and statistical study and the designed questionnaires are distributed among these firms. Selection of firms is done based on pecuniary and administrative abilities as well as their ranking of country management and planning organization. In each table, some questions on one of special components of TQM in design or contractor firms is questioned and their answers are classified in four classes: rarely, usually, often and always which is interpreted on numerical base from one to twenty. Seven firms among nearly forty selected firms have given complete answer to the questions. The received answers are statistically studied and the results of the studies are reflected in tables I to III.

Table I examines the common qualitative components between construction firms (design and contractor). In table II, special components of quality in design firms are separately studied (Faqihi, 2016).

As one can see in tables I, II and III, based on the studies of construction firms, they are at low level in terms of quality and management of quality. Design firms are at higher level than contractor firms when it comes to compliance with quality management and one can note that design firms have a simpler way for establishing quality management and achieving to qualitative standards such as ISO9001(Faqihi, 2016) from data of table I, one can argue that management commitment,

education and participation of employees which are among important components of TQM are at low level in construction firms. There is no program of education of work skills and education of quality in most of construction firms and this derives from negligence of managers of firms to importance of education. The amount of employees participation also isn't at desirable level. The amount of effect of employees view on the director decision making, and attention to views and propositions of employee is at low level and there usually are no suggestion systems in construction firms. Similarly, employees are rarely aware about requirements of customer (employer). When it comes to communication, the amount of information of management on status of firm resources particularly in contractor firms is not at pertinent level and similarly rapidness and quality of information transfer to employee from superior managers is not appropriate.

Table 1. studying TQM in construction firms

Title of questionnaire	Number of questions	Score from 20
Work environment and infrastructure	4	11.05
Organization policy	8	10.86
Documents control	3	10.63
Customer orientation	4	9.88
Relations	6	9.32
Management commitment	5	9.07
Management revision	7	8.4
Education and motivation of employees	6	7.95
Employees participation	6	7.89

Table 2. Examining TQM components in design firms

Number of questions	Score from 20
8	15.69
10	14
6	13.75

Data of table 2 shows that in design firms there is usually no problem solving practices in the form of collective work and one pays less attention to requirements of contractor as customer and the greater attention is paid to employer's need due to gaining pecuniary interests. Design revision and use of value engineering for finding better options in design and registering the outcomes from revision that has a great effect on quality and cost of implementation has been less addressed in design firms. There isn't usually any documented practice for registering the outcomes obtained from

views of employers and contractors in design firms (Faqihi, 2016).

### 3.1. Effect of TQM on improvement of organization performance

In production, service, governmental, educational, transportation sections and other organization, the trend of TQM has been prevailed. Sangeh believes that the reason of failure of many firms and organization lies in their deficient interpretation from concept of TQM and without existence of an overall and extensive framework and concept of quality movement in the society, this concept would be isolated in any country. The important problem in implementation of quality management is that this view faces with some problems depending on its particular position and objectives. Therefore, one cannot implement it as a constant set-up in any organization, yet the most important initiative for implementing it in any formations is adapting the attitudes with the status of that organization. TQM calls for use of information that has been collected in an organized manner during various steps of decision making. This information provide some facts about problems, the reasons of occurrence and selection and trying the solutions. Fourth principle is continuous learning and improvement. Health (survival) of any firms is met when improvement of quality is considered as a continuous way. Sense of commitment for continuance of improvement causes that members of organizations never give up the learning (Hajipour, 2014).

## 4. STUDYING THE USE OF TQM IN OTHER COUNTRIES:

### 4.1. Studying TQM in Japan

During 1950's decade, Japanese goods were well-known for low quality and low price, however during 1970's decade and onward, the products of this country were famous for having high quality and moderate price, consequently, these changes increased the amount of japan exportation and brought about shortage of balance of trade for some countries with regard to japan. This was outcome of revolution of quality in japan industry. Two factors can be studied in this revolution of quality: 1) factors of japan success 2) japan total quality control.

According to studies by syndicate of Japanese scientists and engineers the main driver of these great economic changes in japan was their success of comprehensive activities of quality control of small and big industries. After discussing Deming

view in Japan and accepting it by Japanese industries, this system (TQM) presented by Deming has been studied by scientists such as Juran and Ishikawa. This system has been mixed with sociocultural system and national features and Japanese didactic standards through trial and error.

In Japan, continuous and systematic educations of quality control caused that a great investment and energy is spent for human education for activities of quality control. These educations of quality control are implemented in all levels of organization so that they produce Kaizen everyday (Shekarchizadeh, 2016).

#### **4.2. Examining TQM in United States**

During recent years, United States faced with a drastic competition in global market. From one side, the countries of European Union and from other side Pacific countries and recently, China are among major competitors of United States in the area of productions and economy and international revolution in quality and productivity inserts a heavy pressure on U.S. economy (Shekarchizadeh, 2016).

The viewpoints of American Deming gave a new lease of life to economic life of Japan during 1940's and 1950's decade. Americans noticed hastily that they lag behind regarding the quality. Therefore, they dispatched their experts to Japan and brought Japanese counselors to U.S. showing that at 1980's the motto of U.S. was hunting the quality. Americans managed to update the American TQM variant using new achievements of Japanese TQM and they decreased to some extent their lagging behind in quality with regard to Japan.

#### **4.3. Examining the TQM in Taiwan**

In a study from 500 top firms of Taiwan, as Pacific countries have been damaged from the economic depression, however, Taiwan managed to use the crisis as an opportunity. Along financial factors discussed by economists, the quality management should be viewed as a major driver in this improvement. This study examines how quality topics especially TQM is used during last decade in Taiwan industry. Questionnaires are designed for collecting information from 100 top firms of Taiwan. It presents statistical analysis for evaluation of TQM effects and similarly, some suggestions for improvement. In this study, answering to study rate was 25% (among 300 questionnaires, 75 questionnaires). Two questionnaires were not valid due to impropriety

of answers, finally 73 questionnaires have been studied.

18% firms used TQM more than 10 years, 33% between 5 and 10 years, 36% 1 to 5 years and 13% less than one year (Shekarchizadeh, 2016).

#### **4.4. Studying TQM in Iran organizations**

Studying the client honor program in Iran Insurance corporation along TQM use in governmental firms of Iran in a competitive environment, those organizations can survive that can meet the clients satisfaction. Short term gain to the expense of losing satisfaction of client lead to lack of survival of organization at long term. Instead of adapting the customer with organization services, organization should adapt with customer needs and expectations, thus, the amount of people satisfaction and clients about presented services by organizations serve as one of main indexes of measuring the growth and efficiency of administrative and operational system. Client honor plan, given the approval and agreement of administrative high council is communicated to operational entities as one of seven plans of administrative system change with number 13/18540 dated 2004-4-29. Iran insurance corporation has done some initiatives on implementation of this plan for realizing this approval and the client honor plan is delivered to general office of performance evaluation at the second half of 2013.

After communicating client honor plan by assistant, the plan is sent to all of provinces and branches of country as operational instruction and along this instruction, the general office of evaluation of performance has carried out serious performance (Shekarchizadeh, 2016).

### **5. RESULTS FROM TQM IN CONSTRUCTION ( WITH CASE STUDY)**

At the beginning, the steps of model ISO 9001 which is one of approaches of applying TQM in construction industries are explained for each operational step and its step on increase of profitability is explained.

ISO 9001 model steps include following cases. ISO is divided into four parts that each one has bearing on continuous quality improvement.

1. responsibility of management
2. resources management

3. realization of product

4. measuring, analysis of improvement

The studied building in this research is a 4-stories steel structure building with 60 residential units with steel deck ceiling constructed in Kerman with 6950 meter square total area. Employer of construction of this building is Islamic Revolution Housing Foundation (IRHF).

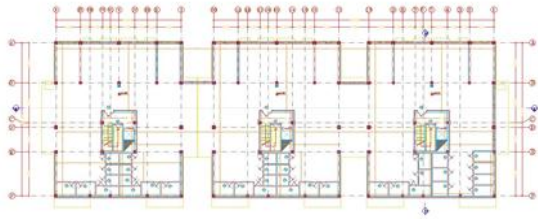


Figure 1: Studied building plan

Therefore, in the following, the effect from applying the TQM in various steps of constructing the building is described in a step by step manner:

#### 5.1. Effect of applying TQM in the step of implementing the foundation:

When it comes to policy of quality, one should pay attention to improvement of methods of implementation and standardization of methods and organizing didactic courses for employees and managers of the site. For example one should use state-of-the art tools of concrete such as concrete pump and spacers of formwork and even new concretes such as self-compact concrete to elevate the qualitative level of product, namely implementation of foundation to result in living up to employer satisfaction. In the studied project, it is needed to use qualified contractor and to use pertinent material such as cement produced in valid factory which has standard and rebar produced in authentic factory with sign of quality standard and with conditions in accordance with the plan to reach to required quality and resistance and one should comply with some points for maintenance of materials for example one should keep the packed cements in pertinent conditions for preventing hunching and bulk cement should be kept in pertinent silo and the required rebar in pertinent conditions for preventing the rust to boost the quality and as one can see by implementation of TQM model in this step one can reach to pertinent and high quality.

#### 5.2. Effect of applying of TQM in the step of implementation of steel structure and steel deck ceiling 22:

In the step of implementation of foundation, in the case of special case of welding and concrete and formwork and reinforcement of ceiling, one uses the qualified consultants of this field to elevate the quality of plan. One should carry out the operation control, that is, based on operational data and information, and operational plans and work instructions one should control the process, for example in the step of cutting and welding of structure and formwork and concrete of ceiling, it is essential to control the codes and instructions. In the subsequent step, one should identify the problems and flaws of the process to repair or destruct in the case of unacceptable products or cases. When it comes to quality policy, one should try to improve the operational methods and standardization of methods and organizing the didactic courses for employees and managers of the site. For example, regarding the standardization and improvement of methods of implementation, one can use the new approaches and tools of welding such as submerged arc welding (SAW) for implementation of structure and one can use new methods and tools of concrete for implementation of ceiling such as concrete pump and concrete spaces of molds and even new concretes such as self-compact concrete to elevate the quality level of product, namely structure and ceiling to result in satisfying the customer satisfaction and similarly, as it has been discussed, the required relations in this step between members of site should be established for applying the intended model. One should use expert HR with skill and the workers of this section such as welders and reinforcement and concrete workers should receive certificate of accomplishing the work so that everyone would be assigned in the work according to expertise. One can see that by applying the TQM in this step, the quality of work is elevated and the final goal, namely satisfying the satisfaction of user and customer is achieved.

#### 3.5. Effect of applying TQM in the step of wall masonry and implementation of door and window:

When it comes to quality policy, one should improve the implementation approaches and standardization of approaches and organizing didactic courses for employees and managers of intended site. For example, regarding the standardization and improvement of implementation approaches one can use new tools and methods and new material of wall masonry

such as LECA blocks or Knauf drywalls and for installation of door and window one can use UPVC profiles and double glazed windows to enhance the quality level of product, namely installation of door and window to result in customer satisfaction. As it has been discussed the required relations in this step between members of the workshop should be realized for applying the intended model. Similarly, in this step, one should use expert HR and the workers of this section such as masonry workers and installers or welders of door and window should receive certificate of work so that everyone would be assigned in the work given the expertise. Also, one should organize necessary trainings for other employees especially the incumbents of maintenance of site machinery to increase the quality in the work and reduction of errors and reworking and decrease of project costs. At the step of wall masonry and implementation of door and window, the planning of the product should be done, that is, in this step, in the case of particular cases of welding and masonry, one should use qualified consultants to increase the quality of the design. One should control the operations, that is, one should control based on data and operational information and plans and work instructions. For example, for installation of door and window and in the step of wall masonry it is essential to control the codes and instructions. In the subsequent step, one should identify the problems and flaws of the work to repair or destroy in the case of unacceptable production. As one can see, implementing the TQM can increase productivity in all steps of construction of the mentioned building and gives rise to optimal use of resources and material for reaching to desired objectives and quality.

## **6. CONCLUSION**

In the step of implementing the metal structure and construction of composite ceiling some problems such as specifying the duties and obligations, training employees and managers, use of new approaches and material and tools, relation between employees, use of expert HR, identifying the required machinery with sufficient number and pertinent arrangement in the site, control of documents such as blueprints, reports, welding and concrete laboratories, and order of work and schedule, control of operations, use of pertinent material and standard and maintenance and warehousing of material in a suitable manner which are among operational points of TQM in this step increase the quality and this increase of quality has a direct relation with productivity, that is, as quality increases, the productivity increases too. For example, use of people with welding skill

card as welders prevent the reworking and consequently the quality of welding is increased, and the cost is decreased and productivity is enhanced. By identifying the machinery and pertinent array of concrete machinery for construction of ceiling there is less time needed for operation and the operation cost is decreased and productivity is increased. As it has been discussed, in this step, the TQM has direct relation with increase of productivity, that is, as one uses TQM, the quality is increased and the productivity is increased.

At the step of wall masonry and installation of door and windows some points such as specifying the duties and obligations, training of employees and managers, use of new approaches and material and tools such as use of new drywall blocks such as LECA and CLC and for installation of door and window, use of UPVC double glazed windows, relation between employee and equipments of installation of wall and installations of door and window, use of specialized HR with related skills such as using masters with masonry skill card for implementation of wall, identifying required machinery and its sufficient quantity with suitable array in workshop, control of documents such as blueprints, orders and schedules, control of operations, use of pertinent material and standard and maintenance and warehousing of material in a suitable manner which are among points of implementation of TQM in this step increase the quality and this increase of quality has direct relation with productivity. That is as quality increases, productivity is increased too. For example, use of new material such as LECA and CLC blocks in wall masonry decreases the dead load and consequently, it increases the quality of drywalls and decreasing of steel profiles in the structure and ceiling gives rise to saving of cost and increases the productivity. As it has been discussed, in this step, TQM has a direct relation with increase of productivity, that is, implementation of TQM system increases the quality and productivity. As it can be seen, implementation of TQM in the steps of construction of studied steel structure increased the quality and in addition to increase of quality, given the optimization and management of costs, it reduced the costs without reducing the quality. That is, applying TQM systems increases quality and productivity, and one can note that TQM not only increases the quality, but also it has the attitude of increases the productivity.

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