Hand-Over Process Improvement in Large Construction Projects

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Key words: construction management, process improvement, six sigma, TQM, CPM, PERT

SUMMARY

Unlike any other industry, construction industry has not fully implemented TQM philosophy. This can be attributed to the complex nature of construction projects, which has numerous and overlapping activities. The present research is an attempt to solve one of the major problems in large construction projects, manifested in the delay of handing-over apartments to end customer in contracted time. The DMAIC procedures of the Six Sigma, problem-solving methods together with the CPM and PERT project planning techniques have been integrated in this research to achieve the required objective.

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1. INTRODUCTION

How to manage the uncertainty and complexity within the characteristic construction conditions of site production, alterations and concurrently working contractors?
When it comes to improving work process, the construction industry does not have a good reputation in comparison with manufacturing industry. The problem however, can be attributed to the nature of the construction industry, which lacks solid data gathering and suffering from the exceptional fluctuation in productivity. Attempting to measure the performance of construction operations are bound to face difficulties such as processing change order, which affects project planning and time scheduling.

2. PROBLEM STATEMENT

Although most of the large construction companies are ISO certified and some of them have quality management systems, and internal/external audits, the present research shows a low performance improvement efficiency to achieve end customer satisfaction for delivering the product, which in our case is the apartment hand-over (H-O) within contracted time.

3. SCOPE AND OBJECTIVES

The scope of this research has been limited to large construction projects. The main objective of this research has been identified as finding a method to solve the problem of delay in delivering the product (apartments hand-over) in construction industry. The study has been conducted to measure the perception and implementation effectiveness of the quality management (such as TQM) in construction industry. This was done to provide means for effective application of the quality management system by integrating it with other operational management methodologies such as DMAIC, problem solving and project planning techniques.

4. RESEARCH METHODOLOGY

To achieve the research objectives, the following methodology was adopted:

1. A survey was conducted for TQM implementation in Egypt, as an example for developing countries, which was compared to another survey done by Syed (2005) in the United State of America, as an example for advanced countries.

2. A new approach has been developed by applying DMAIC technique as a Six Sigma tool for problem solving. This approach is composed of the following phases:

a. Define phase
Define the problem through the case study.

b. Measure phase
Using graphs, trends and questionnaire results.
c. Analysis Phase
Analyzing the data, graphs and questionnaire results.
d. Improve Phase
Several improvement steps have been conducted, namely:
- Applying team approach in daily management and problem solving.
- Proposing a procedure for modifying the apartments.
- Applying CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) to determine the expected project time to finish each modified apartment.

e. Control Phase
A procedure has been proposed for sustaining the achieved results and continuous improvement.

3. QUALITY MANAGEMENT EVOLUTION

Fig. 1, is an illustration of the well-known stages in the evolution of quality management systems, starting from Craftsman and ending with TQM in 1980.

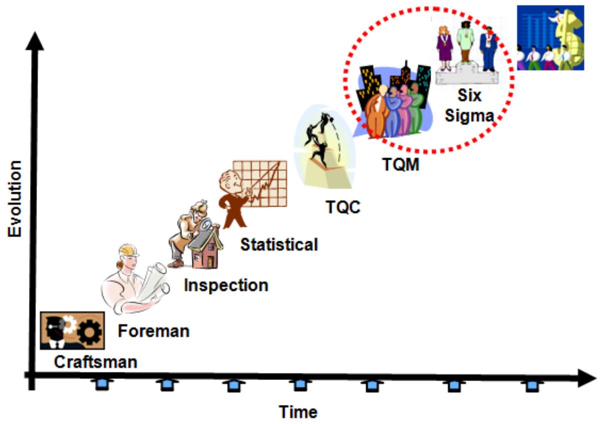

Fig. 1. Quality management systems evolution, Figenbaum (1991)

Recently many firms have started to apply other new operational methodologies for Quality Management such as Six Sigma and Lean Six Sigma.

4. PROJECT IMPLEMENTATION GUIDELINES FOR TQM

Successful implementation of TQM in construction projects can be achieved through persistence, positive hands-on leadership, upfront preparation and continuous maintenance of a sensible plan. The basic steps of the implementation of TQM in construction projects can be summarized as follows, Pheng (1996):
1. Generate awareness, educate project staff and introduce change attitude.
2. Develop and document approach to TQM for projects but do not degenerate into paper bureaucracy.
3. Prepare project quality plans for all levels of work.
4. Install organization and managing bodies.
5. Institute continuous improvement.
6. Promote staff participation and contribution by quality control circles and initiate motivation program.
7. Review quality plans and measure performance.

5. TQM INADEQUACY IN CONSTRUCTION INDUSTRY

According to many researchers, TQM is not adequately implemented in the construction industry. Achieving success in implementation requires integration of interpersonal and technical aspects Love (2000), Snee (1999) and Culp (1993). TQM can be successfully implemented in construction industry by adopting more studies to best employ its philosophy, Burati (1994). TQM in construction industry requires fundamental culture change Love (2000). Quality Improvement is difficult to achieve unless quality is accurately and periodically measured, Trobica (1999).

6. QUALITY IMPROVEMENT FACTORS IN CONSTRUCTION INDUSTRY

Studies have been conducted to define the most important factors that affect the quality of the Egyptian construction industry. Two studies have been conducted to evaluate the change in the weight of factors affecting the quality of the construction industry within 6 years. The results are presented in this way "The higher the weight the more the need for improvement." The studies considered both the suppliers' and consumers' points of views. The first study was presented in 1998, and the second study was presented in 2004, Hassan (2004). Table I, compares the evolution of the factors' weights between years the years of 1998 and 2004. The results can be summarized as follows: four factors experienced improvement (reduced weights), nine factors had the same relative importance (almost same weights) and three factors had higher weights in 6 years. This means that only 25% of the factors had passed steps of improvement, while 75% still need improvement.

TABLE I
COMPARISON OF MOST SIGNIFICANT FACTORS WEIGHT AFFECTING CONSTRUCTION QUALITY BETWEEN 2004, and 1998 in EGYPT, Hassan (2004)

No.	Factor Description	1998	2004
1	Improving design and planning during the	16.67	9.3
2	Developing and improving quality	10.52	8.7
3	Improving utilization of resources	4.93	7.9
4	Improving the financial performance	9.2	7.6
5	Improving the accuracy of Cost Estimating	8.18	7.5
6	Proper classification of contractors,	7.07	6.9
7	Improving training of contractors, owners,	5.26	6.8
8	Employee conscientiousness	6.25	6.7
9	Increasing contractors' technical and	4.93	6.1
10	Encouraging ISO 9000 implementation	5.1	6
11	Improving maintenance systems during	4.93	5.9
12	Encouraging and improving specialization	4.27	5.2
13	Participating and co-operating with large	3.12	4.3
14	Co-operation with national construction	4.27	4
15	Defining responsibilities between project	2.96	3.8
16	Encouraging implementation of simpler	2.14	3.4

7. WHAT IS SIX SIGM?

Six Sigma is a management methodology that attempts to understand and eliminate the negative effects of variation in processes. Define, Measure, Analyze, Improve and Control (DMAIC) is a map, or step-by-step approach, to understand and improve organizational challenges. At the heart of Six Sigma is the principle of variation reduction to achieve "Six Sigma quality," a statistical reference to 3.4 defects per million opportunities, Thomas (2005).

Dating back to mid 1980s, application of Six Sigma method allowed many organizations to sustain their competitive advantage by integrating their knowledge of the process with statistics, engineering, and project management, Anbari (2002). Six Sigma is a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on outputs that are of critical importance to customers Snee (1999).

Mikel Harry (2000) offered another definition of Six Sigma: "Six Sigma is a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste in resources while increasing customer satisfaction.

Frank Anbari (2002) pointed out that Six Sigma is more comprehensive than prior quality initiatives such as Total Quality Management (TQM) and Continuous Quality Improvement (CQI). The Six Sigma method includes measures and reports financial results. It uses more advanced data analysis tools, focuses on customer concerns, and uses project management tools and methodologies, Bechtel Corporation (2008). Six Sigma management method can be summarized as follows A. Syed (2005):

Six Sigma=TQM+Stronger Customer Focus+Additional Data Analysis+Financial Results+Project Management (1)

8. DMAIC PROCESS

DMAIC is a closed loop process that eliminates unproductive steps, often focuses on new measurements, and applies technology for continuous improvement. Table II, presents key steps of Six Sigma using DMAIC process, McClusky (2000).

TABLE II
KEY STEPS OF SIX SIGMA USING DMAIC PROCESS, McClusky (2000)

Six Sigma Step	Key Processes
Define	-Define the requirements and the expectation of the customer -Define the project boundaries -Define the process by mapping the business flow
Measure	-Measure the process to satisfy customer needs -Develop data collection plan -Collect and compare data to determine issues and shortfalls
Analyze	-Analyze causes of defects and sources of variation -Determine the variation of the process -Prioritize opportunities for future improvement
Improve	-Improve the process to eliminate variations -Develop creative alternatives and implement enhanced plan
Control	-Control process variations to meet customer requirements -Develop strategy to monitor and control the improved process -Implement the improvement of systems and structures

9. CASE STUDY

The case study of this research was the San Stefano Grand Plaza Project. This project is considered as one of the biggest complex buildings in Egypt. It was built on an area of 32,455 m^2 with 170 m as frontage alongside the beach. The project consists of 30 floors of mixed use, which comprises:

- Four Season Hotel
- 954 residential units
- Six Floors for retail stores, entertainment and food courts and 10 Movie theatres.
- Three floors underground parking,
- Beach Cabanas and Marina activities.

As a big construction project it included multi concurrently operating organizations. These organizations included the owner, the consultant, the management company, and a big number of contractors and suppliers. Fig. 2, shows the relationship between the project parties.

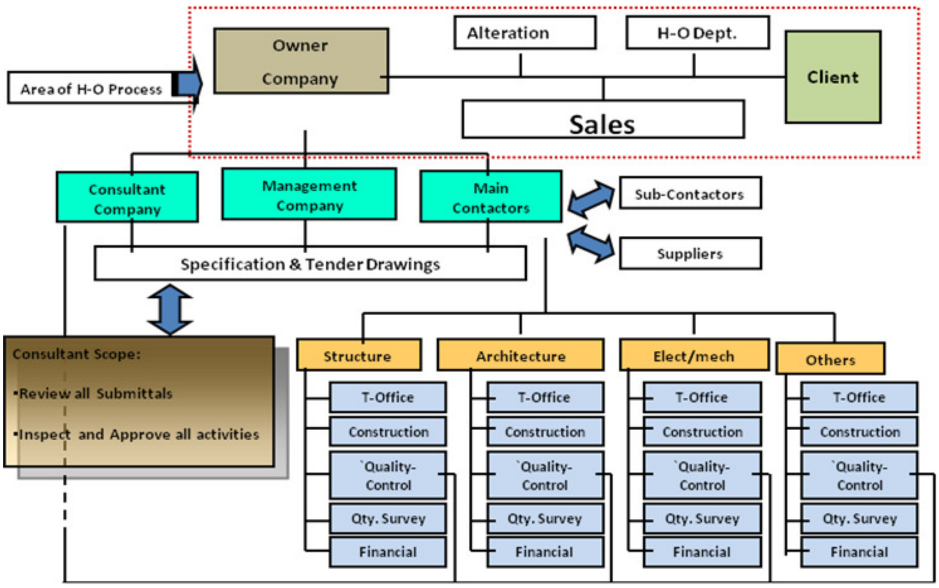

Fig. 2. Flowchart of relationship between parties in the case study project

10. DMAIC PROCEDURE IN THE CASE STUDY

The DMAIC methodology maybe used when the applied quality management process does not achieve the customer satisfaction or is not performed efficiently. The DMAIC process starts with the define Phase.

10.1 Define Phase: Identifying case study problem

The case study problem was the delay of handing-over the apartments (product delivery) to the end customer beyond the time schedule. The problem was identified through:

1. The process of internal audit, which is a routine procedure;
2. The tenant's complaints; and
3. The individual meetings between the chief executive officer of the project and the departments' mangers.

10.2 Measure Phase

The objective of this phase was to measure the current process performance. In this phase, data were collected for a period of 12 months. The actual number of apartments handed-over was compared to the number of apartments that were contractually expected to be handed-over. Table III displays a sample of collected data; the population was 100 units of apartments, which were delayed in handing-over.

TABLE III
MEASUREING THE CURRENT PROCESS PERFORMANCE

No.	Type	Area (m^2)	Finish	No. of Contractors	Delay (month)
1	U	290	S	2	> 12
2	A	402	M	2	3-6
3	A	402	S	2	3-6
4	C	361	S	2	3-6
5	C	361	M	2	3-6
6	A	402	M	2	6-12
7	A	402	M	2	6-12
8	A	402	M	2	6-12
9	A	402	M	2	6-12
10	U	290	M	2	> 12

The sample included the relevant data for the handed-over apartments, which is summarized as follows:
1. Apartments' types for example, type A, B, C, U…..etc.;
2. Apartment area;
3. Finishing type; Standard (S) or Modified (M) upon client request;
4. Number of contractors executing the works in each apartment;
5. Delay period month's slots.

Fig. 3, shows the contractual (planned) and actual number of handed-over apartments in a period of 12 months. Instead of handing over 180 apartments, only 135 apartments were handed-over, which means a 25% delay in product delivery.

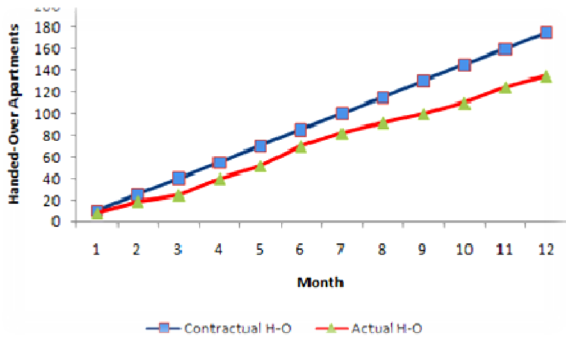

Fig. 3. Comparison between contractual and actual number of handed-over apartments within an interval of 12 month

To diagnose the reasons behind the delay, investigation had to be carried out through interviews and questionnaires. These were carried out with the executive managers of the different parties involved in the project as well as the tenants. Questionnaire #1 was designed to measure the contractors' current perception of TQM. Questionnaire #2 was designed to identify the processes that need improvement from the customers' point of view. Questionnaire #3 was designed to point out the most possible causes for the hand-over delay of apartments. The structure of the three questionnaires is shown in Fig. 4.

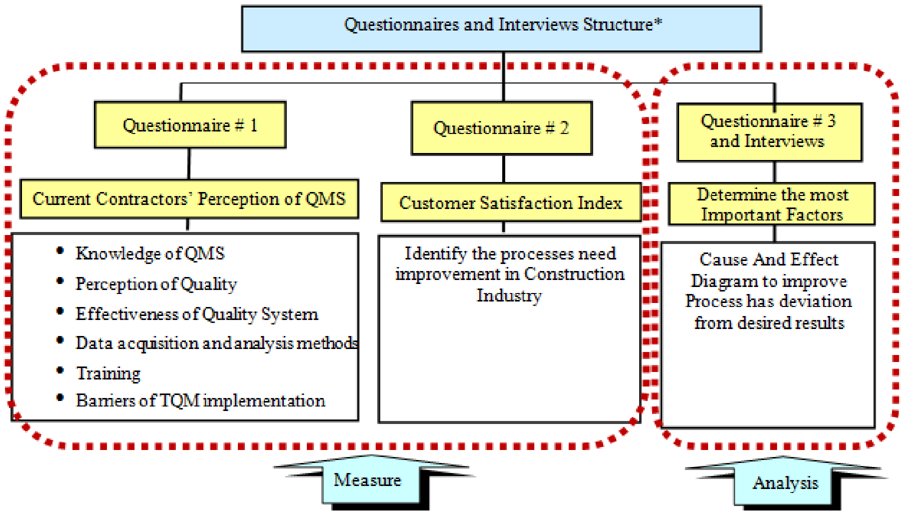

Fig. 4 Structure and objectives of the designed questionnaires

From the result of questionnaire #1, some obstacles were discovered, which hinder an effective implementation of TQM in the case study project as a sample of large construction projects. Some of the obstacles were:

1.Changing behavior and attitude of employees;
2.The need to emphasis on short-term objectives;
3.Lack of expertise in TQM;
4.Lack of training to drive the improvement process;
5.Lack of top management commitment;
6.Too much paper work required (lack of documentation ability); and
7.Tendency to cure symptoms rather than getting to root causes of a problem.

From the results of questionnaire # 2 it is was easy to identify the causes behind the customer dissatisfaction, which could be summarized as follows:

1. Poor planning;
2. Lack of attention to client priorities;
3. Poor Scheduling; and
4. Inadequate change orders processing.

10.3 Analysis Phase

From the questionnaires and records data analysis, some facts have been discovered, which contributed to the problem of delaying the handing–over of the apartments. These causes could be summarized as follows:

1. Most of the delayed apartments had change order processes, which are modifications requested by the clients as shown in Fig. 5.
2. Most of the delayed apartments had more than one contractor working on the alterations. Therefore, the delay was mainly due to miss coordination between contractors, as shown in Fig. 6.
3. The data collected showed also that, as a standard procedure, the company was giving a contractual commitment to finish all the apartments' modifications within a period of six month, no matter what the nature of the modifications were or how complex they are.

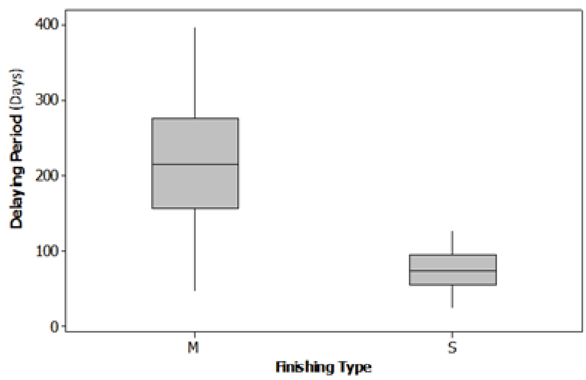

Fig. 5. Box plots comparing the delaying period between Modified(M) and Standard (S) Apartments

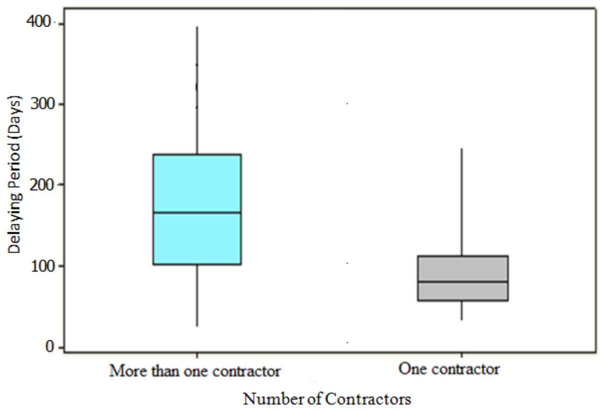

Fig. 6. Box plot displaying the relationship between delaying period and number of contractors.

Fig. 7, shows the flow chart followed in case of a customer request for apartment modification. The Fig. displays how complex and the amount of communication needed for this process.

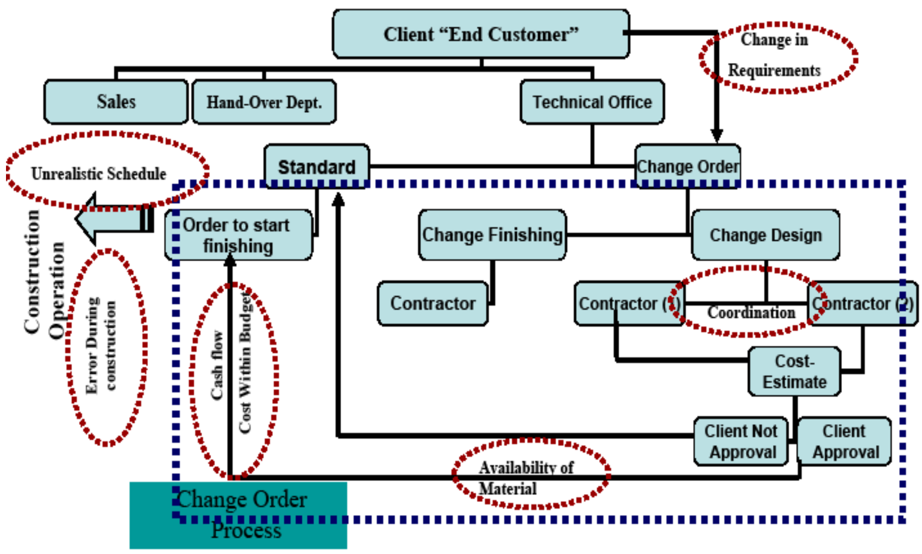

Fig. 7. Apartments' modification and hand-over interrelated functions and flow chart

The objective of the analysis phase was to examine the data collected in the measure phase and generate a prioritized list of sources of variation that are factors of the customer dissatisfaction. Based on the data analysis, it was obvious that the work procedures of alterations and handing over of the modified apartments needed review and improvement. Fig. 8, shows a fishbone diagram that includes the causes and sub-causes leading directly and indirectly to the customer dissatisfaction. The factors are marked with doted ellipses.

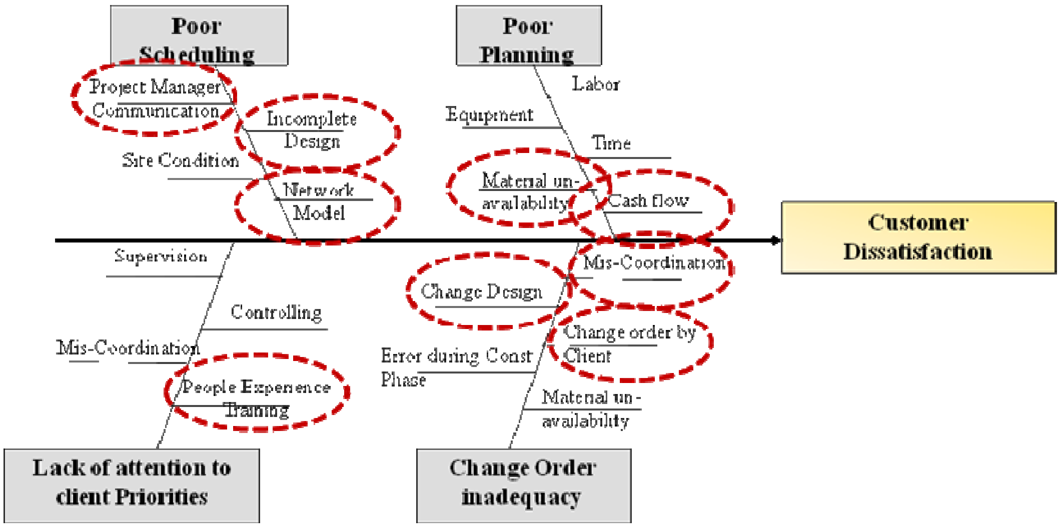

Fig. 8. Fishbone Diagram for causes and sub-causes leading to customer dissatisfaction

During the interviews of questionnaire number 3, causes were given an importance number on a scale from 10% to 100% from the point of view of the interviewed person. The most important factors leading to the problem of delayed hand-over of apartments were ranked according to their average importance as shown in Table IV.

TABLE IV
MOST IMPORTANT FACTORS AFFECTING CUSTOMER SATISFACTION

Factor	Factor Description	Importance
1	Change order by client	80%
2	Incomplete, omissions or defective design	76%
3	Mis-coordination between contractors	75%
4	Design changes	74%
6	People's lack of experience / training	72%
7	Unavailability of materials	71%
8	Project manager mis-communication	71%
9	Lack of cash flow	71%
10	Problems in activities logistics	70%

10.4 Improve Phase

In this phase, developed techniques have been proposed to improve the procedures of handing-over process especially for modified apartments with modifications (change order process). It is worth mentioning that in the case study more than 12% of total apartments have been modified upon clients' request. In attempting to resolve the conflicts and remove the obstacles that may occur during the handing-over process for modified apartments, three steps have been proposed to improve the process as follows:

1.Applying the team approach for daily problem solving.
2.Developing a new procedure for change order processing.
3.Applying the critical path method (CPM) or the project evaluation and review technique (PERT) project planning techniques for modified apartments.

10.4.1 Applying team approach in daily problem solving

The notion of team approach in this research is adopted from the Six Sigma methodology. Several important players are needed to successfully implement the Six Sigma program. The individuals involved in the program were the executive leaders who in turn select the team for solving the identified problems, Fig. 10. The practice proved that, getting the views of a multi-functional team in solving a problem is better than getting only the view of the directly related function. This approach made all other functions that may be connected to the problem aware of its progress. This led to a much better communication in the work environment and hence reduced the time needed to solve the problems.

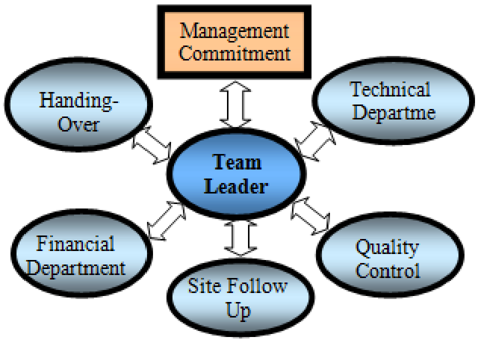

Fig. 10. Team approach and departments involved in the handing-over process

10.4.2 Developed procedure for change order (modified apartments) request

To achieve customer satisfaction the apartment should be handed-over in the stated time. Therefore, new procedure of change order process was developed, Fig. 11, explores this procedure.

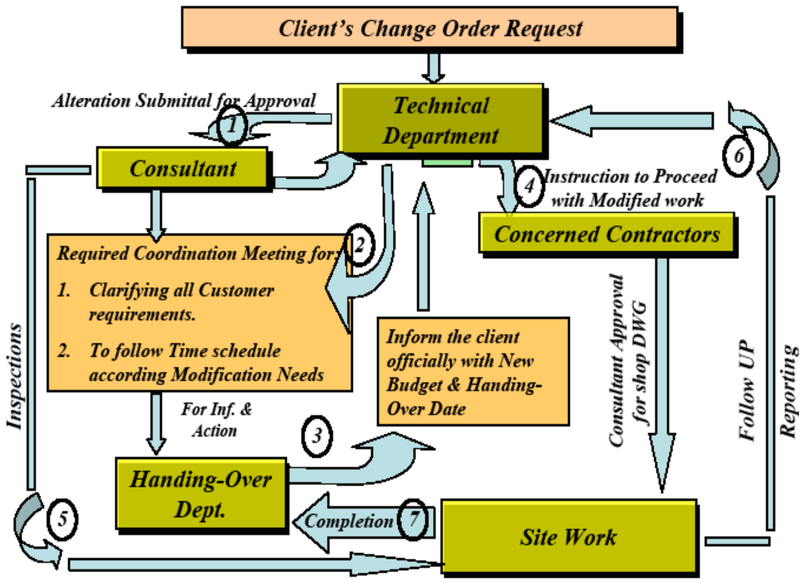

Fig. 11. Proposed procedure for change order process

The developed change-order process is summarized as the follows:

1. Once received the client's request to modify the apartment, all documents and drawing should be submitted to the consultant for approval;
2. After approval, coordination meeting should be arranged between all concerned parties to clarify all customer requirements. In this meeting, the contractor should submit a time schedule for modification. The schedule should be discussed and the client approval for new budget should be obtained;
3. Minutes of meeting should be submitted to hand-over department as an official document;
4. The involved contractor(s) should be followed up and audited on site against the shop drawings periodically. The consultants should carry on the audit activities during and after completion of work to prevent any error or delay on site.
5. Members of the follow up team should provide periodical progress reports to the team leader and should report any obstacles that may delay the work progress; and
6. The client should officially be informed once the work has been completed and final inspection by the consultant has been performed.

10.4.3 Applying network models technique for optimizing handing-over time

The main steps required to apply the network technique in the process of apartment modification is to deal with this situation as a mini project and construct a model for the required project activities that include the following:

1. A list of all activities required to complete the project
2. Estimate the time (duration) that each activity will take to complete; and
3. Specify the dependencies among activities.

The following example illustrates the application of the CPM technique for modifying an apartment. There were twelve activities involved in the modification.

Fig. 12, is the network model representation for the modified apartment required activities. The network facilitates the decision-making on the time needed for modification. Using the estimated time values, CPM calculates the longest path of planned activities to the end of the project, and the earliest and latest time that each activity can start and finish without delaying the project. The critical path showed a 30weeks time needed for modification instead of the unrealistic 24 weeks that was given to all customers.

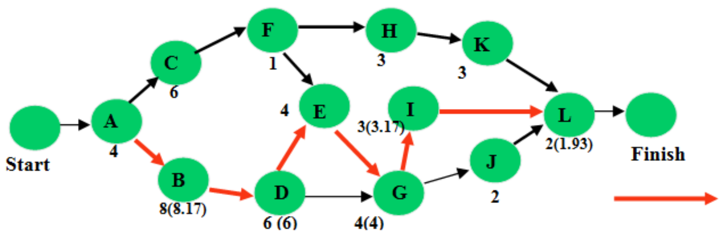

Fig. 12. Applying network model for modified apartments

Table V shows that the estimated project duration equals the length of the longest path through the project network. This longest path is the critical path. The critical path was

(Start→A→B→D→E→G→I→L→Finish) and the estimated project duration was equal to 30 weeks.

TABLE V
PATHS AND PATH LENGTHS THROUGH THE PROJECT OF MODIFIED APARTMENT

Path	Length (weeks)
A→C→F→H→K→L	4 + 6 + 1+ 3 + 2 + 2=21
A→B→D→E→G→I→L	4 + 8 + 6 + 4+ 3+ 3+2 =30
A→C→F→H→K→L	4 + 6 + 1+ 3+ 3 + 2= 19
A→C→D→G→J→L	4 +6 + 6 + 3 + 2+ 2= 25
A→B→D→G→J→L	4 + 8 + 6 + 4 + 3 +3 + 2 + 2=25

The Program (or Project) Evaluation and Review Technique, commonly abbreviated as *PERT*, is a model for project management designed to analyze and represent the tasks involved in completing a given project especially the time needed to complete each task, and identifying the minimum time needed to complete the total project. Applying PERT is more logical than CPM as it depends on three time estimates for each activity namely the optimistic (a), the most likely (m) and the pessimistic time (b), which is the case in most of the construction projects due to the uncertainties that the construction industry deal with.

The expected time (t), and variance (V) for each activity were calculated, which were used to calculate the time and variance for the critical path, and hence modifying the apartment. PERT can give the probability of completing the project on or before a certain time. This example illustrates that, it is necessary to deal with any alteration as a separate project accounting for all activities using the network model to make sure that the actual finishing duration does not exceed an expected time.

10.5 Control Phase

After applying the improvement phase, the team members have to monitor the changes undertaken in the preceding steps to make sure that they are still getting the desired results. Fig. 13, explores the methodology and procedures that have been applied for monitoring and controlling the performance of change order process.

These procedures could be summarized as follows:

10.5.1 Applying statistical methods

- Calculate the frequency of apartments handing-over periodically.
- Analyze the collecting data through graph trends.

10.5.2 Business procedures

- Team members should record site performance and issues on reports
- Project performance should be evaluated from the issued reports.
- Evaluation for both statistical and reported performance should be shared by the teams' leaders and members.
- If the assessment results are acceptable, the control loop should be stopped.

If the assessment results are not acceptable, re-measure and analyze the deviation of current performance then take corrective actions and re-check by repeating control procedures.

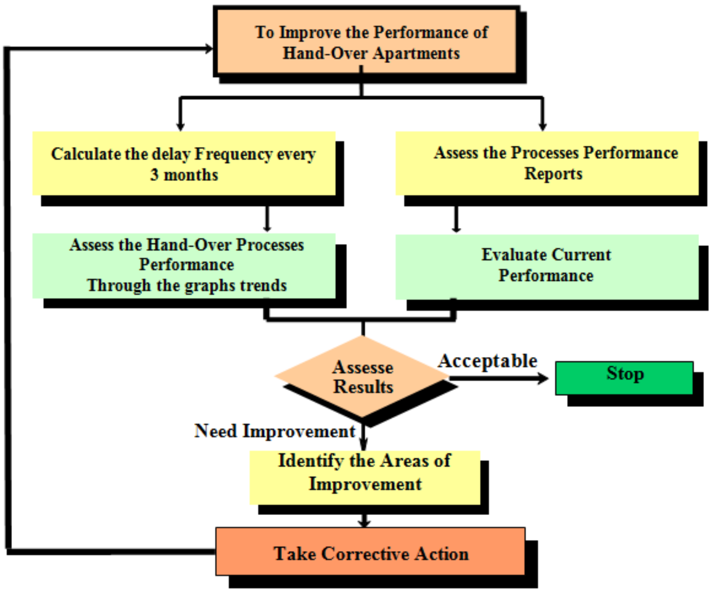

Fig. 13 Proposed procedures as a control loop for Hand-Over process

Applying the above-mentioned improvement techniques resulted in the reduction of the percentage of delayed hand-over apartment during the next 12-month period from the previous 25% to only 4%, which is an improvement of 21% over the previous period as shown in Fig. 14. In the Fig., out of the 180 apartments that were planned to be handed over, 173 apartments were delivered on time.

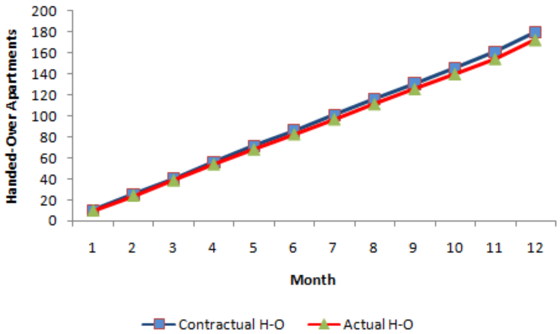

Fig. 14. Comparison between contractual and actual number of handed-over apartments within an interval of 12 month after improvement

11. CONCLUSIONS

Quality management programs in the construction industry still need further development. The basic problem in the large construction projects could be attributed to the lack of communication and planning among the multi-activity parties involved in the project. From the practical point of view, it is hard to determine what variables to measure and how to measure unless there is an effective management system. The system should focus on the performance deviations from the planned results. Using statistical techniques and project planning methods, should be applied in every aspect during the project life. Applying the team approach should help in the diagnoses of the root causes of problems and hence aid in the planning for the countermeasures.

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