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A FRAMEWORK FOR TOTAL QUALITY MANAGEMENT IN THE CONSTRUCTION INDUSTRY IN BAHRAIN

By

JASIM AL-SEHALI
HND, Diploma, Msc.

A Doctoral Thesis submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of Loughborough University

September 2001

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ABSTRACT

The quality of any finished project in the construction industry relies mainly on the specifications written for that project. The specifications are benchmarks for the quality of the project, which should be referred to during all phases of the project. Successful specifications are normally associated with accuracy, clarity, coverage of all clauses, precession and the effectiveness of the description of the materials and methods of fixing. On the other hand, poor specifications often result in delays in handing-over, escalation of prices due to variations, disputes, high penalties, loss of trust and compromise in the quality of the finished project.

The construction industry in Bahrain often suffers from poor specifications. In order to determine the severity of the problem, a questionnaire survey was undertaken to analysis the present standard of specifications used in the construction industry in Bahrain. The outcomes of the survey revealed major setbacks in the standard of the existing specifications such as inappropriate repetition, excessive conflict, unclear and uncompleted clauses with little precession. The majority of respondents called for a change in the situation.

Improvement of quality has become a major challenge faced by the construction industry and can involve, reducing cost, solving problems of rework, reducing maintenance cost and improving the life cycle value of the buildings. Total Quality Management has become one of the best solutions to overcome the problems, and specification could be used as a gate to introducing TQM to the construction industry. Specifications are approach to setting the standard of quality for any construction project, and used as a tool to get design and construction teams committed to the projects quality standards through all stages of the construction process.
The overall aim of this thesis is to develop a framework for implementing Total Quality Management (TQM) in the construction industry in Bahrain, by developing a dynamic specifications model which will help to improve performance in the construction industry, improve consultant-client-constructor-supplier chain relation, control the budget of the project and reduce disputes, claims and variations in the construction industry. The objectives of the research were to:

- improve the quality standard of specification by avoiding discrepancies and achieving clear concise and consistent specifications;
- develop a software package through the dynamic model to write-up specifications, obtain bill of quantities, obtain planning control charts, cash flow and budget control charts; and
- implement TQM to specification by improving communication, introduction of teamwork, creating a common culture, maintaining continuous improvement and implementing value engineering techniques.

The research findings were based upon a literature survey, specification questionnaire, total quality management questionnaire and the proposed model validation questionnaire. From these, the research produced the following achievements.

- The identification of the present problems in the construction in Bahrain, with a focus on the problems with the present specifications in use.
- The study of TQM concept with its relation to the construction industry.
- Analysis of the information technology used in the construction industry.
- Evaluation and comparison between the common software packages used in the construction management.
The development of a dynamic model "PROMANSYS" to be used by the design and construction teams of the quantities, planning control charts, material, labour and plant control charts, budget control charts and apply value engineering techniques to specifications.

The implementations of TQM to the model through the achievement of teamwork, effective communication, creation of culture, continuous improvement of the model and the implementation of value engineering techniques.
CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this thesis, and that neither the thesis nor the original work contained therein has been submitted in support of an application for another degree or qualification at this or any other university or other institution of learning.
ACKNOWLEDGEMENT

I express my sincere thanks to my supervisor Professor. A. D. F. Price for his continuous encouragement, excellent guidance, careful supervision and valuable advice. Without his support, this research would not have been possible, completed and successful. I would also like to express my gratitude to Professor R. McCaffer, for his support and advice as the director of my research.

The author also wishes to thank all government, semi-government, technical offices, consulting engineering offices, constructors and the staff of Andalus engineering in Bahrain who participated in the specification and Total Quality Management questionnaires.

I am also very grateful to the continuous support of my wife Khulood and my children Jenan, Mohamed and Jumana for tolerating me through this research.

I would like to thank Mr. Reynaldo Cabguing for his assistance and help with matters relating to computer programming. My sincere thanks to Mrs. Glenys Davis and Pascale Davis from British Council in Bahrain for proof reading this thesis.

I also would like to express my gratitude to my mother Mooza, who passed away after two years from the start of this research, for her great support and encouragement. To her soul I dedicate this work.
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CHAPTER ONE

INTRODUCTION
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INTRODUCTION

1.1 Introduction to subject

As the world evolves a more global economy, Total Quality Management (TQM) has become a necessity for business survival. TQM can be used by construction firms to fulfil customers' expectations and requirements, and be competitive. The manufacturing industry and other service organisations have already adopted and become proficient in TQM and continuous improvement. Design and construction teams are expected to participate in the quality process as well. Designers and constructors, who can not show a dedication to quality, with an established programme for continuous improvement, will not be able to offer the expected services to their clients.

Egan (1998) identified five key drivers of change which are needed to set an agenda for the construction industry at large: committed leadership; a focus on the customer; integrated process and teams; and quality driven agenda and commitment to people. Targeting an annual reduction of ten percent in construction cost and construction time, it is also proposed that defects in projects should be reduced by twenty percent per year. Prior to Egan Latham (1994) had called for a target of thirty percent cost reductions in the delivery of UK construction projects. Both the Egan and Latham reports call for an increase in client satisfaction, and improvements of product and services provided by the organisation. John Bank (1992) stated that, "getting it right first time, zero defects, prevention, the internal customer, competitive benchmarking, cost of quality, synergy in teamwork, self-management, self-inspection, are all key words and phases in the move towards Total Quality Management."
The research presented in this thesis focuses on the implementation of TQM in the construction industry in Bahrain and the development of a framework for implementing TQM by improved specification production and use, through the proposed dynamic model, project management system named "PROMANSYS".

The construction industry in Bahrain suffers from many weaknesses in the: quality of the finished building; methods of construction; standard of construction specifications used in the industry; number of conflicts and disputes resulting every year from construction sites; level of organisations' management available in the industry; level of workmanship; and constant search for better modes of procuring services within the construction industry.

The survey results showed a lack of awareness for the purpose of specifications and the use of TQM in the construction industry in Bahrain. Level of awareness must be raised through authorities technical offices, technical institutions, engineering and managerial societies and through the media. To improve the level of quality of building in every phase of the construction process of the project until handover to client, to full satisfaction.

Achieving the objectives of the implementation of the framework in this research to the construction industry in Bahrain should work parallel with the raising of the awareness to the importance of specifications and TQM to the construction industry as a whole. This can only be achieved by the joint contribution of the private and public sectors together through all different channels in the construction industry in Bahrain. Like any other quality systems results are achieved with a certain period in time, for TQM program result usually achieved within three to five years in the construction industry organisations.
Achieving these targets comes through the implementation of TQM programmes, which increase customer satisfaction, producing a tidal wave of goodwill and additional business. This in turn encouraged the production of new products and services helping to develop a more effective management focused on the right priorities and empowering people. TQM improves company morale and encourages genuine involvement in decision-making, John Bank (1992).

John S. Oakland (1995) stated that, "continuous cost reduction, productivity and quality improvement have proved essential for organisations to stay in operation". It is not possible to avoid seeing how quality has developed into the most important competitive weapon, and many organisations have realised that TQM should be the way of managing in the future. TQM is far wider in its application than assuring product or service quality, it is a way of managing business processes to ensure complete "customer satisfaction" at every stage, internally and externally.

There are many theories, techniques and tools in the concept of TQM, they generally have the same aim, which is to improve performance through customer-client-constructor-supplier relationships.

In order to initiate and implement TQM in the construction industry through specifications, the main TQM elements, teamwork, effective communication, culture, continuous improvement and value engineering, had to be well implemented in the proposed dynamic model in order to achieve full customer satisfaction and requirements, at the lowest internal cost, whilst maximum teamwork effort in the organisation.
This leads to the definition of TQM described by Dahlgaard, Kristensen and Global (1998) in their book "Fundamentals of Total Quality Management" which states that TQM can be the culmination of a hierarchy of quality definitions:

- Quality: is to continuously satisfy customers' expectations.
- Total Quality: is to achieve quality at low cost.
- Total Quality Management (TQM): is to achieve total quality through everybody's participation.

1.2 Research justification

Lack of TQM

TQM has never been fully implemented in the construction industry in Bahrain. The problems of the present situation in the construction industry in Bahrain generate substantial losses in the national economy, due to the poor quality of finished buildings, maintenance costs, conflicts and disputes resulting from weak specifications, rework and revisions, delayed projects and loss of time and money. The current situation calls for immediate action to solve the problems. TQM is the best solution to these problems. Specification is the key element, which relates to all problems between all parties in the design and construction of the project. Developing a framework to implement TQM in the construction industry in Bahrain through specification is the aim of this research to improve the performance of the construction industry.

Dependency on specifications

Webster's Dictionary gives the following definition of the term specifications: “Specifications (usually plural) - A written or printed description of work to be done, forming part of the Contract and describing qualities of material and mode of construction, and also giving dimensions and other information not shown in the drawings”.

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Specifications remain as important as ever, they are a fundamental part of all contract documentation in whatever they are presented Willis & Willis (1989). The quality of a building is defined by the requirements of the owner, within budget and time constraints. The functional specification must therefore reflect the quality standard needed by the owner and must continue to be useful after the construction of the project to include commissioning, operating and maintenance of the building through its whole life cycle. The owner thus relies heavily on the quality of the specification and its durability.

Architects
Architects need the specification to reflect the owner's requirements and to define things that cannot be illustrated in the drawings; much information can not be shown on the drawings alone. The architects use the specifications to identify the type of material to be used, its strength, dimension, quality, source, colour and method of fixing. Also, the information developed by the architect assists the owner in obtaining prices for the work, executing the contract and administering the project as it is built.

Engineers
A grading plan for civil engineering works show existing and new elevations and levels. Without the specifications, it is not easy to describe the kinds of soil that are suitable for backfilling, the depth of the layers of fill, the compaction degrees and frequency of tests of the sub grade. Mechanical issues are answered as well. The equipment schedule on the drawings will indicate the basic model numbers of air conditioning units, but the schedule can not describe that an extra charge of refrigerant is to be provided, together with an extra charge of filters or that a brass coil is required instead of a galvanised steel one. In the electrical drawing the fixture schedule can show the light fixture required but it does not have the colour of the fluorescent tubes indicated, or the pattern of the prismatic acrylic lenses.
Constructors
Well-written specifications can be extremely useful to constructors. The specifications should provide constructors with the tools and the criteria for continually checking their work and sub-constructors' work, and rejecting defective or insufficient work long before it comes to the attention of the architect and owner. The specifications will also help the general constructor decide which parts of the work will be performed by direct labour and which are to be sub-contracted. Constructors also depend heavily on the specifications when managing project requests for substitutions, methods of submittal procedures for preparation and submission of payment requests. These are a few of the administrative processes described in detail in the specifications.

Quantity Surveyors
Quantity Surveyors need the specifications as their basis for taking-off work, which is the main document for their bidding process. Good quantity surveyors will judge the quality of specifications by raising any ambiguities or inconsistencies in clauses of the specifications and ask for clarifications. The quantity surveyors use the specifications to determine the total budget of the project and use it to control the cash flow. They also need the specifications to make sure that the bidding is done on an equal basis so that everybody is bidding the same way on the same thing.

Attorneys
Attorneys become involved with specifications when preparing contracts. Many attorneys rely heavily on the specifications and discussions with their clients to understand the project. The attorneys need specifications to resolve disputes and depend on them as a reference to their legal points. The terminology, punctuation and sentence structures all become subject to intense scrutiny in determining what
the various parties of the contract documents said, what they meant and how they were interpreted. The accuracy, completeness and consistency of the specifications thus become critical in solving any disputes.

Disputes and claims from specifications
Most specifications do not anticipate problems or solve disputes that may arise from the construction process. The specifications must establish lines of communications and administrative procedures, and clarify intent of the documents to ensure that all parties know what is happening. They must protect workers, property and each party's interest. They must establish rules for: changing; the contract; stopping work in the event of non-performance of either party; and correcting defects since these issues are best addressed before problems occur.

In Bahrain, nearly all specifications lack most of these things, therefore, both parties who sign it - the owner and the constructor- end up in court to resolve their disputes in an expensive and time consuming way. Many cases end up in court every year. The specifications used in Bahrain are generally short, brief and do not cover all activities taking place on the construction site. Many disputes and conflicts arise from inadequate specifications and many high claims arise at the end of the project. Chesley and Ayers (1975) categorised disputes into three categories: those where the constructor wants to produce less than what is specified; those where the owner wants something but not to pay for it; and honest disputes where the owner and the customer interpret the same words in a different manner.

Discrepancies in specifications
The specifications should be consistent and the terminology used in one place should match wherever it occurs. The principles of terminology are described in BS3669, but of more practical importance is BS6100: Glossary of Building and Civil
Engineering Terms, a detailed specification in six parts covering all sections of building and civil engineering construction. Willis and Willis (1989) stated that it is important that the specification should be consistent in all parts, though this may sometimes be difficult when the drafting is spread over any length of time. It is obvious that interpretation of document, confusion is bound to arise if the same word or expression is used in different senses in different parts of the document, and conversely, if different words or expressions are used with the same meaning. Many problems arise from specifications due to discrepancies. The specification should be checked carefully during preparation to assure the cross references are correct. These things seem to be obvious, but it is amazing how often they occur. Specification should not duplicate information shown on the drawings but should amplify, explain and qualify that information. In many cases the information shown on the drawings conflict with those in the specifications. Also, the specification should be clear, concise and consistent with regard to type of material made, colour, brand name, method and place of fixing. Clauses that are not clear, concise and consistent should be avoided to enhance the smooth progress of the project.

Copying specifications
Most design offices in Bahrain and government authorities that are involved in the preparation of specifications and contract conditions, copy from other specification that have been produced by somebody else earlier. Any mistakes, discrepancies, inconsistencies and unclear wording are repeated once again in a new project due to the copying of the clauses. The most commonly used specifications, which are taken, as standard specifications in Bahrain are the specifications published by the Public Works Directorate in the Government of Bahrain but not prepared by them.
Out-of-date specifications lead to construction disputes, delayed projects and unhappy clients. In most cases this happens due to taking a copy of old specifications and using it in new jobs with information already ten years old if not older. The designer preparing the specifications should endeavour to be at the leading edge of industry information. The designers, who are not, will spend a lot of time talking to the bidding constructors who would constantly call to obtain more information before bidding the project. The out-of-date designer will spend time writing an addendum to incorporate the corrections identified by bidders call in. They will also spend time on construction disputes that arise out of the assumptions bidders made when reading the design documents and many other problems.

Delayed projects due to poor specifications
Poor specifications will inevitably end up causing delays to the project thus creating disputes, penalties and pointing fingers on whom to blame the designer; the constructor; or the client. The client will be the one who suffers more in the long term since he could be facing great financial risk due to arranged commitments with banks or other financial establishments and could end-up making a financial loss or even be able to complete the project. There could also be other arrangements such as signing a contract of lease to another party, who is committed through other channels, if the building is not handed over to the client on the agreed date.

Over-budgeted project due to poor specifications
Poor specifications, unclear, inconsistent and out-of-date specifications will raise the project’s budget to a limit that might result in a dissatisfied client. He might be faced with a budget that he can not meet or arrange due to the accelerated prices or variations in the construction process. The project will stop, all parties will end up in court, arbitration will take place, time will be consumed, money will be wasted
in legal procedures, which is not wanted and desired by any of the agreed parties in the contract. The only people who will benefit from this are the lawyers who make good money from poor specifications and for them this is a source of income.

Specifications lacking team co-ordination and partnering
Specifications are usually only prepared by the designer of the project, who may not trouble himself writing specific specifications for the job in hand and might take an easy short-cut by copying the specifications of the last project which may be similar in its features. By doing this, the designer deletes the contributions of other design team members. Thus, no team work management is implemented, as the electrical engineer, mechanical engineer, planning engineer, structural engineer, material engineer, plants engineer, quantity surveyors and value engineer are not involved. All of who should put their thoughts and effort jointly to have a well co-ordinated work in every aspect of the job. With good communication, clear, concise and consistent specifications should be written without any discrepancies or duplications in the information. Therefore, the team will have some value of thoughts and goals for the project creating a common culture at work.

The need for continuous improvements towards master specifications
Specifications without continuous improvements are like a door hinge without movement which will end up jammed corroded and ineffective. The more the specifications are regularly improved, the fewer problems will arise from them. This is not the case in reality, where every designer takes specifications from previous projects, copies specifications, uses out-of-date specifications and never up dates himself with the latest industry information. The use of electronic information sources nowadays, for example the Internet, could make it much easier to improve and be updated with the latest information in every field of the construction industry. With the introduction of knowledge management as an engine built into the specifications to learn from past experience to resolve any
future problems or unforeseen disputes in any construction job. All these steps
definitely lead to master specifications, which are useful to everybody in the
construction industry, accessible and can be referred to at any time.

The role of Value Engineering in specifications
Many projects have been designed, executed and operated without the interference
of the value engineer. The value engineer can save large amounts of money and a
lot of time by going through the design drawings and the specifications, by
suggesting alternative materials with better workability, durability and longer life
cycle and by suggesting new layouts and designs for better utilisation of the land to
be developed and easy future maintenance. Therefore, the role of the value
engineer in the preparation stage of specifications is very important to advise of
any changes in material selections, method of fixing, operating and maintenance.
To achieve the client's goals and objectives with regard to quality, budget, time and
life cycle. Specifications detailed the required function and form. The function is
represented by structural strength and durability. Form deals with appearance and
can be subjectives depending upon the views of various parties in the project. The
specifications are part of the communication process with the client, and must
ensure that the client gets what he is expecting. The value engineer must play a role
within the work team preparing the specifications. There will be a great difference
between the value engineer being in the team or out of it.

1.3 Research philosophy
The research philosophy in this thesis is summarised as follow.
1. The identification of the present problems in the construction in Bahrain, with a
   focus on the problems with the present specifications in use.
2. The study of TQM concept with its relation to the construction industry.
3. Analysis of the information technology used in the construction industry.
4. Evaluation and comparison between the common software packages used in the construction management.

5. The development of a dynamic model “PROMANSYS” to be used by the design and construction teams of the quantities, planning control charts, material, labour and plant control charts, budget control charts and apply value engineering techniques to specifications.

6. The implementations of TQM to the model through the achievement of teamwork, effective communication, creation of culture, continuous improvement of the model and the implementation of value engineering techniques.

Main problems with specification in Bahrain

- Use of old specifications from finished projects for the new projects.
- Use out-of-date specifications.
- Conflict in specifications clauses.
- Most of the specifications are not consistent, unclear and unconsise.
- Most of the designers preparing the specifications are not up-to-date with the latest construction products and industry information.

The main reason for these problems as follow.

- No authority or body taking the responsibility of preparing master specification to suit the requirement of the construction industry in Bahrain.
- Lack of awareness to the purpose of specifications.
- In experienced designers preparing the specifications.
- Laziness in preparing new specifications to completely suit the new project in hand. Therefore coping of old, out-of-date and inadequate specification becomes the solution.
- Lack of teamwork spirit, proper communication and culture in the construction industry
1.4 Aim and objectives

Aim
Develop a framework to implementing TQM in the construction industry in Bahrain, by developing a dynamic specification's model which will help to improve performance in the construction industry, improve consultant-client-contractor-supplier chain relationships, control the budget of the project and reduce disputes, claims and variations in the construction industry.

Objectives
1. Analyse the current status of the construction industry in Bahrain.
2. The study of TQM concept with its relation to the construction industry.
3. Analysis and use of information technology in the construction industry.
4. Analysis and improvement of the construction specifications used in Bahrain to avoid discrepancies and achieve clear, concise and consistent specification.
5. Overview of the application of different software packages in the construction management.
6. Developing a dynamic model for writing-up specifications to be used by the design and construction team of the project and produces: bill of quantities; planning control charts; material control charts; budget control charts and applying value engineering techniques.
7. The implementation of TQM to the construction specifications using the proposed dynamic model.

1.5 Organisation of the thesis

This thesis contains eleven chapters. The schematic guide to the thesis layout is illustrated in Figure (1.1). A brief description of each chapter is presented below to summarise the thesis.
Chapter one provides an introduction to the subject of the thesis, research justification and philosophy. Aims and objectives of the research, summary of main findings and organisation of the thesis are also presented.

Chapter two discusses the research methodology adopted for this research, method of analysing the problems of the construction industry in Bahrain and specifications, and formulation of the objectives of the research. The research design, strategy and phases are discussed and explained. The three main phases are the literature review, data collection and the analysis of the survey responses discussed.

Chapter three focuses on the construction industry in Bahrain with an analysis of the design stage, specification problems, supervision, constructors, suppliers, workmanship, and material quality and quality control problems at the present time with a discussion on the quality of the buildings in Bahrain, the defects and the causes of the defects. This chapter also discusses the barriers to the implementation of total quality management in the construction industry in Bahrain.

Chapter four explains the evolution of TQM with time, the TQM gurus who have contributed to the training and practice the quality improvement. The chapter describes the meaning, principles, tools, and techniques of TQM and discusses the recent research and developments in the quality of construction industry. Adam's six sigmas, meaning, objectives, principles, and their relation to TQM are discussed at the end of the chapter.

Chapter five analysis the different traditional documentation in the construction industry such as specification, drawings, contract conditions, bill of quantity, tender document and agreements. Also discussed are the modern information
technology systems that are used in the construction industry both as software and hardware.

Chapter six analyses the general practice in specification writing in Bahrain, the source of specification, and the problems arising from the present situation in Bahrain. It discusses the need for an improved specification in the construction industry in Bahrain.

Chapter seven describes the importance of the different software packages in the industry as a tool of information technology. A list of all the software packages that are most frequently used in the construction industry are provided with a description of their advantages and disadvantages in relation to Total Quality Management and the proposed dynamic model in this research.

Chapter eight presents the survey questionnaire which is comprising of two sections: section one is the specification questionnaire and section two is the TQM questionnaire. The questions and responses are presented in the form of pie charts, the analysis, discussions and results of the two sections of the questionnaire are also described in this chapter.

Chapter nine describes the project management system (PROMANSYS) as a specification based software package linking other tools of planning, cash flow, bill of quantities, reports and charts. PROMANSYS functional flow and data hierarchy is discussed, with the advantages of the software and hardware requirements. "PROMANSYS" is proposed in this research as an information system, a discussion with this regard is provided in this chapter. All the PROMANSYS screens with descriptions, the case study project drawing and sample of printouts are provided. The model validation questionnaire is analysed, discussed and results are also given in this chapter.
Chapter ten presents thorough discussion of the implementation of TQM to the dynamic model is given in this chapter. The elements of Total Quality Management such as teamwork, creation of a culture, improving communication, implementing value engineering and continuous improvements are all explained as general concepts. The inclusion of TQM within the proposed dynamic model, "PROMAN SYS" is also discussed.

Chapter eleven presents the conclusion of the research and the main recommendations for further research.
1.6 Summary of main findings

The improvement of quality has become an everlasting challenge faced by the construction industry to improve performance, reduce cost, solve problems of rework, reduce maintenance cost and improve the life cycle of the buildings. TQM system has become one of the best solutions to overcome the problems. Specifications can be used as a gate for introducing TQM to the construction industry, since specifications are the basis for the standard of quality for any project in the construction industry, and are used as a tool to get design and construction teams committed through all stages of the construction process. The main achievements of this research include the following.

1. The identification of the present problems in the construction in Bahrain, with a focus on the problems with the present specifications in use.
2. The study of TQM concept with its relation to the construction industry.
3. Analysis of the information technology used in the construction industry.
4. Evaluation and comparison between the common software packages used in the construction management.
5. The development of a dynamic model “PROMANSYS” to be used by the design and construction teams of the quantities, planning control charts, material, labour and plant control charts, budget control charts and apply value engineering techniques to specifications.
6. The implementations of TQM to the model through the achievement of teamwork, effective communication, creation of culture, continuous improvement of the model and the implementation of value engineering techniques.

The introduction of a TQM framework in the construction industry in Bahrain, by the development of a dynamic specification model, has improved many important
TQM elements in the construction industry. These elements are identified as follows.

1. Effective improvement of teamwork, especially at the specification writing stage of the project.
2. Improving communication at the pre-contract and post-contract stages of the project.
3. Introducing an effective method to create a culture to the design and construction team members.
4. The introduction of an effective method to continuously improve the quality standard of the project.
5. The introduction of value engineering techniques at the specification writing stage of the project.

The technique of specification writing in the proposed dynamic model named "PROMANSYS" combines many tasks together in one software package. These tasks include bill of quantity, preparation of specifications manually, preparation of planning control charts, material control charts, labour control charts, plant control charts and budget control charts.
CHAPTER TWO

RESEARCH DESIGN AND METHODOLOGY
CHAPTER TWO

RESEARCH DESIGN AND METHODOLOGY

2.1 Introduction

This chapter discusses the research design and methodology. The steps of a scientific method of research are highlighted. The methodology of this research is based on these steps where the research problems are defined through a preliminary literature review. The identified problems led to formulate the research objectives. They are: analysing the construction industry in Bahrain to identify the problems of specification; developing a framework for TQM in the construction industry in Bahrain by developing a dynamic specification model; and implementing TQM to specification to improve the performance of the construction industry in Bahrain.

Various research strategies are highlighted and the strategy adopted for this research is rationalised. To meet the research objectives, this research was undertaken in three phases. Phase One was the literature review which investigated: various issues relating to the concept of TQM; the present status of the construction industry in Bahrain; and the problems of specifications in the construction industry in Bahrain; Phase Two was data collection. The two primary methods of data collection used in this research are discussed in detail, the techniques of planning, designing and executing the mailed questionnaire are also discussed. Phase Three was the analysis of survey responses where the main problem with postal surveys was highlighted and the response rate of the questionnaire is analysed and discussed.
Phase Four: development of a dynamic model. The main objective of developing the dynamic model is to use it as a framework to implement TQM to the construction industry in Bahrain, through specification writing technique. With the introduction of other functions and features to the model, such as Bill of Quantity, planning charts, budget control charts, material, labour and plant charts and the implementation of value engineering technique.

2.2 Research design and objectives

The guiding principle for developing any research methodology is that it must completely address the research questions identified Black (1993). The need for an appropriate research design arises whenever there is a need to generalise research findings, either in terms of frequency or prevalence of particulars or variables, or about the relationship between them.

According to Buckly (1976) the scientific method of research should comprise the following steps.

- Knowledge steps from observations, which take place through a definable searching process.
- The research problem is defined, which means answering why the research is being undertaken and what purpose it is supposed to achieve.
- A research plan must be formulated comprising the selection of appropriate strategies, domains and techniques.
- Inquiry ensues in accordance with the plan and is directed by the need to obtain relevant and sufficient evidence.
- The outcome of the inquiry is stated in explicit terms which may result in support or rejection of the existing hypothesis.
- The conclusions are documented with sufficient support and clarity that they establish what was done, what was found and what significance findings may have.
Buckly (1976) described these steps as crucial to the assurance of quality research. The methodology followed in this research is based on the previous steps. Based on the first two steps, the research problems were defined through a preliminary literature review.

The identified problems led to formulate the following objectives.

1. Analyse the construction industry in Bahrain to identify the problems associated with specifications.
2. Overview of the application of different software packages in the construction management.
3. Analyse the use of the information technology in the construction industry to implement it to the proposed dynamic model.
4. Study the concept of TQM and develop a framework for Total Quality Management in the construction industry in Bahrain by developing a dynamic specification model.
5. Implement TQM to specification to improve communication, create teamwork, create a culture, implement value engineering, and maintain continuous improvement.

Having identified the research problem and objectives, the next step was to choose the appropriate strategy that would help to achieve the objectives. Buckley (1976) suggested the following four methods.

- **Opinion research**
  If the researcher seeks the views, judgement or appraisals of other persons with respect to a research problem, he/she is engaged in opinion research (e.g. questionnaires, opinion polls and interview).
- **Empirical research**
  An empirical research strategy requires the researcher to observe and/or experience things for himself/herself rather than through the mediation of others (e.g., case study, field study, and laboratory study).

- **Archival research**
  This is concerned with the examination of recorded facts (e.g., original documents or official files or records, publication of data by other investigators).

- **Analytical research**
  Analytical research relies on the use of internal logic on the part of the researcher. The researcher has the resources required for solving the problem himself/herself. No explicit reference to external data is necessary.

The preliminary stage of this research focused on the observation and analysis of the construction industry in Bahrain, specifically the subject of specification and the implementation of TQM. At this stage of identifying the problems and forming the objectives, there was a large volume of literature on the subject of TQM and construction specifications. Therefore, archival research was used at the initial stage of the research. The empirical, opinion and analytical research were deemed inappropriate at this stage. These techniques are useful for identifying new variables and possible relationships between variables.

The research strategy was based on a combination of different techniques in accordance with the research objectives. Archival research was used to define research problems and formulate objectives. This approach was also used with opinion research to collect data of TQM and specification in the construction
industry in Bahrain. Also, the archival research was used to analyse the data and propose a dynamic model to implement TQM to specification. The empirical research was then used to implement the dynamic model on a case study to validate the model and implement TQM. See Figure 2.1.

**ARCHIVAL RESEARCH**
To define research problems and formulate objectives.

**ARCHIVAL and OPINION RESEARCH**
To collect data on the use of TQM and specifications in the construction industry in Bahrain.

**ARCHIVAL and ANALYTICAL**
To analyze data and propose a dynamic model

**EMPIRICAL RESEARCH**
To implement the dynamic model on a case study, validate the model and implement TQM.

Figure 2.1: Research Strategy

### 2.3 Research phases
To meet the research objectives, this research was undertaken in three phases as presented in Figure 2.2.

Phase one involves a literature review, basically reading and critically appraising what others have written about TQM and the Construction Industry in Bahrain.
with emphasis on specification. This was achieved through a comprehensive literature survey, use of the Internet as a source of information, attending conferences, seminars and workshops. The process resulted in: a review of the concept of TQM, its elements, tools, techniques, gurus and their theories; and investigation into the different types of specifications existing in the construction industry in Bahrain.

Phase Two involved the preparation of two sections of questionnaire surveys, and structured interviews. Section One was a questionnaire in specification, and Section Two was a questionnaire in TQM. Section One aimed to collect data and information about the use, sources, methods of writing, and problems arising from the current specifications used in the construction industry in Bahrain. Section Two of the questionnaire was constructed to collect data and information about: the implementation of TQM in the construction industry in Bahrain; the readiness of the industry to accept and implement it as a tool for the improvement of the quality of buildings and for the achievement of customer satisfaction.

Phase Three was the analysis of the data and information collected from Phase Two and the development of a framework for the implementation of TQM to the construction industry in Bahrain, through the proposed dynamic model.
Aims and Objectives

Questionnaire Survey on

Specification
Governement Technical Offices

TQM
Design Offices

Constructors

Analysis of questionnaire results and identification of the problem

Structured Interviews

Data Analysis and Discussion of Results

Proposed dynamic model and Case study

Conclusion and further research work

Figure 2.2: Research Phases
Having decided on the appropriate strategy, the research was undertaken in the following three main phases.

Phase One: Literature review
Phase Two: Data Collection
Phase Three: Analysis of the survey responses

2.3.1 Phase One: Literature review

A literature review was undertaken to investigate various issues relating to Total Quality Management; Information Technology in the construction industry; and the different construction management software packages. Most of the literature was obtained from the Pilkington Library (Loughborough University). In addition, many books were bought from the UK to be used for the research in Bahrain.

There is a lack of information in the construction industry in Bahrain with regard to specification, implementation of TQM to the industry, and any other literature describing and analysing the construction industry in Bahrain in general. The literature review and findings have been presented in Chapters Three to Seven.

Most of the findings on the construction industry problems in Bahrain and the analysis of its current situation were obtained from questionnaires, interviews and the exercise of the author in the industry being a Consulting Engineer.

2.3.2 Phase Two: Data collection

Data collection method

There are two primary methods, which have been widely used for data collection. These are mailed questionnaire method and interview method. In this study, both methods were used in order to obtain representative information and a high response rate. In Table (2.1) S.G.Naoum (1998) describes the comparison between a postal survey and interview techniques.
Table 2.1: Comparison between a postal survey and interview technique  

<table>
<thead>
<tr>
<th>Features</th>
<th>Interviews</th>
<th>Postal Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identity of respondents</td>
<td>Known</td>
<td>Unknown</td>
</tr>
<tr>
<td>2. Interaction between Interviewer and Respondents.</td>
<td>Close</td>
<td>Distance</td>
</tr>
<tr>
<td>3. Time involving the Researcher.</td>
<td>Long time to go through the interview.</td>
<td>Short time.</td>
</tr>
<tr>
<td>6. Skill and experience.</td>
<td>The interviewer needs to have the skill to ask questions and, if necessary, to probe.</td>
<td>No skill required.</td>
</tr>
<tr>
<td>7. Control the process.</td>
<td>High.</td>
<td>Low.</td>
</tr>
<tr>
<td>8. Flexibility</td>
<td>Allows great flexibility to reword questions and clarify terms that are not clear.</td>
<td>Rigid. The answers are accepted as they are.</td>
</tr>
<tr>
<td>10. Interviewer bias</td>
<td>The flexibility of interviews allows for bias. Sometimes the non-verbal communication or behaviour of the interviewee may mislead the interviewer to incorrect judgement.</td>
<td>If sample is selected appropriately, there should be no bias.</td>
</tr>
</tbody>
</table>

Content analysis

The results of the data collected from the questionnaires and interviews were analysed according to the content analysis method (textual analysis), identifying
the meaning of the texts given by the respondents. Content analysis assumes inferences about the relationship between intent and content or between content and effect can validly be made, or the actual relationships established.

**Definition of content analysis**

Content analysis is a type of textual analysis the aim of which is to identify the meaning of the text. Lindkvist (1981) identified it as follow.

"content analysis particularly consists of a division of the text into units of meaning and quantificating of these units according to certain rules. That content analysis is systematic implies inclusion and exclusion of categories according to consistently applied rules. The possibility that the researcher will use only material supporting his hypothesis is thereby eliminated".

Content analysis may be generally defined as the systematic and objective use of techniques to quantify any form of communication. Types of communication range from the conventional documentary sources such as books and periodicals to recordings of observations, music, and pictures. Basically, this method of analysis consists of identifying and counting indicators of the variables in question.

Content analysis may be envisioned as one form of documentary analysis. It could be placed on a continuum ranging from those types which are most literary or historical to those involving counting and statistical analysis at the nominal and ordinal level. The less one uses quantification type techniques, the more one depends on the techniques derived from history and the humanities. Thus, this type of research may be seen as an intermediate process used to categorise verbal or behavioral data for purposes of classification, summarisation, and tabulation.

Some of the purposes of this type of research identified by Best (1981) are:

1. to describe prevailing practices and conditions;
2. to discover the relative importance of, or interest in, certain types of problems;
3. to discover the level of difficulty of a book or publication;
4. to evaluate bias or prejudice in a book or publication;
5. to analyse types of errors in students' work; and
6. to identify the literary style and beliefs of a writer.

The basic rationale for a case study is that there are processes and interactions such as aspects of social functioning and personality which cannot be studied effectively except as they interact and function within the entity itself.

Application and elements of content analysis
Burger (1993) described the application and elements of content analysis as follow.

1. Responses are first broken down into its constituent policy tasks by identifying goals and actors (a policy task is something recommended by a policy that has a goal and an actor).
2. Rationale each task identified, the rationales are then classed into one of two groups: those that can be evaluated by information science and those that cannot.
3. Tallies of the identifications and classifications are made and analysed, after examining the responses.
4. Finally, the assumptions and limitations of the study are presented.

The elements of content analysis are as follow.

Policy task. A policy task consists of a goal and an actor or group of actors to achieve the stated goal. Therefore, the identification of each policy task depends on identification of the goal and actor.
Goal. Any statement that presents the purpose or objectives of the policy task. It may contain the words “should”, “urge”, “request”, “must”, “consider”.

Actor(s). The person, institution, or group designated in the policy task to implement it. There may be more than one actor per policy task.

Rationale(s). A rationale is the fundamental reason for something an, exposition of principles or reasons, or a hypothesis.

Presentation of the results of the content analysis.
The actor, goal and rationale are explicitly identified following the text of the responses. In many cases responses consist of more than one policy task. A rationale is identified and classified for each individual policy task within a response. Furthermore, in order to minimise misidentification of the rationale, one of the three possible sources is identified for each rationale. The rationale is also classified according to the criteria presented above. In many cases, a discussion of the basis for the classification is also presented.

Interviews
There are twenty-two interviews conducted at the preliminary literature review stage to support the preliminary literature review, and stand on. The main problem the construction industry is suffering from. The interviews followed the same techniques listed below and recommended by Weisbery and Bowen (1977). The other part of the interviews were conducting after obtaining the questionnaires response obtained from the questionnaires results, the number of the interviews conducting at this stage were ten interviews.

The total number of the interviews is thirty-two interviews. The preliminary interviews helped in identifying the major problems in the construction industry in Bahrain and formulate the objectives of the research, as it supported the preliminary literature review. The interview-conducted after the data of the
questionnaires collected and analysed, helped with the analysis of the responses shown in chapter eight below some of the questions pie chart.

The samples of the interviews were selected for the preliminary research stage for Ministry of Housing, Ministry of Public Works, Central Municipal Council, consulting engineer and large slice of well known constructors. The sample selected after the data collected and analysed were selected according to the question's responses that needed clarification as shown in Chapter Eight.

Method of conducting the interview

Face-to-face Interview

Interviewing is a powerful method for obtaining reliable information with high rates of response. On-site interviews of domain experts of the leading civil and building constructors, material suppliers, technical staff, supervisors, engineers, managers and directors in the public and the private sectors of Bahrain were carried out.

The interview technique was used for the following reasons.

- To enable the validity of the questionnaire content to be confirmed before sending it to companies.
- High response rates were required.
- Accuracy and reliability of information was essential for the survey analysis.

The interviews were conducted following the guidelines listed by Weisberg and Bowen (1977) and Fink and Kosecoff (1985) to obtain reasonable and clear replies from the respondents. These guidelines include, the following.
• **Introduction**
  The interviewer should give a brief statement to describe who is conducting the interview and the objective of the interview and indicate the confidentiality of the answers provided and the importance of the interview.

• **Privacy**
  The interview should be conducted only with the respondents concerned without an audience.

• **Asking the questions**
  The questions should be asked exactly as they have been written and in clear language.

• **Opinion free questions**
  The interviewer should ask the questions only and not produce their own answers in order to elicit the real attitudes of the respondents.

• **Establishing rapport with the respondent**
  The interviewer should build a rapport with the respondents to obtain a successful interview. Asking easy questions to gain their interest and trying to engender confidence and trust can achieve this.

• **Probing**
  The interviewer should encourage the respondent to clarify or amplify an answer if the respondent's answer is unclear. Probing should be carried out carefully to avoid any biased information.

**Mailed Questionnaire**
The mailed questionnaire is a self-completion form that is designed by the researcher to gather information from individuals located in different areas of the country.
Cost
Survey costs depend on a multitude of factors. Some of them, as quoted by Fowler (1988) are the amount of professional time required to design the questionnaire, the questionnaire length, the geographic dispersion of the sample, the availability and interest of the sample, the call back procedures, the respondent selection rules, and the availability of trained staff.

- So that responses were available quickly.
- It is a cost efficient method of data collection for the size of the sample.
- The questionnaire was short and the amount of information required was limited.
- It was important to verify information obtained by other methods such as interview.

Justification for the use of postal questionnaire
The data collected from the postal questionnaire were analysed using Trend technique and Pattern analysis technique. The responses in the questionnaire are analysed according to the characteristics of communication content, the causes of contents, and the consequences of content.

"The most valuable use of studies of content is in noting trends and changes in content. Systems of classification may be inadequate and unstandardised, nevertheless, if a system is used consistently over a time period valuable facts may appear". This indicates the importance sometimes attached to this application of content analysis, although it seems an overstatement in view of more advanced uses of content analysis. The classification into a single set of categories of similar samples of communication content taken at different times provides a concise description of content trends, in terms of relative frequencies of occurrence. Such descriptions of trends are often useful in themselves, in addition, they provide data
which can be correlated with corresponding changes on the part of the communicator or the audience.

Such trend studies provide a valuable historical perspective against which the current content of the communication media can be more fully understood. This is certainly one area in which content analysis can be applied to good effect. In this connection, it is important to point out that most of the existing trend studies have dealt only with subject matter categories, although the addition of other categories (e.g. direction, authority, emotionality) would make such studies even more valuable.

Pattern codes are explanatory or inferential codes, ones that identify an emergent theme, pattern, or explanation that the site suggests to the analyst. They act to pull a lot of material together into more meaningful and parsimonious units of analysis.

For the qualitative analyst, pattern coding has four important functions, Miles and Huberman (1984):

1. it reduces large amounts of data into a smaller number of analytic units;
2. it gets the researcher into analysis during data collection, so that later data collection can be more focused;
3. it helps the researcher build a cognitive map, an evolving schema for understanding what is happening locally; and
4. when several researchers are engaged in individual case study work, it lays the groundwork for cross-site analysis by surfacing common themes and causal processes.
A comprehensive description of data collection method is reported by Weisberg (1977) and Fowler (1993). The following section provides a brief description of the methodology implemented for planning the survey.

Planning the survey

Sampling

The sample is of major government technical offices, constructors and engineering offices, who are involved in design and construction in the construction industry in Bahrain, who influence the methods and quality of the construction industry project and buildings.

A questionnaire survey (110 questionnaires) was posted and distributed to the Ministry of Housing (22), Ministry of Public Works (17), Central Municipal Council (16), Building Constructors (30) and Engineering Offices (25) questionnaires.

Questionnaire Design

The design of the questionnaire in this survey was established using the procedures recommended by Hoinville (1977), Fowler (1993) and Prescott (1993). These recommendations include the following.

1. The questionnaire must be clear, unambiguous and easy to answer.
2. The questionnaire should be attractively spaced and uncluttered.
3. The questionnaire should use short sentences and be brief.
4. The questionnaire should be written in simple language.
5. The questions should be ranked in order of importance.
6. Biased terms should be avoided in order to get a real view from the respondents.
7. The questionnaire must be designed to enable easy analysis.
8. The questionnaire should be self-explanatory.

The types of questions used in this survey were:

- open questions (those for which enough space is provided for the respondents to write their replies); and
- closed questions (those for which a list of acceptable answers are provided to the respondents, normally by ticking one box or more). In some questions, a space is provided as an option for the respondents to provide additional information.

A copy of the questionnaire is included in Appendix (C).

- Important questions to respondents were asked first to gain respondents interest.
- The questionnaire clearly indicated how to record the answer to each question.
- Enough space was allowed for the respondents to express their views and record their comments.
- An instruction was included where necessary on where to go next.
- A brief definition was given to some questions where it was necessary.
- Questions were consistent in style.
- Questions with similar content were kept together.

**Questionnaire Form**

Fowler (1988) advised that when a self-administered questionnaire is used, it is better to have closed questions - that is, questions that can be answered by simply ticking a box or circling the proper response from a set provided by the researcher. If the questionnaire contains open-ended questions, it will usually require an interview.
2.3.3 Phase Three: Analysis of data

Data analysis and responses. All the data collected from the literature review, interviews and questionnaire are analysed and presented in Chapter Eight.

2.3.4 Phase Four: Development of the model

Developing of a dynamic model objectives of the development of the dynamic model are as follow:

1. model objectives;
2. model layout;
3. model formation;
4. model characteristic;
5. model functional flow and data hierarchy;
6. model inputs;
7. model outputs;
8. model testing;
9. model screens;
10. model as an information system; and
11. model validation; questionnaire; and analysis.

Model objectives

The objectives of the model PROMANSYS in this research include the following:

- improved specification writing techniques.
- a framework to implement TQM.
- involve the maximum number of design and construction teams members in the use of the model to achieve teamwork.
- involve the maximum number of activities and functions in the model to create a culture of unified aims; objectives; and beliefs; and
- provide an efficient flow of information for the project to achieve an effective communication between project team members.
Capability of the model to be continuously improved to cater for any developments in the construction industry.

Cost
Survey costs depend on a multitude of factors. Some of them, as quoted by Fowler (1988) are the amount of professional time required to design the questionnaire, the questionnaire length, the geographic dispersion of the sample, the availability and interest of the sample, the call back procedures, the respondent selection rules, and the availability of trained staff.

The Covering Sheet
A cover sheet was prepared and enclosed with each questionnaire to provide the respondents with:

- a brief introduction about the research;
- the objectives of the research;
- the confidentiality of the information provided;
- an affirmation that of the analysis of the results would be returned if so requested; and
- the name and phone number of the person who should be contacted if there were any difficulties or queries about the questionnaire.

A copy of the covering letter is presented in Appendix (B).

Pilot-testing the questionnaire
Pilot testing is a method used to test the validity of the draft questionnaire either by sending the questionnaire to a small sample or by interviewing. The pilot testing was conducted to check the following:

- the format of the questionnaire;
- the order of the questionnaire;
- the flow from one question to the next;
- any difficulties in understanding the questions;
- the interest areas of the respondents; and
- the time required answering the questions.

Response rates

The problem of non-response is central to the use of mail surveys. Fowler (1988) stated that, "if mail questionnaires to a general population sample with appropriate follow-up procedures is followed, the rate of return is likely to be less than 30 percent". Without the follow-up procedures being utilised and if the project is otherwise well designed and executed, response rates can be obtained for mail surveys similar to rates obtained using other modes.

The main problem with most postal surveys is often poor response. However, the power efficiency of tests could be improved, if the sample size is increased. Hence, in this type of research, it was considered that a sample of more than 30 firms would be enough for statistical analysis to be performed. It was decided to post 110 questionnaires. According to Fowler's assumption, the response rate in excess of 30 percent of 110 (i.e. 39) firms is accepted. The questionnaire was sent to 110 government offices, constructors and engineering offices. A total of 43 responses were returned, giving an overall return rate of 39 percent, which is an accepted and reasonable response.

2.4 Summary

This chapter has described how the research was undertaken and justified the methodology adopted during this research. The formulated research objectives were discussed.
Formulated objectives were discussed.
1. Analyse the current status of the construction industry in Bahrain.
2. The study of TQM concept with its relation to the construction industry.
3. Analysis and use of information technology in the construction industry.
4. Analysis and improvement of the construction specifications used in Bahrain to avoid discrepancies and achieve clear, concise and consistent specification.
5. Overview of the application of different software packages in the construction management.
6. Developing a dynamic model for writing-up specifications to be used by the design and construction team of the project and produce bill of quantities; planning control charts; material control charts; budget control charts and applying value engineering techniques.
7. The implementation of TQM to the construction specifications using the proposed dynamic model.

The research strategy was based on a combination of different techniques in accordance with the research objectives. Archival research was used to define research problems and formulate objectives. This approach was also used with opinion research to collect data on TQM and specification in the construction industry in Bahrain. The archival research was also used to analyse the data and propose a dynamic model to implement TQM to specification. The empirical research was then used to implement the dynamic model on a case study to validate the model and implement TQM.

The research was undertaken in the following three main phases: literate review; data collection; analysis of the survey responses. The questionnaire sampling and responses rates were reported.
CHAPTER THREE

THE CURRENT STATUS OF THE CONSTRUCTION INDUSTRY IN BAHRAIN
CHAPTER THREE

THE CURRENT STATUS OF THE CONSTRUCTION INDUSTRY IN BAHRAIN

3.1 Introduction

In the last 25 years, Bahrain has seen a boom in the construction industry, Multi-story buildings, hospitals, industrial buildings, factories and other residential villas and Ministry of Housing dwellings have become noticeable to the country’s visitors. The face of Bahrain has changed due to the economical boom and the trend to go towards an economy relying on industry and tourism and not oil production as a main source of income to the country.

This increase in the number of different buildings and projects has brought an increase in the building industry related to manufacturers and trades. For example: The number of building material suppliers has increased tremendously with different sources of materials, the number of ready-mix concrete and pre-cast slab factories has increased from 3 to 8 factories and also the number of constructors for small, medium and large projects.

This chapter focuses on the construction industry in Bahrain, discussing issues such as the design and construction in the construction industry in Bahrain, the quality of buildings in Bahrain and the barriers to the implementation of TQM to the construction industry in Bahrain.
3.2 The State of Bahrain

The State of Bahrain is located in a relatively central position on the world map. Geographically, it is located on the southern shore of the Arabian Gulf, between 25 32, 26 50 Latitude and 50 20, 50 50 Longitude. On the eastern side, 22km away is the eastern shore of Saudi Arabia and a little more further to the west is the State of Qatar.

The State of Bahrain’s population is 568,000, and it is an archipelago with an area of 707 kms consisting of more than 36 islands. The largest among them is the island of Bahrain, which contains the Capital – Manama, then comes the second largest - Muharraq, then Riffa, Sitra, Budaiya and others.

The urban clusters in Bahrain vary according to their location, history and economical social activities. Three types of urban clusters can be found in Bahrain namely:

- clusters, which have an Islamic identity such as Manama and Muharraq;
- rural areas which depend on agriculture and fishing activities such as Sanabis and Budaiya; and
- new urban areas such as Isa Town and Hamad Town, the new neighbourhoods and extensions to new cities and villages.
Figure 3.1: Location of Bahrain on the World Map

Figure 3.2 The State of Bahrain
Source: Ministry of housing in Bahrain (1999)
3.3 The construction industry in Bahrain

The ex-minister of Development and Industry in Bahrain Mr. Yousif Ashirawi, commented on the construction industry (Construction Magazine, January, 1998), that, "the construction industry in Bahrain has traditionally been considered the barometer of the economic climate prevailing at any given time"

In the 1970's, Bahrain saw unparalleled economic activity - the explosion of construction activities ranging from roads, schools, housing, and agriculture to basic industries to cities and mega-sized infrastructure and development projects.

The early 1980's saw the beginning of a period of consolidation and the end of the era of big projects. This lull in activity was largely due to the reduction and at times significant drops in the price of oil. Steady oil production and steady oil pricing will mean steady economic growth in the coming years.

Bahrain has to create development projects for future sources of revenue and for employment opportunities. Hence today, a number of projects are being considered in the aluminium, petroleum, petro-chemical, gas and other industries. All these will directly create considerable construction activities.

The construction industry in Bahrain must play its part in the development process. The constructors that remain in business, both international as well as regional, will have to perform differently than before. There is much greater awareness of the need to control costs, to demand and achieve a higher quality of performance. There will be a requirement that the constructors utilise both national labour and locally manufactured materials. The construction industry has to become part of the national development plan and not merely take profit out of the development plan.
Much has been said about the transfer of technology and one of the easiest and best ways of absorption of technology is for the national engineers and construction organisations to invest in such expertise and know how, which will remain resident in this area by utilizing the national workforce. This will not be achieved over night, but will require conscious decisions, determination and foresight to embark on this course. It will be expensive, hard work, effort and time consuming but there is no choice. It should start now, to create a niche in the international economic arena.

3.4 The system of design and constructions in Bahrain

3.4.1 Design Offices

The following table shows the number of Engineering Consultancy Offices in Bahrain and the categorisation of the offices with regard to the years of experience and the capability of taking designs of large projects.

Table 3.1: Classes of engineering offices in Bahrain.
Source: Committee for Organizing Engineering Professional Practice – Bahrain, 2000.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Class A</th>
<th>Class B</th>
<th>Class C</th>
<th>Class D</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Offices</td>
<td>42</td>
<td>23</td>
<td>7</td>
<td>12</td>
<td>84</td>
</tr>
</tbody>
</table>
Class "A": Are those offices that have more than ten years of experience and can take projects with a budget of more than three million Bahrain Dinars (£5 million).

Class "B": Are those offices that have less than ten years and more than six years of experience and can take projects with a budget of up to three million Bahrain Dinars (£ five million).

Class "C": Are those offices that have less than six years of experience and can take projects with a budget of up to one and a half million Bahrain Dinars (£ 2.5 million).

Class "D": Are those technical offices inside the government or semi-government offices, who do in-house designs for the use of their own departments and not for the private sector.

The following table is extracted from the list of the Engineering Offices published by the Ministry of Commerce in Bahrain, (Government Bulletin - Issue No.2420, April 2000). It is excluding Class "D" offices, as it is not functioning for the private sector. It displays the number of offices in each category, their classification in every category and the origin of each office in every category either Bahraini or non-Bahraini.
Table 3.2: Classification and categories of engineering offices in Bahrain.

Extracted from the list of Engineering Offices published by the Ministry of Commerce in Bahrain, in the (Government Bulletin – Issue No.2420, April 2000).

<table>
<thead>
<tr>
<th>Office's Category</th>
<th>Total</th>
<th>Classification</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Architecture</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Civil</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Arch. /Civil</td>
<td>30</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Arch. /Civil/ Interior</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Arch. /Civil/ Land Surveying</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Arch. /Civil/Building Services</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Arch. /Civil/Mechanical</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Arch. /Civil/Mech./Elect.</td>
<td>3</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Civil/Elect./Mech.</td>
<td>6</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Civil/Mech.</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Elect. / Mech.</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Land Surveying</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quality Surveying</td>
<td>4</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Marine / Mechanical</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Marine Surveying / Mech.</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Elect. / Environmental</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Civil/Mech./Elect./Inst.</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Arch. /Civil/Mech./Elect./Inst.</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Civil / Electrical/ Chemical/Mech./Inst.</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Arch. /Civil /Elect. / Mech. / Land Surveying / Interior Design</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Arch. /Civil / Interior Design/ Building Services/ Quality Surveying</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Marine</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>72</td>
<td>42</td>
<td>23</td>
</tr>
</tbody>
</table>
3.4.2 Conceptual design

During this stage, the scope and nature of the work are defined. For example, the client desires a building to be designed – the overall number of storeys and layout for the same will be developed.

Projects in Bahrain can be categorised into three types namely large projects, medium projects and small projects. Most of the clients in the small and medium projects want to spend the lowest budget for a maximum investment return. Without consideration to the adversal effect of this on the quality of the project. This principle of work affects the quality of the design and the quality of the finished project.

The consultants in the small and medium sized projects do not have proper checklists for the preparation of the working drawings. Many details are missing and errors frequently found in the working drawings, which cause delay and problems at the implementation stage. Also many consultants do not work on the quality and type of materials to be used in the design as a main issue, rather than as an aesthetic feature to the project many projects are structurally over designed, which causes hidden costs to the client, therefore increasing the budget of the project. Over design can cause damage to the building. For example: using excessive reinforcement steel in the project will result in cracking of the beams and columns. Bahrain is known as an island having a salient environment, the effect of carbonation and high chloride content materials with excessive reinforcement can cause severe damage to the structure of the building.

The reinforcement of any element should be thoroughly analysed from a structural point of view, and a decision should be taken as to whether it is necessary. The conceptual design or design options should be communicated by the designer to
the client and address the main points outlined including the scope of work, type of structural facility, design life, durability and any required maintenance.

It should be noted that any design decisions taken at this stage have a far greater consequence than at any other stage in the project. Yet these are the decisions that are all too often omitted or rushed through. This is particularly the case where the client obtains sanction for the project and the design must be carried out in a very short period without allowing adequate time for a considered review.

3.4.3 Detailed Design

Once the conceptual design for the building is approved, the detailed structural and architectural designs along with the working drawings will take place. Design details are of much importance in the working drawings. Problems could easily arise at sites due to some missing details or inadequate drawing.

There is far more to a design than the strength of a structure, the details must be right. It is critical that the durability of the structure is addressed at the early stage of the structural design and appropriate decisions taken as to the required concrete mix design or any special durability measures. Other decisions to be taken at this stage should include the mix design strength, any special performance with regard to permeability, cover to embedded steel and the use of special protection measures such as cathode protection or epoxy coats reinforcement.

In Bahrain, for example in the housing industry, especially the private sector, a two-storey villa is rarely designed with load-bearing walls. Most of the villas whether one or two storey, are structurally designed with heavy isolated footings, large sections of columns and heavy deep beams, with over reinforcement. It is possible, as seen all over the world, to design villas with load-bearing walls and strip footing. The method of designing with load bearing is implemented in large
scale only in the Ministry of Housing Villas. But in the private sector, effort is still needed to raise the awareness to gain more confidence in economical, cost-effective and durable designs such as load-bearing structures.

3.4.4 Specifications

Most of the consultants operating in Bahrain especially in the medium and large projects each have a large technical specification and detailed sections. For example on concrete work, which is often not tailored to the region and more frequently not tailored to the particular project.

Consultants will typically develop a general specification for concrete work with the intention of applying it to all projects that they are engaged on. However, there are cases where the specification does not cover the particular type of work being carried out, yet provides a bulk of unwanted material that is of no use, and just makes the document difficult to use.

There are no specifications tailored for the construction industry in Bahrain or any of the Gulf's countries. There is a greater need to have specifications to meet the weather requirements in Bahrain or the type of original raw materials used in the construction industry.

However, the issue of the specifications in Bahrain will be dealt with more in detail in Chapter Six.

3.4.5 Supervision

Supervision in Bahrain was not compulsory until February 1999. The Central Municipal Council in Bahrain enforced supervision on the projects of housings and multi-storey buildings. The clients must first submit a copy of the supervision agreement with an engineering office to the Municipality before obtaining the
building permit. This compulsory procedure from the authorities came after realising that the quality of the buildings was decreasing and the constructors were using sub-standard materials in the construction of the projects. Many defects were noticed in buildings in the first three to five years after construction.

Unfortunately, the investors do not appreciate this procedure much as they are not happy to face extra expenses, which will have to be paid to the consultants for the execution of the supervision works.

Before February 1999, supervision was optional, but on large projects all the sites were supervised. Supervision on medium project was rarely seen on those sites or on small projects, especially in the housing sectors. The clients were far away from implementing supervision, to them it was going to create a burden and increase the cost of the construction and many thought it was unnecessary.

3.4.6 Constructors

Constructors in Bahrain are classified into three classes namely - First Class, Second Class and Third Class. The classifications are related to the size of the establishment, the number of the employees, the financial ground of the establishment and the number of years it has been functioning in the market. These classifications come from the Ministry of Commerce, the body who issues the Commercial Registration to practice construction in Bahrain. However, technically there are no measures or control over the classification of the constructors. For example - until the time of writing this thesis there is no constructors' law in Bahrain. Anybody in Bahrain can obtain a Commercial Registration; there are no requirements such as experience or qualifications of the owner or of the technical staff working with him and no control over their capability to execute the work.
On the large projects, the professionals who are behind the large constructors in Bahrain are expert engineers who are of highly experienced and skilled. Either they are practicing the job as a joint venture or as an international company by themselves in Bahrain.

3.4.7 Suppliers

Construction has been performed in Bahrain for a number of years now and they have established national and international suppliers for raw materials such as aggregates and cement as well as ready-mix concrete. During this period, the businesses or companies that have been operating had a wealth of data accumulated in the form of tests on different materials or concrete and cement aggregates. However, in most instances this information is very poorly maintained and filed and does not allow early retrievability.

Many suppliers of either aggregates, cement or ready-mix concrete view the need to test the materials as forced on them by the project consultants and they do not use this information to their advantage. If all the test data on a particular aggregate source is gathered and entered into a computer database the information will give a far more accurate assessment of the quality of the material than a solitary test taken at the approval stage on a particular project.

There is a great variety in the physical characteristics of the constituent parts of the building materials. In concrete, the aggregate sand, cement and water must meet the specified standard and from production to use must have been tested, mixed, transported, placed, compacted and carried correctly.
3.4.8 Workmanship

In the small and medium projects in Bahrain, poor workmanship and inadequately supervised process are too numerous to list. Among them are incorrectly mixed concrete, where site mixers are used, errors in the setting out of foundations, incorrect alignment of columns, insufficient covers to steel reinforcement and it is difficult to read the working drawings.

There are no quality control programmes implemented for the workmanship by the constructors. The quality of the project is reflected by the quality of the project's consultant, if a consultant was appointed to supervise the project. Defects due to workmanship cannot be completely blamed on the constructor or the labourers. Defects may be due to errors in structural design, lack of attention to detail design drawings, incorrect, inadequate or incomplete materials, and errors in construction methods, lack of quality assurance programmes on site and the use of poor and unclear specifications.

3.4.9 Concrete Quality

The majority of ready-mix concrete facilities in Bahrain are modern automated plants with facilities that allow the print out of batch tickets that accurately affect the qualities. The supply and transportation of ready-mix concrete is very much a production line activity and several ready-mix suppliers in Bahrain are certified to ISO 9000 of quality standard. Although this is not specifically tailored for the read-mix industry it is considered a useful management checklist. Such a quality system would generate various standard documentation that should be used as verification that work is being carried out correctly. The method of placing the concrete should be discussed at the pre-pour meeting. If necessary that constructor will have to check the accessibility of the pump to the location and the reach of the boom.
3.4.10 Quality Control

In large projects in Bahrain, the most cost-effective construction sites for the client have been those where the resident engineer or supervising architect appoints an experienced member of the staff to design and monitor quality control programmes that have been tailor-made for the project. Cost effectiveness and quality is also assured where the client approves independent testing laboratories to ensure that the quality programme is being adhered to and the main constructor, the supplier and the sub-constructors execute the various construction process within the quality programmes that formed a part of their pre-qualification submission to the client.

Since the architect, constructor and resident engineer cannot be expected to read each other's minds, the existence of quality assurance programmes and procedures can provide a way to handle day-to-day decisions in a consistent and orderly fashion.

3.5 Quality of the buildings in Bahrain

Rapid development in Bahrain has focused attention on the problems that have been associated with construction. The widely prevalent deterioration of concrete structures in Bahrain is caused by the cumulatively interactive effect of environmental severity, incorrect material specifications, bad workmanship, absence of engineering supervision and defective construction practices. Corrosion of reinforcement salient environmental chloride is the main deterioration factor. Corrosion of reinforcement outweighs the other factors by a wide margin.

Some measures of success have been achieved as international consultants working in the country mainly on large government financed projects have accumulated
expertise. The state of the art in this field, especially in respect of concrete materials and mix design, is today far more advanced than it was fifteen years ago.

Unfortunately, this notable success seems to have been totally ignored by one sector of the economy, which is the privately financed building and development sector. This group, which until recently was not required even to name an engineer or architect to supervise and be responsible for the construction works, was able to carry on building huge reinforced concrete structures, without proper specifications or supervision and with the use of sub-standard materials.

In Bahrain, there are three different levels of construction as categorised earlier - first among them are the large projects for the government, which are usually designed by international consultants and built by large international or joint-venture constructors. The second group is the locally based constructors who usually take the medium sized projects. Finally, there are the small building projects, which are usually under the control of local architects and local builders some of whom may lack technical skill in the construction industry.

3.6 Barriers to the implementation of TQM to the construction industry in Bahrain

These barriers were concluded at the data collection phase of this research, mainly from the interviews conducted and the survey questionnaire results. The barriers are as follow.

3.6.1 Awareness of TQM

Many organisations in Bahrain have a misunderstanding about TQM. These organisations believe that to improve the services and promote quality, it has to be done by spending money through investment in technology. Awareness of TQM,
method of application, tools and techniques is still not in the organisation book. Some organisations misunderstand the functionality of TQM and are not sure whether it is important to be applied or not. These organisations do not know how, where, when and why to apply TQM.

3.6.2 Mixed Cultures
The workforce in the construction industry in Bahrain consists mainly of workers who come on a renewable two-year contract. The Bahrainese own most of the organisations but they hire foreign workers such as technical managers, engineers, supervisors, and foremen. The essence of the implementation of TQM is creating a culture shared with beliefs and objectives. This culture is supposed to be the spine of the organisation, where it is to be improved continuously through teamwork and with proper communication. In the case of foreign staff and workers, changing every two years from one organisation to another or leaving the country, it is difficult to create a stable and permanent culture in the organisation.

3.6.3 Awareness of productivity
There is a misunderstanding about what is really meant by productivity. Many people believe productivity is only equated with production. For example, if more output of goods and services is achieved, then productivity is assumed to have increased. It is believed that anything which relates to production will be apparent to measure its output. Another common misunderstanding in some organisations in Bahrain related to productivity is that it is only related to the labour input. This assumption has no reasonable basis, as an organisation's success is dependent on the effectiveness with which it utilizes all the resources such as raw material, capital equipment, energy and labour. The view that productivity can only be applied to labour is risky. It results in a failure to capitalize on significant opportunities to improve performance through better equipment utilization and reduction on material losses.
3.6.4 Lack of long-term objectives

A common problem with many organisations in Bahrain is that they do not establish a long-term plan for the organisation and make firm commitment to future objectives and targets of the organisation. Most of the organisations do not have a philosophy for quality or a vision. They also lack the availability of documented procedures that show how the organisation is operating.

3.6.5 Time – Scale to implement TQM

It takes three to five years for any TQM programme to work in an organisation, depending on the size of the organisation and the type of product or service. In Bahrain, many organisations do not know if they can survive in the market for the coming two or three years because these organisations are not established on strong financial, managerial or technical grounds. The lack of planning, programming and continuous improvement of the organisation leads to frequent risks in the market.

3.6.6 Resistance to change

Many organisations in Bahrain, especially those run by a sole proprietor, are illiterate in TQM issues. These managers especially when they are of the older generation, think what they have learnt and done in the past, even though it brings small profit, is better than any ideas or methods that are new. These managers will resist and object to any new techniques, tools and theories in management.

These are only some barriers and obstacles which are specifically focused to the construction industry in Bahrain. There are many barriers and obstacles to the implementation of TQM to the construction industry in general which are dealt with in the next chapter.
3.7 **Construction in Bahrain compared to U.K.**

The outcomes from the literature reviews and data collected revealed a major setback in the construction industry in Bahrain compared to the construction industry in the United Kingdom. Even though the construction industry in Bahrain is much smaller in size and mature in its capability compared to UK construction industry, but the problems existing in the construction industry in Bahrain are major and deep in its effect. Most of the problems and a critical analysis of the situation in Bahrain’s construction industry are discussed in detail in chapters Three and Six, the major problems currently existing in the construction industry in Bahrain are summarised as follow.

- Nearly all projects don’t finish on time due to unclear specifications, variations and disputes.
- The allocated budgets are always raised due to changes and high cost of variations.
- Disputes arise due to unclear, vague or incorrect specifications. This is reflected by the high number of cases at the courts of justice between clients and constructors.
- The quality of the building is always compromised to finish the project, due to unclear specification of quality standards, specification of the wrong materials and methods of fixing.
- Penalties correspondence and time consuming instruction orders between the architect, the constructor and the owner, due to missing information in the specification.
- At the end of the project there are always disputes and finger pointing between the architect and the owner, due to lack of information, inadequate or poorly prepared specifications and the low quality of the finished project.
The British construction industry is the fourth largest in Europe and represents over 10 percent of total EU construction activity. UK construction companies are also responsible for a significant amount of work undertaken overseas, usually on behalf of British consultants and constructors (Technology Foresight report 1995).

Egan (1998) described the UK construction industry in the rethinking construction report that at its best the industry is excellent. Its capability to deliver the most difficult and innovative projects matches that of any other construction industry in the world. Nevertheless, there is deep concern that the industry as a whole is under-achieving, especially in the following areas.

1. It has a low and unreliable rate of profitability. Margins are characteristically very low. The view of the task force is that these are too low for the industry to sustain healthy development and wish to see those companies who serve their clients well making much better returns.

2. It invests little in research and development and in capital. In house R & D has fallen by eighty percent since 1981 and capital investment is a third of what it was twenty years ago. This lack of investment is damaging the industry’s ability to keep abreast of innovation in.

3. There is a crisis in training. The proportion of trainees in the workforce appears to have declined by half since the 1970s and there is increasing concern about skill shortages in the industry. Too few people are being trained to replace the ageing skilled workforce, and too few are acquiring the technical and managerial skills required to get full value from new techniques and technologies. Construction also lacks a proper career structure to develop supervisory and management grades.

4. Too many clients are undiscriminating and still equate price with cost, selecting designers and constructors almost exclusively on the basis of tendered price. This tendency is widely seen as one of the greatest barriers to
improvement. The public sector, because of its need to interpret accountability in a rather narrow sense, is often viewed as a major culprit in this respect. The industry needs to educate and help its clients to differentiate between best value and lowest price;

5. Under-achievement can also be found in the growing dissatisfaction with construction among both private and public sector clients. Projects are widely seen as unpredictable in terms of delivery on time, within budget and to the standards of quality expected. Investment in construction is seen as expensive, when compared both to other goods and services and to other countries. In short, construction too often fails to meet the needs of modern businesses that must be competitive in international markets, and rarely provides best value for clients and taxpayers.

6. The under-achievement of construction is graphically demonstrated by the City's view of the industry as a poor investment. The City regards construction as a business that is unpredictable, competitive only on price not quality, with too few barriers to entry for poor performers. With few exceptions, investors cannot identify brands among companies to which they can attach future value. As a result there are few loyal, strategic long-term shareholders in quoted construction companies.

7. Discussions with City analysts suggest that effective barriers to entry in the construction industry, together with structural changes that differentiated brands and improved companies' "quality of earnings" (i.e. stability and predictability of margins), could result in higher share prices and more strategic shareholders. We believe such a change towards stability of profit margins would be at least as highly valued by the City as a simple increase in margins.
3.8 Summary

The construction industry in Bahrain must play its part in the development process. The constructors in business, both international as well as regional, will have to perform differently than before. There is much greater awareness of the need to control costs and to demand and achieve a higher quality of performance.

Projects in Bahrain can be categorised into three types namely - large, medium and small projects. Most of the clients in the small, medium and some of the large projects want to spend the lowest budget for a maximum investment return without thinking of the effects of lowest prices and quotes on quality issues.

There are no specifications tailored for the construction industry in Bahrain or any of the Gulf countries. Consultants will typically have developed a general specification for concrete work with the intention of applying it to all projects that they are engaged on. However, there are cases where the specifications do not cover the particular type of work being carried out, yet provide a bulk of unwanted material that is of no use and just makes the document more difficult to use.

Defects of workmanship in the construction industry in Bahrain come from errors in structural design, lack of attention to detail design, incorrect, inadequate or incompatible specifications, errors in construction methods, lack of quality assurance programmes on design offices and on site and the use of inadequate, unclear specifications.

Rapid development of Bahrain has focused attention on the problems that have been associated with construction. The cumulatively interactive effect of environmental severity, incorrect material specifications, bad workmanship, absence of engineering supervision and defective construction practices cause the widely prevalent determination of concrete structures in Bahrain.
Barriers to the implementation of TQM to the construction industry in Bahrain are briefed in the following points:

- lack of awareness of TQM;
- existence of mixed culture;
- lack of awareness of productivity;
- lack of long-term objectives;
- time scale needed to implement TQM; and
- resistance of managers to change.
CHAPTER FOUR

THE CONCEPT OF TOTAL QUALITY MANAGEMENT
CHAPTER FOUR

THE CONCEPT OF TOTAL QUALITY MANAGEMENT

4.1 Introduction

The principles of TQM are valuable to individuals, groups of people and organisations, and many organisations have now discovered a relationship between quality and profitability. It has now become important for organisations to develop strategy by adopting the principles of TQM. Superior product or service customer satisfaction, lower cost and continuous improvements are the aims of any organisation to survive and compete in business. TQM will allow any organisation to reach these aims through a culture-based system, commitment, leaderships; teamwork, communication and continuous process improvement using integrated tools, techniques and training.

The survey results showed a lack of awareness for the purpose of specifications and the use of TQM in the construction industry in Bahrain. Level of awareness must be raised through authorities technical offices, technical institutions, engineering and managerial societies and through the media. To improve the level of quality of building in every phase of the construction process of the project until handover to client, to full satisfaction.

Achieving the objectives of the implementation of the framework in this research to the construction industry in Bahrain should work parallel with the raising of the awareness to the importance of specifications and TQM to the construction industry as a whole. This can only be achieved by the joint contribution of the private and public sectors together through all different channels in the construction industry in Bahrain. Like any other quality systems results are
achieved with a certain period in time, for TQM program result usually achieved within three to five years in the construction industry organisations.

Improving quality is very often regarded as an activity, which is going to increase cost. This view confuses the terms used in industry concerning quality and grade. Improving or raising the grade of service or product relates to the use of more expensive materials or processes to produce a product and will raise product costs. Improving quality means, among other things, making less faulty products with the same amount of effort or cost, which usually gives a lower unit cost.

The essence of this research is TQM, where the aim is to develop and implement a framework for TQM in the construction industry in Bahrain. Therefore, a comprehensive review of literature on the concept of TQM had to be undertake to study the historical evolution, philosophy, principles, elements, techniques and methods of implementing TQM.

A comprehensive research in the concept of TQM had to be done to learn and understand those points. There were a large variety of sources to get this information: university library books, a lot of books were bought, the Internet, magazines related to TQM and previous researches in TQM. Unfortunately most of these sources are not available in Bahrain, most of them where obtained from the UK.

This chapter reviews the principles, techniques and the evolution of TQM with a comparison between traditional quality approaches and TQM, describing the main obstacles to the implementation of TQM to the construction industry and reviewing the recent researches in quality.
4.2 What is TQM?

TQM is a culture-based system, focusing on customer satisfaction through continuous improvement. Feigenbaum (1951) commented that the notion of value had to be included in any quality definition: Quality does not have the popular meaning of "best" in any absolute sense. It means, "best for certain customer conditions". These conditions are (a) the actual use and (b) the selling price of the product. Product quality cannot be thought of apart from product cost.

The ECI TQM Task Force (1993) defined TQM as follows.
"TQM is a management-let process to obtain the involvement of all employees in the continuous improvement of the performance of all activities, as part of normal business, to meet the needs and satisfaction of the customer whether internal or external".

Sashkin and Kiser (1993) defined TQM as follows.
"TQM means that the organisation's culture is defined by and supports the constant attainment of customer satisfaction through an integrated system of tools, techniques and training. This involves the continuous improvement of organisational process resulting in high quality products and services.

QPMA (Quality and Productivity Management Association 1993) defined TQM by mainly focusing on the customer and improvement of performance.

"Total Quality is a client-focused, strategic and systematic approach to the continuous improvement of performance" (pp 444).

(The Japanese Industrial Standard Z8101 - 1981) states that Quality Control is:
"A system of means to economically produce goods or services which satisfy customers' requirements".
Dahlgaard, Kristensen and Kanji (1998) stated the quality of TQM definition, where TQM can be said to be the culmination of a hierarchy of quality definitions.

1. Quality – is to continuously satisfy customers' expectations.
2. Total Quality - is to achieve quality at low cost.
3. Total Quality Management – is to achieve total quality through everybody’s participation.

4.3 How TQM developed with time?

The term 'Total Quality Control” originated in the United States in the late 1950’s. The first reference to the term appeared in an article by Armand V. Feigenbaum. He was the first to use the term “Total Quality Control”, meaning essentially what is now called “TQM” in the classic article “Total Quality Control”, Harvard Business Review, November/December 1956. He expanded on this in his book, “Total Quality Control” 1961.

Figure (4.1) characteristic of the different stages in TQM by Dahlgaard, Kristeen and Kanji (1998) shows the different stages for the evolution of TQM from the year 1910 to 1980 as follow.

Table 4.1: Characteristic of the different stages in TQM

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>QI (1910)</td>
<td>Salvage</td>
</tr>
<tr>
<td></td>
<td>Sorting</td>
</tr>
<tr>
<td></td>
<td>Corrective action</td>
</tr>
<tr>
<td></td>
<td>Identify sources of non-conformance</td>
</tr>
<tr>
<td>QC(1924)</td>
<td>Quality manual</td>
</tr>
<tr>
<td></td>
<td>Performance data</td>
</tr>
<tr>
<td></td>
<td>Self-inspection</td>
</tr>
<tr>
<td></td>
<td>Product testing</td>
</tr>
<tr>
<td></td>
<td>Quality planning</td>
</tr>
</tbody>
</table>
Satish Goyal (2000), described in his paper at the Quality Beyond 2000 Conference in Bahrain, “The Quality Journey”, that quality has changed its function with the passage of time from the 1950’s – 1990’s.

1950’s – Inspection  
1960’s – Quality Control  
1970’s – Quality Assurance  
1980’s – Quality Circles  
1990’s – Total Quality Management

**Inspection**

This is a process of sorting good or bad. It is a post-operation inspection, which is unsatisfactory since it does nothing to prevent the occurrence of defects. It does not matter how much a defective part is inspected, it will not make it any better. All
inspection can do is to segregate well from bad. Inspecting a good product only adds to its cost, not to its value. The next step in the evolution of quality was how to prevent defects in the first place. This was the birth of quality control.

**Quality Control**

The main aim of quality control is defect prevention. David Hutchins (1992) stated that the first breakthrough came when Walter Shewhart, a statistician, was appointed to head the Quality Control Activities at the Hawthorn works of the Western Electric Corporation in the United States. On his staff were up-coming engineers named Juran, Levenforth and Elton Mayo. Shewhart quickly recognised the opportunity for the application of his statistical background to the inspection function and invented the X/R chart concept diagram according to Figure (4.1). Juran was the first person to use the technique when he applied it to the manufacture of relays. Following World War II, statistical quality control was regarded as state-of-the art and applicable mainly to the high-volume manufacture of engineering products. This was the situation when Deming (1950) followed by Juran (1954) and Fiegenbaum (1958) went to Japan. Each of these gurus viewed quality differently but each of them regarded quality as a management activity.
CL: Control Limit

UCL: Upper Control Limit

LCL: Lower Control Limit

Figure 4.1: X/R chart

Source: David Huchins (1992)
Quality Assurance

The concept of quality evolved from a narrow, manufacturing based discipline to one with implications for management throughout a firm. Statistics and manufacturing control remained important but co-ordination with other areas, such as design, engineering, planning and service activities also became important to quality. While quality remained focused on defect prevention, the quality assurance era brought a more pro-active approach. It is a management system designed to control the activities at all stages (design, production, delivery and service) to prevent quality problems and ensure only conforming products reach the customer. ISO 8402 defines it as follows. “All the planned and systematic activities implemented within the quality system, and demonstrated as needed to provide adequate confidence that an entity will fulfil requirements for quality”.

Quality Circles

Sashkin and Kiser (1993) reported that quality control became popular in Japan during the 1960's and 1970's. They began formally in 1962 and by 1980 there were over 1,00,000 Quality Circles in operation in Japanese organisations of all types. Workers would meet in teams around a table at a regular time during the week, usually before or after working hours. The team members would discuss problems, usually concerning the quality of production. Based on these discussions they would develop solutions and pass these ideas on to the management. The aim was usually to improve product quality, which is why it was called “Quality Circles”.

American firms began using QC’s in the mid-1970's they gained in popularity throughout the 1980's. By 1986, QC’s were common, but it was noted that QC’s seemed to mix results. Not every QC installation was a grand success. The new managers were much less supportive of or interested in the QC programme, therefore, they abolished the programme.
After QC's failures, managers realized that for QC's to take root and make a long-term difference more would be needed than a room with a table and chairs and an hour week overtime pay for the workers. The organisational culture in which these employees worked was very different from that of the typical Japanese firm involved in QC's. Instead of a history of loyalty to the organisations based on trust and support, there was a history of acrimony and deception. Instead of a shared sense of purpose and problems, there were strong differences in how employees and managers defined both the purposes and problems of the organisation.

It was about this time that American management discovered Quality Improvement (which has now become so popular that it has all but replaced earlier attention to Productivity Improvement).

**Total Quality Management (TQM)**

Quality Assurance and Quality Control aims were to determine problems by inspection of already completed work. TQM seeks to prevent mistakes in the manufacturing process, as opposed to the detection of mistakes typical to QA/QC. TQM seeks the continuous improvement of product manufacturing processes by allowing everyone who is part of the process to become involved in the improvement process.

There was a need for products with superior quality, lower cost and more reliable delivery. The Japanese firms gained market shares, achieved immense profitability while American firms were under pressure, and made losses due to product liability suits for defective products and constant pressure from consumer advocates Bound, Yorks, Adams Ranney (1994).

The word “Total” conveys the idea that all employees, throughout every function and level of an organisation, pursue quality. The word “Quality” suggests
excellence in every aspect of the organisation. “Management” refers to the pursuit of quality results through a quality management process. While the Japanese term for their approach is “Company-Wide Quality Control” (CWCQ), to label approaches to management that are quite similar to what American managers call “Total Quality Management”. (Bound Yorks, Adams, and Ranney 1994).

There are many recognized gurus in the theory of Quality Management or continuous process improvement. The most noted include Philip B Crosby, Edwards Deming, Joseph M Juran, Taiichi Ohno and Kaoru Ishikawa. These gentlemen and many others have greatly advanced the theory and practice of quality management, throughout the manufacturing and service industries, from Japan to America.

Sashkin and Kiser (1993) stated that in the late 1940’s the Bureau of the Census sent Edward Deming to Japan to help the post war Japanese government improve its census-taking capability. In the 1950’s still generally ignored by American industry he returned to Japan at the invitation of a new professional organisation of engineers and scientists. The founders of this organisation, the Japan Union of Scientists and Engineers (JUSE) were concerned about the very poor quality of Japanese products. They intended to change this situation. Deming agreed to help with a lecture tour, talking to large groups of technicians, researchers, engineers and plant managers. Deming realized that he had to lecture and teach his methods not only to engineers and technicians as he did in America. When his methods were not implemented for a long time in Japan, he asked a top executive of a Japanese organisation, Ichiro Ishikawa, who was a former professor, whether it was possible to arrange a special session with a group of top industrial managers. Unlike American managers, Japanese top managers paid attention to Deming. They went to work with passion; they knew they had to re-build their industrial base if Japan was to prosper in the coming years. They were well aware of Japan’s
reputation for inferior quality. To become a real competitor in the world economy, Japan had to change and improve.

Throughout the 1950's Japanese firms viewed among themselves to see which could go the furthest in applying Deming's ideas. They quickly established an all-industry competition and an annual prize for the organisation that demonstrated the most comprehensive and effective applications. Teachers are honoured and respected in Japan so they named the prize after their first and most important teacher W Edwards Deming.

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Figure 4.2: The PDCA Deming cycle
Source: John S. Okland (1995)

Deming taught the Japanese Shewhart's principles of scientific thinking embodied in the Plan, Do, Check, Act (PDCA) Cycle, which the Japanese soon referred to as
the Deming Cycle see Figure (4.2). The PDCA cycle provides managers with a scientific method for learning how to make improvements. Deming introduced the Japanese to modern approaches to consumer research and suggested methods for relating the research to continuous improvements. Under the intellectual leadership of business leader's like Kaor Ishikawa, the Japanese continued to refine the Shewhart/Deming approach to continuous improvement. They introduced other techniques to support an approach to continuous improvement, which focused on the means (the causes) and not just the ends (the results). For example, Ishikawa developed the cause/effect or fish-bone diagram as a format for documenting ideas about cause/effect relationships. Ishikawa suggest that the turning point for the Japanese came with the arrival of two other Americans, Joseph M.Juran and Armand Feigenbaum, Bound, Yorks, Adams and Ranney (1994).

4.4 TQM Gurus and their theories

A “Guru” is defined as a good man, a wise man and a teacher. They also tend to have charismatic characters, often well ahead as their time that contribute significantly to their chosen field. In spite of criticism and occasional ridicule, people destined to be defined as Gurus will stick to their beliefs because they are sincere and often passionate about their beliefs John Gilbert (1992). Gurus have contributed to the thinking and practice of the quality improvement movement in two ways. Some of them concentrated on the philosophical aspects of quality improvement and others concentrated on the tools of quality. John Gilbert (1992) categorized the gurus into three categories as follows.

The Early Americans
W. Edwards Deming Management Philosophy
Joseph M. Juran Planning and Quality Costs
Armand V. Feigenbaum Total Quality Control
The Japanese
Kaoru Ishikawa
Tools
Quality Circles
Company-wide Quality
Genichi Taguchi
Minimum Prototyping
Shigeo Shingo
Poka-Yoke (Zero defects)

The Westerners
Philip B Crosby
Awareness
Zero Defects
Do it right first time
Tom Peters
Customer Orientation
Claus Moller
Personal Quality

The Early American Gurus
(I)W Edwards Deming

Deming introduced the concept of “Variance” to the Japanese and a systematic
approach to problem solving which eventually was called the PDCA Cycle (Plan,
Do, Check, Act). Later Deming pushed the need for management involvement and
produced Deming’s famous 14 points:

1. Create constancy of purpose for improvement of product and service.
2. Adopt the new philosophy.
3. Cease dependence on mass inspection.
4. End the practice of awarding business on prize tag alone.
5. Improve constantly and forever the system of production.
6. Institute training.
7. Institute leadership.
8. Drive out fear.
9. Breakdown barriers between staff areas.
10. Eliminate slogans, exhortations and targets for work.
11. Eliminate numerical quotas.
12. Remove barriers to pride of workmanship.
13. Institute a vigorous programme of education and improvement.
14. Take action to accomplish the transformation.

II Joseph M. Juran
Along with Deming, Juran is credited with the Japanese success in quality management because of his work and lectures in that country after World War II. Juran’s career in quality in the United States began at the Western Electric Company, where he became chief of the inspection control division. In 1951 McGraw-Hill published his textbook “Quality Control Handbook”, which came to be regarded as the “Bible” of the quality improvement process in both the United States and Japan Kubal (1994). Juran emphasized a project-by-project approach to quality improvement that is solving quality and defect problems at a specific part of the manufacturing process versus the overall-general improvement approach to quality management. Juran’s quality process includes the following steps.

- Create a management philosophy of quality and an awareness of the need for improvements.
- Establish goals for quality improvement on a project-by-project basis.
- Create a quality council to guide and co-ordinate employees to meet their goals.
- Complete projects, find problems and solve them on a project-by-project basis.
- Establish a programme of training and education.
- Communicate the progress of quality improvement by keeping score.
- Recognize those who have contributed to the process.
- Maintain momentum by making the quality controls, planning and improvement.
• Processes a standard part of the management process.

(III) Armand Feigenbaum

Feigenbaum believes in total quality control where a systematic approach should be used involving all the functions of the organisation and not just manufacturing. Quality should be built in at an early stage, and the system should be allowed to develop gradually. Feigenbaum sees quality improvement as the single most important force leading to organisational success and growth. He originated the concept of total quality control and claimed, “Quality is in its essence a way of managing the organisation” John Gilbert (1992) and requires:

• a clear understanding of international markets;
• that management needs a thorough grasp of total quality strategy with a hands-on style; and
• that total quality process is the single most powerful change agent for companies today.

The Japanese Gurus

(I) Kaoru Ishikawa

The late Ishikawa, who was a professor at the University of Tokyo, first began surveying and studying quality control when Ishikawa joined a research group set up by the Union of Japanese Scientists and Engineers (JUSE) in 1949. In the same year Kaoru Ishikawa was the first to recognize that quality improvement is too important to leave in the hands of specialists. Ishikawa stated that it should be company-wide from board room to back-room, top to bottom and an all pervasive influence on the way business is conducted Gilbert (1992).
Ishikawa invented the cause and effect diagram as a device to assist groups (quality circles) with their improvement efforts. The diagram often bears Ishikawa’s name and is a useful way to find, sort out and document the causes of variation of quality.

(II) Genichi Taguchi
Taguchi developed a methodology for minimum prototyping in product design and trouble shooting in production. The methodology is concerned with the routine optimisation of product and process prior to manufacture, rather than the use of inspection as a tool of quality. The design aspects of off-line quality control are divided into three stages:

- System Design;
- Parameter Design; and
- Tolerance Design.

System design is the art of creating a design concept or “an up and limping” prototype. Parameter design is the crucial step, and involves testing the design features in order to find the ones that are least sensitive to outside changes. Tolerance design is then applied to reduce further variations. If necessary, better raw materials or equipment will be purchased Gilbert (1992).

(III) Shigeo Shingo
Shigeo Shingo was one of the key figures in the development of just-in-time manufacturing and its promotion and use outside Japan. Shingo was one of the 20th century’s greatest engineers and was honoured by the whole world for the major contributions he made not only to the thinking process behind quality improvement, but also the methodology of the processes.
Shingo is best remembered for his work on the development of quick change over (SMED), (Single Minute Exchange of Die) and (Poka-Yoke) Mistake Proofing.

The Poka-Yoke system (mistake proofing or defect = zero) for production processes is based on the use of preventive measures. Shigeo Shingo said that the process should be stopped whenever a defect occurs, exhaustively investigated and steps taken to elaborate the cause and prevent the re-occurrence of the defect by eliminating the cause. This requires constant monitoring of potential error sources, so as to nip them in the bud before they become a problem.

Shingo also worked on machine set-up reduction for engineering companies to develop methods of reducing or minimizing set-up time. This methodology is known as Single Minute Exchange of Die (SMED).

The Western Gurus

(I) Philip B. Crosby

Crosby's quality programme includes the commitment to zero defects; it is based on fourteen steps to achieve "Zero Defects". This programme began while Crosby was in-charge of the quality programme for the Pershing missile at the Martin Corporation Kubal (1994).

Crosby is well known for the concepts of "Do It Right First Time", and Zero Defects. Crosby's bases his quality improvement methods on the four absolutes of quality management:

- conformance to requirements;
- prevention not appraisal;
- zero Defects; and
- measurement of the price of non-conformance.
Crosby's fourteen steps to Quality Improvements as the method of implementing the process Gilbert (1992) are as follows.

1. Management Commitment.
2. Form Quality Improvement Teams.
3. Measure to find improvement areas.
4. Evaluate the cost of quality.
5. Raise quality awareness.
6. Take actions to correct problems.
7. Establish progress monitoring of the improvement process.
8. Train supervisors.
9. Hold a "Zero Defect" day.
10. Encourage people to establish improvement goals.
11. Encourage people to tell management about the obstacles they face.
12. Recognise and appreciate those who participate.
13. Establish quality councils to communicate on a regular basis.
14. Repeat the programme all over again.

Tom Peters

Peters emphasises the importance of customers, innovation, people, leadership and systems. Peters sees leadership rather than management as the central issues behind quality improvement and is an advocate of management by walking about as a mechanism for:

- listening (Caring);
- teaching (Value transmission); and
- facilitating (Helping).
Peter is the guru who talks most about customers, and in his book “Thriving on Chaos”, deals with each key area in terms of “Prescriptions” as the way to bring about the necessary “Management Revolution”.

(III) Claus Moller

Moller developed the concept of personal quality as the central element of TQM and talks about the 12 Golden Rules to aid quality improvement.

1. Set personal quality goals.
2. Establish own personal quality account.
3. Check how satisfied others are with your efforts.
4. Regard the next link as a valued customer.
5. Avoid errors.
6. Perform tasks more effectively.
7. Be committed.
8. Learn to finish what you start.
10. Be ethical.
11. Demand quality.
12. Utilise resources well.

Claus Moller also has the 17 hallmarks of a quality organisation. He emphasises administrative procedure improvement rather than the improvement of production processes. Moller further emphasizes the use of checklists and the two standards of personal quality, Ideal performance (IP) and Actual Performance Level (AP). Overall, Moller believes in people improvement as the key to quality improvement Gilbert (1992).
The informations taken for the following table are from a variety of sources, and a comparison between America, Japanese and western gurus representing three schools of thoughts relating to TQM, presented in Table 4.2.

**Table 4.2: Comparison between the three TQM schools**

<table>
<thead>
<tr>
<th>American</th>
<th>Japanese</th>
<th>Western</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originated the concept of Total Quality Control.</td>
<td>Recognise that quality improvement is to important to leave in the hand of specialists, it should be company-wide, from board-room to back-room top to bottom and an all pervasive influence on the way business is conducted.</td>
<td>Development of do it right first time, zero defects, prevention not appraisal and conformance to requirements as bases to quality improvement.</td>
</tr>
<tr>
<td>Took the quality message to the Japanese after the second world war because they were not listened to at home.</td>
<td>Used the cause-and-effect diagram to great effect as a device to assist groups quality circles with their improvement efforts.</td>
<td>Emphasizes the importance of customers, innovation, people, leadership and systems.</td>
</tr>
<tr>
<td>Introduced the concept of ‘variance’ to the Japanese.</td>
<td>Developed a methodology for minimum prototyping in product design and trouble shooting in production.</td>
<td>Leadership rather than management as the central issue behind quality improvement and is an advocate of management by working about (MBWA).</td>
</tr>
<tr>
<td>Introduced a systematic approach to problem solving which eventually was called PDCA (plan, Do, check, Act).</td>
<td>Developed a methodology for minimum prototyping in product design and trouble shooting in production.</td>
<td>Developing of the concept of personal quality as the central element of TQM.</td>
</tr>
<tr>
<td>Pushed the need for management involvement.</td>
<td>Design aspects of off-line quality control are divided into three stages: system design, parameter design and tolerance design.</td>
<td>Emphasises administrative procedure improvement rather</td>
</tr>
</tbody>
</table>
Quality control should be conducted as an integral part of management control.

A systematic approach should be used in TQM involving all the functions of the organisation and not just manufacturing.

Development of Just-in-Time manufacturing and its promotion and use outside Japan.

Development of (SMED) single minute Exchange of Die, for reducing or minimizing set-up time.

Emphasises the use of check list and the two standards of personal quality, Ideal Performance (ID) and Actual Performance (AP).

Believe in people improvement as the key to quality improvement.

4.5 The Foundations, tools and techniques of TQM

4.5.1 The Foundations of TQM

Americans and Japanese quality “Gurus” have each set down a number of points or absolute-words of wisdom in management and leadership and many organisations are using these to establish a policy based on quality. These have been distilled and modified to ten points for senior management to adopt Oakland (1995).

1. The organisation needs long-term commitment to constant improvement.

There must be a constancy of purpose and commitment to it, which must start from the top. The quality improvement process must be planned on a truly organisation wide basis. The place to start the quality process is in the boardroom. Leadership must be by example. Then the process must progressively expand to embrace all parts of the organisation.
2. Adopt the philosophy of zero errors/defects to change the CULTURE to right first time. This must be based on a thorough understanding of the customer's needs and expectations and on teamwork, developed through employee participation.

3. Train the people to understand the CUSTOMER - SUPPLIER relationships
The commitment to customer needs must start from the top, from the Chairman or Chief Executive. Without this, time and effort will be wasted. Customer orientation must then be achieved for each and every employee, directors and managers. The concept of internal customers and suppliers must be thoroughly understood and used.

4. Do not buy product or services on price alone - look at the TOTAL COST
Demand continuous improvement in everything, including suppliers. This will bring about improvements in product, service and failure rates. Continually improve the product or the service provided externally, so that the total costs of doing business are reduced.

5. Recognize that improvement of the SYSTEMS needs to be managed
Defining the performance standards expected and the systems to achieve them is a managerial responsibility. The rule has to be that the systems will be in line with the shared needs and expectations and will be part of the continuous improvement process.
6. Adopt modern methods of SUPERVISION and TRAINING - eliminate fear
   It is all too easy to criticize mistakes, but it often seems difficult to praise efforts and achievements. Recognize and publicise efforts and achievements and provide the right sort of training, facilitation and supervision.

7. Eliminate barriers between departments by managing the PROCESS - improve COMMUNICATION and TEAMWORK
   Barriers are created by "Silo Management" in which departments are treated like containers that are separated from one another. The customers are not interested in departments; they stand outside the organisation and see slices through it - the process. It is necessary to build teams and improve communications around the processes.

8. Eliminate the following
   - Arbitrary goals without methods.
   - All standards based only on numbers.
   - Barriers to pride of workmanship.
   - Fiction. Get FACTS by using the correct TOOLS.

At all times it is essential to know how well the organisation is doing in terms of satisfying the customer's needs and expectations. Help all employees to know how they will achieve their goals and how well they are doing.

Traditional piecework will not survive in a TQM environment or vice versa because it creates barriers and conflict. Train people to measure and report performance in language that the people doing the job can understand. Encourage each employee to measure his/her own performance. Do not stop with measuring performance in the organisation. Find out how well other organisations (competitive or otherwise)
are performing against similar needs and expectations (benchmark against best practice). The costs of quality mis-management and the level of fire fighting are excellent factual indicators of the internal health of an organisation. They are relatively easily measured and simple for most people to understand.

9. Constantly educate and retain-develop the "EXPERTS" in the business
The experts in any business are the people who do the job every day of their lives. The 'Energy' that lies within them can be released into the organisation through education, training, encouragement and the chance to participate.

10. Develop a SYSTEMATIC approach to manage the implementation of TQM
TQM should not be regarded as a woolly-minded approach to running an organisation. It requires a carefully planned and fully integrated strategy, derived from the mission. That is why it will help the organisation to realize its vision.

Figure 4.2 shows a TQM model, that identifies customer-supplier relationships, manage processes, change the culture, improve communication and show commitment surrounded by the management necessities of the systems (based on international standard), tools (for analysis, correlations and predictions for action for continuous improvement to be taken and teams (the council, quality improvement teams, quality circles and corrective teams). The model is in a multi-dimensional TQM 'Vision' against which a particular organisation's status can be examined or against which a particular approach to TQM implementation may be compared and weaknesses highlighted.
4.5.2 Tools and Techniques of TQM

4.5.2.1 Seven old tools

Most of the seven old tools have been used for many years. Like the quality circle technique, it is not the tools themselves that are really new. Rather it is their use as an integral part of TQM. The tools are just ways to display information visually,
ways that help managers or those responsible for quality and performance see how a system or process is operating. Managers can then interpret information to identify problems, look for causes and take a rational approach to solving the problems that are identified.

The seven tools are listed by Sashkin and Kiser (1993) as follows.

1. Control Charts
2. Pareto Charts
3. Fishbone Diagram
4. Run Charts
5. Histograms
6. Scatter Diagram
7. Flow Chart

(The source of all diagrams is Sashkin and Kiser, 1993).
1. Control Charts

Control charts display the results of statistical process control measures. They provide a clear visual display that quickly tells one when a process is out of control. The production process can then be corrected and brought back into control. In a normal distribution most of the measures are close to the overall mean or average, few things are ever exactly average. The typical or average difference of the random measures from the overall mean is call the "standard deviation". The standard deviation tells how variable a measurement is. To set up a control chart one must obtain sample measures and then determine the average and the range.

Figure 4.4: Control Charts
Then the upper control limit (UCL) and lower control limit (LCL) can be calculated based on an estimate of variability and assuming a normal distribution. Every control chart shows the (UCL) and (LCL) so one can easily see whether the actual measures ever exceed the (UCL) or go below the (LCL).

2. Pareto Charts

![Pareto Chart](image)

Figure 4.5: Pareto Chart

A Pareto chart is a simple tool, used to count and display the number of defects or problems of various types over a certain period of time. The results are displayed on a chart as bars of varying lengths. The underlying principle, based on the work
of the nineteenth-century Italian economist Vilfredo Pareto, is that about 80 percent of all problems can be traced to only 20 percent of all the varied possible causes, the remaining 80 percent of causes account for only 20 percent of the problems and defects.

To get the most out of improvement efforts, one should always begin by attacking those few causes that are responsible for the majority of all quality problems. Pareto charts help identify the relatively few categories of causes that account for most problems. The chart can also be useful for identifying points in the production process at which defects of certain types are most likely to occur.

3. Fishbone Diagram

![Fishbone Diagram](image)

Figure 4.6: Fishbone Diagram
Sometimes called cause-and-effect or Ishikawa Diagram (after Kaor Ishikawa, who first developed this tool). The diagram looks somewhat like a fishbone, with the problem on detect—the effect—defined at the “head”, on the “bones” growing out of the “spine” occurrence. The chart can help point put how various separate problems causes might interact. It also shows how possible problem causes occur with respect to one another, over time, helping to start the problem-solving process.

4. Run Charts

Run Charts, sometimes called Trend Charts; are used to display measurements made over specific time intervals—a day, a week or a month, for example. One can then construct a graph, with the quality measured on the vertical axis and time along the horizontal axis. A Run Chart is little more than a running tally. Its major
use is to help determine whether there are critical times that problems of various types occur. One can then investigate why this is so.

5. Histograms

A histogram is also known as a Bar Chart. On this chart the number of products in each control category (that is, at each of a number of separate, measured values) is represented by the length of a bar. Each category is labelled and the bars are placed next to one another, horizontally. This shows which categories account for most of the measured values as well as the comparative size of each category. Histograms give a picture of the actual distribution of measures. They can show whether or not the distribution is normal.
Scatter diagrams provide a standard way of showing how one variable, for example tensile strength of a steel reinforcement bar, relates to another, such as the steel bar diameter. In the example shown, the strength of bar of various diameters was tested by pulling on the steel bar until it broke. The exact strength required to break each bar was then recorded. The results are graphed with diameter on the horizontal axis and strength on the vertical axis. It is then possible to clearly see the relationship between wire tensile strength and wire diameter. This sort of information is useful for product design.
7. Flow Charts

```
Incoming Materials

Quality Check  Fail  Return to

Cutting Process

Quality Check  Fail  Rework / Scrap

Rolling/Shaping Process

Quality Check  Fail  Rework / Scrap

Smoothing/Finishing

Quality Check  Pass  Rework / Scrap

Packing

Shipping
```

Figure 4.10: Flow charts
Flow Charts, sometimes called input-output charts, give a visual description of the specific steps in a work activity. They can be extremely helpful for understanding exactly how things are being done and then determine how to improve that process. The procedure can be applied to the entire organisation to visually track and chart the way the organisation operates.

Flow charts use certain standard symbols to refer to certain types of activities (such as decisions, shown by diamonds and activities shown by boxes) but these conventions are not as important as recording a clear description of the sequence of work activities. Flow Charts can also be used to design improved work processes, by showing how things should happen and comparing this with the way things actually occur.

4.5.2.2 Seven new tools

Seven new tools may be used as part of quality function deployment to improve the innovation processes. These do not replace the old seven tools described previously neither are they extensions of these. The new tools are systems and documentation methods used to achieve success in design by identifying objectives and intermediate steps in the finest detail. The seven new tools are listed by John S. Oakland (1995) as follows:

1. Affinity diagram.
2. Inter-relationship diagraph.
3. Tree diagram.
4. Matrix diagram or quality table.
5. Matrix data analysis.
6. Process decision programme chart (PDPC).
7. Arrow diagram.

(The source of all diagrams is Oakland, 1995).
Figure 4.11: The seven new tools.

1. **Affinity Diagram**

Why do issues remain unresolved?

- That's not my job
- Resourcing priorities
- Too many teams or committees that get bogged down
- Multiple ownership
- No buy-in from boss
- Lack of initiative
- Too busy doing paperwork
- No one wants to take responsibility
- We only work on crises

Figure 4.12: Example of an Affinity diagram
This is used to gather large amounts of language data (ideas, issues, and opinions) and organise them into groupings based on the natural relationship between the items. In other words, it is a form of brainstorming. The affinity diagram is not recommended when a problem is simple or requires a very quick solution. The output of the exercise is a compilation of a maximum number of ideas under a limited number of major headings. These data can then be used with other tools to define areas for attack. One of these tools is the inter-relationship diagram.

2. Inter-relationship diagram

![Inter-relationship diagram](image)

Figure 4.13: Example of the inter-relationship diagram.
This tool is designed to take a central idea, issue or problem and map out the logical or sequential links among related factors. While this still requires a very creative process, the inter-relationships digraph begins to draw the logical connections that surface in the affinity diagram.

The interrelationship diagraph is adaptable to both specific operational issues and general organisational questions. It has also been used to deal with issues underlying the problem of getting top management support for TQM.

3. System Flow/Tree Diagram

Figure 4.14: Example of a tree diagram.
The Systems Flow/Tree diagram is used to systematically map out the full range of activities that must be accomplished in order to reach a desired goal. It may also be used to identify all the factors contributing to a problem under consideration. Major factors identified by an interrelationship diagraph can be used as inputs for a tree diagram. One of the strengths of this method is that it forces the users to examine the logical and chronological link between tasks. This assists in preventing a natural tendency to jump directly from goal or problem statement to solution.

4. Matrix Diagram

![Matrix Diagram](image)

- 🌟 Strong Correlation
- 🟢 Some Correlation
- ⬆️ Possible Correlation

IR   Improvement Ratio
SP   Sales Point
RQA  Relative quality Weight

Figure 4.15: Example of matrix diagram (quality table).
The matrix diagram is the heart of the seven new tools and the house of quality. The purpose of the matrix diagram is to outline the inter-relationships and correlations between tasks, functions or characteristics and to show their relative importance. There are many versions of the matrix diagram but the most widely used is a simple L-shaped matrix known as the Quality Table.

Quality Table: In a quality table, customer demands (The what's) are analysed with respect to subtitle quality characteristics (the how's). Correlations between the two are categorized as strong, moderate and possible. The customer demand shown on the left of the matrix is determined in co-operation with the customer. This effort requires a kind of a verbal 'Ping-Pong' with the customer to be truly effective; ask the customer what he wants, write it down, show it to the customer and ask the customer if that is what was meant then revise and repeat the process as necessary.

5. **Matrix Data Analysis**

<table>
<thead>
<tr>
<th>Maintenance work</th>
<th>Repair method</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Remove damaged section of work and rebuild</td>
<td></td>
</tr>
<tr>
<td>Surface repair</td>
<td>● Treatment of wall surface with chemicals</td>
<td></td>
</tr>
<tr>
<td>Replaster and</td>
<td>● Wall injection method</td>
<td></td>
</tr>
<tr>
<td>paint wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paint wall only</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 4.16: Example of matrix data analysis*
Matrix data analysis is used to take data displayed in a matrix diagram and arrange them so that they can be more easily viewed and show the strength of the relationship between variables. It is used most often in marketing and product research. The concept behind matrix data analysis is fairly simple but its execution can be complex.

A good idea of the use and value of the construction of a chart for matrix data analysis may be shown in a simple example in which types of pain relievers are compared based on gentleness and effectiveness. This information could be used together with some type of demographic analysis to develop a marketing plan. Based on the information, advertising and product introduction could be effectively tailored for specific areas. New product development could also be carried out to attack specific niches in markets that would be profitable.

6. Process Decision Programme Chart

\[ 
\begin{align*}
\text{Repair crack wall} \\
\text{Clean wall} & & \text{Break around crack} & & \text{Expose reinforcement} \\
\text{Remove scales} & & \text{Use wire wear to clean bars} \\
\text{Replace defected bars} & & \text{Anticorrosion paint} \\
\text{Plaster and paint} 
\end{align*} 
\]

Figure 4.17: Process Decision Programme Chart.
A process decision programme chart (PDPC) is used to map out each event and contingency that can occur when progressing from a problem statement to its solution. The PDPC is used to anticipate the unexpected and plan for it. It includes plans for counter-measures on deviations. The PDPC is related to a failure mode and effect analysis and its structure is similar to that of a tree diagram.

7. **Arrow Diagram**

![Arrow Diagram]

- **Circles** = Beginning or ending of an event
- **Solid arrows** = Job or activity
- **Dashed arrows** = Relationship between jobs. Take no time.

*Figure 4.18: Example of Arrow Diagram*
The arrow diagram is used to plan or schedule a task. To use it, one must know the sub-task sequence and duration. This tool is essentially the same as the standard Gantt chart. Although it is a simple and well-known tool for planning work, it is surprising how often it is ignored. The arrow diagram is useful in analysing a repetitive job in order to make it more efficient.

4.6 The main obstacles to implementing TQM within Bahrain construction industry

4.6.1 General Obstacles

The general obstacles to implement TQM in the construction industry in Bahrain are summarised as follow. These points are concluded from the interviews conducted and questionnaires result.

A. In the construction industry there are many parties involved in the process of constructing a project e.g. consultant, client, main constructor, sub-constructors and suppliers. All these parties have different cultures, backgrounds and managerial skills. Many organisations collaborate in the construction industry to produce a project, and from one project to another the players change. The business structure and contractual relationships of the parties involved in the production of a project, can sometimes make the implementation of the TQM virtually impossible. Each organisation has its own rules, regulations and policies.

For TQM to succeed, the senior management of an organisation must be fully committed to quality, and the achievement of quality for its client must be a primary organisational aim. TQM is achieved by: using TQM tools to achieve the aim of quality for clients; and creating an appropriate culture with shared values and beliefs. The adopted Culture should support the aim
of quality and encourage the commitment of all organisation members to that end.

B. Usually, quality is easily achieved if it has one single designated party responsible for establishing where, when and how the error or mistake occurred. However, there must be common ownership of the process. In the manufacturing industry there are usually customers who are going to use the end product while in the construction industry it is more complex as there are considerably more internal customers other than shareholders. The internal customers are designated as those who are not the end users, but whose material, equipment or labours are used in the ultimate construction of a project. In the construction industry there are the main constructors, the trade constructors and the suppliers. The external customers in the construction industry are the client who is going to receive the project according to the specified quality, within a budget and hopefully within time.

4.6.2 Specific obstacles

The owner

The owner's brief, needs and requirements are passed to the design team. Architects and engineers are responsible for interpreting the owner's brief into a set of specific written and drawn instructions, plans and specifications. Design is then translated into actual physical construction using these instructions. These instructions are the basis of quality of most construction projects. Not every client is precise, definite and clear with these instructions. This makes it difficult for the designer to get the instructions as clear as possible with regard to budget, standard of quality and level of function of the project with regard to the investment return. Also, as the project progress, market conditions outside of the clients control may make it necessary to change the performance criteria for the project.
When quality brief is given in a proper way to the design team, the owner must ensure that this level is attained at all times; from the concept to the completion of the project, which is not the case in many projects due to the extra fees needed or relying fully on the architect for plans and specifications. Fast tracking of projects may also create a problem through lack of early design details. Ashworth (1998) stated that fast tracking results in the letting and administration of multiple construction contracts for the same project at the same time. It is appropriate to large construction projects where the employer needs to complete the project in the shortest possible time. The process results in the overlapping of the various design and construction operations of a single project. These various stages may therefore result in the creation of separate contracts or a series of phased starts and completions. When the design for a whole section of the works, such as foundations, is completed the work is then let to a contractor, who will start this part of the construction work on site while the remainder of the project is still being designed.

Architects and Engineers

Design teams have direct input over building product quality, in addition to having direct control over the selection of materials, systems and design. These teams play a vital role in the success of any quality management programme for construction projects.

Contractual arrangement way result in professional liability and risk being transferred to other team members, including the constructors and trade constructors. Architects and engineers justify such actions by claiming their fees and the costs of their insurance premiums for professional liability are not in proportion to the risks of the construction process.
Architects and engineers should involve the constructors in the pre-construction phase, construct ability and value engineering reviews may not be completed if the constructors are not involved, thus preventing the owner from enjoying the full benefits offered by the industry. Also new and better quality methods, systems or materials available at or below the originally specified product cost may not be used simply because of concerns over professional liability should failure occur as a result of being innovative.

**Project Managers**

Ashworth (1998) stated that the function of a project manager is to provide a balance between function, aesthetics, quality control, economics, and the time available for construction. The project manager's aims are to achieve an efficient, effective and economic deployment of the available resources to meet the employers requirements, interpreting them as necessary and communicating them clearly to the various members of the design team and through them to the constructor.

Sometimes the project manager oversees the general constructor and trade constructors as a consultant. In certain situations, when the project manager, acts as the consultant, another layer of management is added to the project manager team which further complicates quality processes. In this situation, the actual control of finished product quality is less defined particularly when the project manager is operating under a fee arrangement. In this type of procurement format, managers have little if any contractual responsibility other than consulting.

Team members, including the architect, may defer quality issues such as shop drawing review, material substitution approval and trade contractor selection to the project manager. The project manager, having no contractual obligation, may
not have the same goals as the owner in terms of quality, cost and time but makes decisions concerning these matters.

**General constructors**

It is difficult nowadays to appoint a general constructor who actually completes a project’s site work with his or her own construction workers. They emphasis on sub-contracting the works to reduce their exposure to liability and loss of profits. The only staff provided by the constructors and project managers is usually restricted to management staff and possibly site engineers. The reduced amount of work completed by the constructors has made it necessary for them to improve their ability to monitor and control quality. Smith (1995) stated “As a general rule constructors should be independent, self-sufficient and ‘at arm’s length’ and promoter’s aim should be to manage the contract, not the constructors.”

**Trade constructors and sub-constructors**

As it is the constructors workers that do the actual physical construction, trade and sub-constructors have direct influence over the finished project quality, however, they have little if any influence over process quality controlled by the design team and the general project manager or the general constructor.

There is growing recognition in the construction industry of the need to move away from confrontational relationships, which cause the majority of disputes, problems, delays and ultimately expense Ashworth (1998). Trade constructors and sub-constructors could benefit from partnering through long-term commitment with the main constructors, for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant’s resources.
Construction Workers

The construction workers have an influence over the quality of the project. While the architects and other members of the design choose the products to be incorporated into a building, constructors workers control the quality of installation and the resulting quality of the completed project.

Especially in the Arabian Gulf region, it has been common for construction workers to be dominated by new immigrants who are paid minimum or slightly above minimum wages, most if not all have little training. The only training they gain is on the job training, with no little or formal programmes to ensure that they are receiving proper training. They are subsequently put quickly into positions of increasingly technical responsibility.

Material Suppliers

The construction industry as a whole has not invited participation by manufacturers as contributing team members for process improvement. With the leading TQM programmes occurring in the manufacturing sector, the construction industry could well learn from these programmes and the advice manufacturers can offer on process improvements for the construction project can be crucial.

For example, an effective process requires a review of a proposed design by manufacturers involved to ensure that products are compatible and to prevent construction problems during site construction. Few designers utilise this option. It is the manufacturers that best know and understand their products abilities and limitations, consequently a manufacturers advice during the design phase is often indispensable. The inclusion of manufacturers earlier can lead to product substitution that is in the interest of an owner or the overall project quality.
Building Codes

Building codes directly control the minimum standards of many components of a building project and are responsible for much of the finished project quality. Regulations controlling the manufacturing of the construction processes are much more restrictive in the construction site than in most manufacturing and service industries.

Building codes and regulations can often restrict the ability of constructors and their construction workers from instituting any work method improvements without a lengthy approval process. By the time approval has been obtained a project would long since have been completed, thus there is often little incentive for attempting a gain approval of the proposed method. Additionally, manufacturers of construction materials and systems face a similarly long and costly process of approval that increases the cost and time necessary for implementing improvements in a building product.

4.7 TQM and Partnering

Partnering is a quality management improvement process in a long-term commitment between two or more organisations for the purpose of achieving business objectives, CII (1991). By opening communications among the project management personnel of all the organisations involved, the team completes the project in a team spirit, with all members working together to reach mutual project goals. It creates a team environment to accomplish a set of goals. Using the partnering concept, individuals learn to respect other team member’s roles in a project and recognize the inherent risk associated with their professional responsibilities Kubal (1994).

Improvement Goals of Partnering include the following

- Open communication.
- Profitability of all team members.
- Improved schedules.
- Improved safety programme.
- Better business reputations.
- Innovations.
- Reductions in or elimination of dependence on legal assistance.
- Improved levels of trust among the individuals and companies.

Kubal (1994) listed some of the partnering components as detailed below.
- The individual team members make each other aware of their individual goals.
- The team defines the common objectives.
- A structured programme is evolved for determining how to co-operate to reach the individual and common goals.
- A method of accountability, measurement and evaluation of these goals is established.
- Open communications are established to resolve problems before they become more serious.
Table 4.3: Relationship between Partnering and TQM


<table>
<thead>
<tr>
<th>Partnering</th>
<th>TQM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win-win solutions</td>
<td>Reduce Quality Cost</td>
</tr>
<tr>
<td>Long-term relationships</td>
<td>Long-term Process</td>
</tr>
<tr>
<td>Trust and openness</td>
<td>Breakdown Barriers</td>
</tr>
<tr>
<td>Environment for long-term profitability for all</td>
<td>Reduced Quality Costs</td>
</tr>
<tr>
<td>All are encouraged to address problems openly</td>
<td>Breakdown Barriers</td>
</tr>
<tr>
<td>All understand that neither benefits from</td>
<td>Breakdown Barriers</td>
</tr>
<tr>
<td>exploitation of the other in the long-term</td>
<td></td>
</tr>
<tr>
<td>Innovation is encouraged</td>
<td>Continuous Improvement</td>
</tr>
<tr>
<td>Each partner is aware of the other's needs and</td>
<td>Understanding customer needs and meeting them</td>
</tr>
<tr>
<td>is interested in helping their partner to meet their requirements.</td>
<td></td>
</tr>
</tbody>
</table>

4.8 TQM and ISO 9000

Since its introduction in 1987, national standards bodies all over the world have adopted the ISO 9000 almost universally. Within each nation, there has been a pattern of lateral expansion starting in heavy manufacturing industries and moving into lighter manufacturing organisations and then into government and service organisations. At the same time, major companies have influenced their suppliers to establish ISO 9000-based quality systems. They, in turn have required their own suppliers to do the same.

The ISO 9000 series of standards have become an internationally recognised means of managing contracts. At the present time, quality systems based on specifications may be found in organisations in all sectors ranging from chemical plants and clothing manufacturers to banks, hospitals and sports facilities.
ISO 9000 is a formal framework within an organisation, which is intended to provide adequate controls at every step in the management of a contract with a customer. The necessary scope of these controls depends on the scope of the organisation’s activities or processes. However, ISO 9000 specifies requirements for controls at each stage of the organisation’s core process from receiving an enquiry or invitation to tender to delivering the product and, where appropriate, providing after sales support (servicing). It also specifies requirements for supporting processes, such as training and document control.

The scope of requirements in each standard is intended to be appropriate to the range of activities in certain types of organisations. ISO 9001 is appropriate for an organisation which designs or develops products. ISO 9002 is also appropriate for an organisation, which manufactures a product or provides a service in accordance with a given specification. ISO 9003 may be appropriate in a few organisations where inspection or tests are considered to provide adequate assurance of quality. Quality assurance workshop notes (1997). Internal auditor, organised by Bahrain society of engineers.

Total quality is a process to give continuous improvement in the performance of all activities with the participation of all individuals in the organisations, to provide satisfaction for customers, both internal and external and includes principles, tools and techniques.
Table 4.4: The difference between TQM and ISO 9000
Source: “TQM & ISO 9000 for Architects and designers” by Charles Nelson, 1996

<table>
<thead>
<tr>
<th>TQM</th>
<th>ISO9000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely customer focused</td>
<td>Not necessarily customer focused</td>
</tr>
<tr>
<td>Integral customer strategy</td>
<td>Not integrated with corporate strategy</td>
</tr>
<tr>
<td>Philosophy, concept, tools and techniques</td>
<td>Technical systems and procedures focused</td>
</tr>
<tr>
<td>focused</td>
<td></td>
</tr>
<tr>
<td>Emphasis on employee involvement and</td>
<td>Employee involvement not necessary</td>
</tr>
<tr>
<td>empowerment</td>
<td></td>
</tr>
<tr>
<td>Continuous improvement and TQM synonymous</td>
<td>Formal procedures and guidelines-no focus on</td>
</tr>
<tr>
<td>journey.</td>
<td>continuous improvement</td>
</tr>
<tr>
<td>Organisation-wide all departments,</td>
<td>Can be departmentally focused</td>
</tr>
<tr>
<td>function and levels.</td>
<td></td>
</tr>
<tr>
<td>Everyone responsible for quality</td>
<td>Quality department responsible for quality</td>
</tr>
<tr>
<td>Involves process and culture change</td>
<td>More likely to preserve the status quo.</td>
</tr>
</tbody>
</table>

4.9 TQM and Quality Assurance (QA)

Quality assurance (QA) is only part of total quality (TQ). Quality assurance is the prevention of quality problems through planned and systematic activities (including documentation). These will include the establishment of a good quality management system and the assessment of its adequacy, the audit of the operation of the system, and the review of the system itself. Total quality is a process to give continuous improvement in the performance of all activities with the participation of all individuals in the organisation, to provide satisfaction for customers, both internal and external, and includes principles, tools and techniques. The BS55750 and ISO series provide excellent quality systems for Quality Assurance.
Table 4.5: The difference between QA and TQ

Source: EC1 (implementing TQ in the construction industry) 1996.

<table>
<thead>
<tr>
<th>Quality Assurance</th>
<th>Total Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>QA is only part of TQ. It is a systematic approach which gives adequate confidence and satisfies given requirements</td>
<td>TQ is a process to give continuous improvement in the performance of all activities which provides satisfaction for customers, both internal or external and includes principles, tools and techniques</td>
</tr>
<tr>
<td>Part of quality improvement process</td>
<td>A process for continuous improvement</td>
</tr>
<tr>
<td>A systematic approach influencing attitudes of working environment which are met every time</td>
<td>Changes attitudes and the working environment and provides tools, techniques and systems for continuous improvement</td>
</tr>
<tr>
<td>Aims to ensure customers’ requirements are met every time</td>
<td>Creates a “right first time” attitude to delight customers</td>
</tr>
<tr>
<td>Provides a base line for measuring the cost of quality</td>
<td>Cost of quality is recognized as vital and provides measurement for continuous improvement</td>
</tr>
<tr>
<td>Provides confidence to the customer of the quality of the product or service</td>
<td>The suppliers of the product or service is recognized as a quality company by customers and employees</td>
</tr>
<tr>
<td>Provides the means to reduce waste</td>
<td>Seeks to eliminate waste</td>
</tr>
<tr>
<td>Enhances publicity and image</td>
<td>Attracts publicity and company used as role model for quality</td>
</tr>
<tr>
<td>Provides procedures for doing things right</td>
<td>Provides for doing the right things right</td>
</tr>
<tr>
<td>Improvement is by eliminating recurring</td>
<td>Improvement is by cultural change based</td>
</tr>
</tbody>
</table>
problems on measurement of performance and elimination of root causes and constraints

Requires a structured organisation and statement of key responsibilities

Creates a culture in the organisation that seeks to improve in all its activities continuously

Directive and provides Procedures for all activities and working practices

Focuses on a full understanding of the various business processes by the day to day involvement of all concerned

Provides quality records of all activities

Uses quality records for measurement and for continuous improvement

The system relies on regular monitoring and audits to identify and correct non-conformances and improve procedures

Involves gatherings ideas and suggestions for improvements from everyone

Regular management reviews of the procedures and working practices leads to improvement

Stresses the importance that products and services delivered to the customer (whether internal or external) meet the requirements whether specified or not

Ensures that people are trained and experienced

Ensures that everyone in the organisation receives education and training to enable them to do their job effectively and achieve personal satisfaction

4.10 Quality Cost

Quality costs are all the costs incurred by a business to ensure that the total service it provides to customers conforms to the customers' requirements Munro Faure (1992). The cost of quality is a shorthand formula for all the business costs incurred in achieving a quality product or service Bank (1992).
Quality cost may be separated into prevention costs, appraisal costs and failure costs. The so-called P-A-F model was first presented by Feigenbaum. Failure costs can be further split into those resulting from internal and external failure Oakland (1995) the three quality costs are as follow.

Prevention Costs
These are associated with the design, implementation and maintenance of the TQM system. Prevention costs are planned and are incurred before actual operation Oakland (1995). Prevention costs include: Production or Service Requirements, Quality Planning, Quality Assurance, Inspection Equipment and Training.

Appraisal Costs
These costs are associated with suppliers and customers' evaluation of purchased materials, processes, intermediates, products and services to assure conformance with the specified requirements. Appraisal includes: Verification, Quality Studies, Inspection Equipment and Vendor Rating.

Internal Failure Costs
These costs occur when the results of work fail to reach designed quality standards and are detected before transfer to the customer takes place. Internal failure includes: Waste, Scrap, Rework or Rectification, Re-inspection, Downgrading and Failure Analysis.

External Failure Costs
These costs occur when products or services fail to reach design quality standards but are not detected until after transfer to the customer. External failure includes - Repair and Servicing, Warranty Claims, Complaints, Returns, Liability and Loss of Goodwill.
The above figure shows the relationship between the quality-related costs of prevention, appraisal, failure, increasing quality awareness and improvement in the organisation. Where the quality awareness is low, the total quality related costs are high with the failure costs predominating.

As awareness of the cost to the organisation of failure gets off the ground, through initial investment in training, an increase in appraisal costs usually results. As the increased appraisal leads to investigations and further awareness, further investment in prevention is made to improve design features, processes and
systems. As the preventive action takes effect the failure and appraisal costs fall and the total cost is reduced.

4.11 Review of recent researches in Quality

Department of Trade and Industry (DTI)

Every year, the (DTI) invests about £22m in a programme of construction-related innovation and research. The prime purpose of this programme is to foster a climate of innovation in which the UK construction industry improves its profitability, perhaps its competitiveness and most importantly enhances project value for its clients, while promoting sustainable construction and improving the quality of life for building occupants DTI Business Plan (1998). In 1998-99, the (DTI) used a £26m innovation and research budget to help improve the competitiveness, quality and performance of the UK construction industry.

The programme is part of the delivery mechanism within the Construction Directorate (CD) of (DTI) which has strategic aims to help the sectors of the construction industry to succeed in their domestic and world markets by achieving the standards of innovation, quality, reliability, safety and value which its customers require DTI business plan (1998). Among CD’s objectives are as follows.

- Increase its understandings of the construction market, the concerns of each sector of industry and the factors affecting competitiveness.

- Ensure that their issues are taken into account in Government and the European Union.

- Support industry efforts to improve competitiveness, in particular the achievements of 30 percent cost reduction by the year 2000 through improved
process, better training and qualified targeting with the help of the Construction Task Force Chaired by Sir John Egan.

- Stimulate and support best practice, research and innovation and encourage industry representative bodies to improve their capacity to address these issues.

- Work for effective and fair legislation, which protects consumers, and those who work in the industry, while minimizing the burden on it.

- Actively support the industry effort to sell its goods and services in overseas markets and to achieve import substitution at home.

The DTI promotes improvements in the construction industry's competitiveness and productivity through the Construction Industry Board (CIB) and has supported:

- The development of key performance indicators to meet the requirements identified by the Construction Task Force aims to improve the content of statistical publications. Furthermore, as part of its Public Service Agreement, the Department will set new targets for efficiency in the construction industry.

- Innovative and successful UK construction companies and the movement for Innovation has started to monitor innovative construction projects and made the results known through the Construction Best Practice Programme.

- The publication of a strategy for sustainable construction and the establishment of knowledge centre as recommended by the Construction Task Force.

- The improvement by health and safety within the buildings we all use, as well as energy conservation and access to buildings for disabled people.
Latham Report

In 1994, Sir Michael Latham presented “The Final Report of the Government Review of Procurement and Contractual Arrangements in the UK Construction Industry” constructing the team which was commissioned jointly between the Government and the industry. Latham highlighted in the final report that despite widespread agreement on three previous constructions related reports by Simon, Sir Harold Emmerson and Banwell, there had been little in the way to follow up action. Some of the recommendations made in the final report include the following.

Latham Final Report Constructing the Team (1994) include the following:

- Implementation begins with clients.
- Preparing the project and contract strategies and brief requires patience and practical advice.
- A checklist of design responsibilities should be prepared.
- Use of co-ordination project information should be a contractual requirement.
- Design responsibilities in building services engineering should be clearly defined.
- Endlessly refining existing conditions of contract will not solve adversarial problems. A set of basic principles is required on which modern contracts can be based.
- A DTI task force should endorse one of the several quality and price assessment mechanisms already available for choosing consultants.
- Tender list arrangements should be rationalized and clear guidance issued.
- Clients on quality as well as price should evaluate tenders.
- A productivity target of 30 percent real cost reduction by the year 2000 should be launched.
• An Implementation Forum should monitor progress and should consider whether a new Development Agency should be created to drive productivity improvements and encourage teamwork.

Egan and the Construction Task Force

In October 1997, the Construction Task Force, Chaired by Sir John Egan was commissioned by the Deputy Prime Minister to report on the scope for improving the efficiency and quality of delivery of UK Construction, to reinforce the impetus for change and to make the industry more responsive to customer needs. It published its report, Rethinking Construction in July 1998, with the initiative launched at a conference in November 1998.

The main issues raised by Egan in the report are as follows. (DTI - Rethinking Construction – Sir John Egan (1998).

• The Task Force has identified five key drivers of change which are needed to set the agenda for the construction industry at large: committed leadership, a focus on the customer, integrated processes and teams, a quality driven agenda and commitment to people.

• Ambitious targets and effective measurement of performance are essential to deliver improvement.

• The Task Force targets include annual reductions of 10 percent in construction cost and construction time and also propose that defects in projects should be reduced by 20 percent per year.

• The need to make radical changes to the processes through which it delivers its projects. These projects should be explicit and transparent to the industry and its clients. The industry should create an integrated project process around the four key elements of product development, project implementation, partnering the supply chain and production of components.
• If the industry is to achieve its full potential substantial changes in its culture and structure are required to support improvement. The industry must provide decent and safe working conditions and improve management and supervisory skills at all times.

• The industry must replace competitive tendering with long-term relationships, based on clear measurement of performance and sustained improvements in quality and efficiency.

• The Task Force has looked specifically at house building and believes that the main initial opportunities for improvements in house building performance exist in the social housing sector for the simple reason that most social housing is commissioned by a few major clients.

• The major clients of the construction industry must give leadership by implementing projects, which will demonstrate the approach described, to join in sponsoring demonstration projects.

• Initiate a movement for change in the construction industry, for radical improvement in the process of construction. This movement will be the means of sustaining improvement and sharing learning.

• The Task Force invites the Deputy Prime Minister to turn his Department’s Best Practice Programme into a knowledge centre for construction, which will give the whole industry, and all of its client’s access to information and learning from the demonstration projects.

• The Public Sector has a vital role to play in leading development of a more sophisticated and demanding customer base for construction. The Task Force invites the Government to commit itself to leading public sector bodies towards the goal of becoming best practice clients seeking improvements in efficiency and quality through the methods proposed by the Task Force.
The Construction Industry Board (CIB) (At the time of writing-up this thesis CIB was in the process of being part of the Strategic Forum for Construction).

The Construction Industry Board (CIB) was established in 1995 to improve the performance of the UK construction industry, and to implement the recommendations of Sir Michael Latham's 1994 report "Constructing the team". Its main objectives have since been modified in accordance with complementary agenda to merge from the 1998 Sir John Egan's report "Rethinking Construction", it provides a forum for liaison between suppliers and customers from the private and public construction sectors with central government. The CIB's membership comprises four umbrella bodies of the 'supply' side of the industry and two umbrella bodies representing the public and private sector users of the industry's goods and services as listed below.

- Construction Industry Council
- Construction Industry Employer's Council
- Constructor's Liaison Group
- Construction Products Association
- Construction Client's Forum
- DTI

A major review of the CIB was announced in June 1999. This will involve a fundamental reappraisal of the structure and role of the Construction Industry Board.

4.12 TQM and SIX SIGMA PLUS

Adams Associates in the United States of America introduced Six Sigma Plus, which specializes in synergistic combination of strategic planning, leadership and TQM.
Six Sigma Plus only operates under TQM, using the elements and tools of TQM. Six Sigma Plus leaders teach other members of Six Sigma Plus Project Team appropriate TQM philosophy, interfacing with management, coaching leadership skills, teaching TQM tools and changing systems to sustain Six Sigma Plus projects improvements. Once a Six Sigma Plus project is understood using tools and techniques of total quality management then alternatives are generated. Six Sigma Plus Project maintain improvements using Control Tools of TQM. This is define, measure, analysis, improve and control sequence.

Six Sigma Plus was used in many services and processes such as, chemical plants, car industry, mobile phone industry, water plants, railway industry and many others. But it has been used very rarely in the construction industry. It was used in some engineering design offices, but not much in the construction industry as a whole.

Objective of Six Sigma

The objective of six sigma is to achieve world-class performance, a key element of which is Customer Loyalty. It seeks to develop Customer Loyalty to the point that even when approached by a competitor with new benefits, lower prices, better delivery, and additional features, the customer will allow the company the opportunity to address the competition claims.

Definition of Six Sigma

There are three different meanings used with the term Six Sigma:

1. Philosophy of Six Sigma

A philosophy or understanding that detects cost money (defect cost money). A way to become more profitable is to eliminate the defects. Organisations that do
this have a lower cost structure (be competitive producer) and are more likely to have loyal customers.

2. **Statistics of Six Sigma**

Six Sigma is a performance metric meaning that the product or service is performing at a level where the chances of a defect are less than 3.4 in a million opportunities (i.e. 3.4 part per million chances of defect rate.)

3. **Process of Six Sigma**

Six Sigma is a methodology for working on projects utilizing specific phases. These are define, measure, analyse, improve and control when Six Sigma is used to describe a project. It is the application of these different steps for a specific project. The goal of the project is 3.4 ppm defective or less.

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**Figure 4.20: Adams Six Sigma Model**

*Source: Adams Six Sigma associates*
The model shows that the strategy is the foundation of all that occurs. Once the strategic plan and business plan are in place, the implementation plan must be put into action, there are people action plans and systems action plans.

**People Action Plans**

Are the process and activities associated with finding, training, developing and retaining people. Leadership and positive attitude development are two of the most important activities found in the people plan.

**Systems Action Plan**

Are all those processes that are in place, or should be in place, within the organisation. Integral to processes is the concept of improvement of these processes, which includes collection and analysis of data to be converted into useful information and applied to the continuous improvement processes.

Both systems feed into the invented triangle making up the organisations collective "customer focus" activities and plans to produce the quality and "loyal customers."

The full benefit of Six Sigma Plus will not be realized without the active leadership of the Senior Management, which includes the following.

1. A well-defined and clearly communicated strategy used in decision-making.
2. A focus on the paying customer while internal services and processes may improve efficiency and productivity, paying customers decide if to stay in business or not.
3. A Six Sigma champion able to access and communicate effectively with senior managers for guidance and direction.
4. Project leaders, experienced people trained in Six Sigma Plus methodology are needed to lead improvement efforts in the areas consistent with the organisational strategy.

5. Project selection for Six Sigma Plus implementation may be the single most important indicator of success. Management must maintain responsibility for the success of the project just as they would for any other significant activity.

6. There should be a formal review of Six Sigma project by the management on a regular basis. Success, problems, issues, shared learning and of course results should be part of these reviews.

Systems

Systems are integral to the organisational processes and should be coupled with the concept of continuous improvement. Systems define how things are done within the organisation. Not all systems are formally developed and documented, indeed there can be considerable variation in how a specific system is used.

Effective continuous in the system improvement demands that the management collect and analyse needed data and convert into useful information that provides the organisation with needed information as to how to effectively institute change to gain desired business results.

4.13 Summary

This chapter explains the meaning, principal tools and techniques of TQM, and its application to the construction industry. The information given is sufficient to develop a framework to implement TQM to any construction organisation. The evolution of TQM developed between the 1950’s - 1990’s, as the quality changed its function with the passage of time.
1950's - Inspection
1960's - Quality Control
1970's - Quality Assurance
1980's - Quality Circles
1990's - Total Quality Management

TQM gurus have contributed to the training and practice of the quality improvement movement in two ways. Some concentrated on the philosophical aspects of quality improvement and others concentrated on the tools of quality. They are categorized into three categories as follow.

The Early Americans

Edwards Deming          Management Philosophy
Joseph M Juran          Planning and Quality Costs
Armand V. Feigenbaum    Total Quality Control

The Japanese Gurus

Kaoru Ishikawa          Tools
                        Quality Circles
                        Company wide quality

Genichi Taguchi          Minimum Prototyping
Shigeo Shingo           Poka-Yoke (Zero Defects)

The Westerners

Philip B Cosby          Awareness
                        Zero Defects
The gurus set down points of wisdom in management and leadership and many organisations used these to establish a policy based on quality. These points have been distilled and modified to ten points for senior management to adopt, Oakland (1995). These points are as follow.

1. The organisation needs long-term commitment to construct improvement.
2. Adopt the philosophy of Zero errors/defects to change the culture to right first time.
3. Train the people to understand the customer-supplier relationship.
4. Do not buy product or service on price alone- look at the total cost.
5. Recognize that improvement of the systems needs to be managed.
7. Eliminate barriers between departments by managing the process – improve communication and teamwork.
8. Eliminate the following.

- Arbitrary goals without methods.
- All standards based only on numbers.
- Barriers to pride of workmanship.
- Fiction. Get facts by using the right tools.

9. Constantly educate and retrain – develop the experts in the business.
10. Develop a systematic approach to manage the implementation of TQM.
TQM tools are just ways to display information visually and to help managers or those responsible for quality and performance and see how a system or process is operating. There are seven old tools and seven new tools.

TQM still has obstacles and barriers for its implementation in the construction industry; there are general and specific obstacles. The general obstacles refer to the type and nature of the product and the method of construction while the specific obstacles refer to the background of different parties involved in the construction of a project, with regard to the ways of implementing TQM.

Recent research and developments in the quality of the Construction Industry includes the following.

- Department of Trade and Industry (DTI) using £22 million a year innovation and research budget to help improve the competitiveness, quality and performance of the UK Construction Industry.
- Latham Report: Constructing the Team. Several recommendations were made in the final report including cost reduction target of 30 percent.
- Egan Report: Rethinking Construction. Challenging the industry, raising issues such as teamwork, build ability, culture, partnering, safety, cost and quality.
- The Construction Industry Board (CIB) was established in 1995 to improve the performance of the UK Construction Industry and implement the recommendations of Latham and Egan’s reports.

Six Sigma aims to achieve a world-class performance, a key element of which is customer loyalty. It seeks to develop customer loyalty to the point that even when approached by a delivery, and additional features, Six Sigma is a methodology for working on projects utilizing specific phases. These are define,
measure, analysis, improve, and control. When Six Sigma is used to describe a project, it is the application of these different steps for a specific project. The goal of the project is 3.4 parts per million defectives or less.

To continue with the literature review a study of the use of information technology in the construction industry had to be taken which will be looked at in the next chapter.
CHAPTER FIVE

THE USE OF INFORMATION TECHNOLOGY IN THE CONSTRUCTION INDUSTRY
CHAPTER FIVE

THE USE OF INFORMATION TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

5.1 Introduction

Quality in the construction industry relies heavily on the efficiency of the information used and on good communication throughout all the stages of the project, from pre-contract to post-contract and maintenance stage. It is now evident that the use of information technology is essential in the construction industry, to obtain the quality specified, speed and economy in any construction project.

Information technology is affecting almost every business, there is better effective communication in business as a result of information technology. The application of information technology to the tasks of managing personal affair or a business results in an information system. An information system includes more than simply the computer hardware; it includes the programmes that run on the system; the people who use the system; and the data available to the system.

Information technology have changed rapidly over the past years to cater for the rapid changes in life and business. One of the challenges of information technology is how to use it to gain a competitive advantages over others in the same business. Methods include changing the way the organisation deals with suppliers; customers; and competitors, creating or changing its products and services, and improving its internal operations.

The purpose of this chapter is to give an understanding of the construction documentations presently used in the construction industry and the application of
information technology systems, by analysing the field of construction documentation as it relates to managerial end users and the fundamental system concepts used in information technology systems. For managerial end users, the information system function represents a major source of information and support needed to promote effective decision making by managers. This is an important factor affecting operational efficiency, employee productivity and morale, customer service and satisfaction and is an important ingredient in developing competitive products and services that give an organisation strategic advantages in the global market place.

This is how the idea of "PROMANSYS" and the application of TQM to the construction industry in Bahrain developed. To improve performance; communication; quality and be competitive over others in the same industry. The analysis and study of all the information and documentation used in the construction industry and the information technology system was a must to be able to fit the documents and information systems within the proposed dynamic model "PROMANSYS"

Where many of the construction industry documentation were used in "PROMANSYS" (such as presentation of specification manual, bill of quantities, cash flow and budget control charts, planning (material/plant/labour) charts and reports) "PROMANSYS" could be considered as an information system in itself. Every member of the construction project, enters, processes and exchanges data and information related to the project. It is a base to link all the information of the project together in one database software. This information system enters, retrieves, uses and continuously improves the project’s information. It creates a process of standardisation of the information used in the project in-hand and for the future projects, where a library of data is stored and used whenever needed. Due to the fact that "PROMANSYS" links all project team members within the information
system; the communication, understanding and implementation of the information becomes more accurate, effective and productive.

5.2 Changing role of information in construction

Harries and McCaffer (2001) stated that technological developments in the last few decades have elevated the role that information plays in the management of companies, and is causing a re-think in the way organisations in general treat information, information systems and its associated technologies. Until the 1980s, managers in the construction industry generally did not concern themselves with how information was collected, processed and distributed within their organisations. The reliance on paper based communication formed an essential part of the most construction organisations, and often got in the way of real productive work. The use of information within construction has seen a significant change from this position. Within the last three decades the concept of information for construction organisations has shifted from this role of general support for the constructor's operations, to its use as a means for more effective managerial decision-making. The driving force for this shift in the role of information is to improve and speed up the decision-making processes of specific managers and executives in a broad range of tasks both at the project and company level. Figure 5.1 depicts this gradual shift in how construction companies have been deploying information over the last three decades.

From the early 1990s, information has assumed a different role for construction organisations from serving as decision support to one of a strategic resource. The effective deployment of information can affect the competitive-ness of construction companies. This emerging role of information impacts on the way construction businesses have to conduct their functional operations and how they are structured. The strategic
importance of this new role for information in construction derives from the simple fact that its activities at design, site, project and business level are dominated by information. The information is often in the form of documentation, such as drawings, specifications, and conditions that are communicated between parties. As a major resource for sustaining competitiveness, information and associated technologies need effective management if constructors are to benefit from the deployment of this resource.

<table>
<thead>
<tr>
<th>Period</th>
<th>Information use in construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1960</td>
<td>Documentation for record keeping</td>
</tr>
<tr>
<td>1960-1980</td>
<td>Support for operations and tasks</td>
</tr>
<tr>
<td>1980-1990</td>
<td>Managerial decision support</td>
</tr>
<tr>
<td>1990 onward</td>
<td>Strategic resource for competitiveness</td>
</tr>
</tbody>
</table>

Figure 5.1: Progressive change in role of information for constructors.
Source: Harris and McCaffer (2001)
5.3 Analysis of the traditional construction documentation

The Institution of Civil Engineers (ICE) 6th edition Clause 1(1) (e) states that the contract consists of a bundle of documents comprising the following:

- Conditions of Contract.
- Specifications.
- Drawings.
- Bill of Quantities.
- Tender Documents.
- Written Acceptance.
- Contract Agreements.

Conditions of Contract

The Conditions of Contract seeks to establish the legal framework, within which the construction work is to be undertaken. Although the clauses aim to be precise, explicit and to concern any eventuality, disagreement in their interpretation does occur. It is preferable to use one of the standard forms available, rather than to devise ones own personal form. The Constructor will tend to overprice the work even in times of shortage of work, to cover the additional risks involved. Unless there are very good reasons to the contrary, the Engineer should attempt to persuade the Employer to use one of the standard forms available.

The modification of some of the standard clauses, or the addition of special clauses, should only take place in exceptional cases. It is inadvisable to make modifications to the conditions of contract, as the legal results may be different from what was intended.
The parties to a contract agree to take any dispute initially to arbitration rather than to the courts. This can save time, costs and adverse publicity that may be damaging to both parties. If the matter still cannot be resolved, it is then taken to court to establish a legal opinion Ashworth (1998). This is where the importance of partnering comes, as both parties get familiar and customized with each other's contract conditions, through a long-term commitment for the purpose of achieving specific business objectives, and avoid any confrontational relationships.

The (ICE) Conditions of Contracts contain 72 clauses that are grouped under 24 headings or sections. The first edition was published in 1945. Subsequent editions, some with amendments, have resulted in the sixth edition dated 1991, but reprinted with amendments in November 1995.

Specifications
Specifications means that specifications referred to in the tender, and any modification thereof or addition thereto may from time to time be furnished or approved in writing by the engineers (ICE Clause 1 (g)) Allan Ashworth (1998).

The specification should clearly identify the following.
- Quality of Materials.
- Standard of Workmanship.
- Samples of materials/finished work that will be required.
- Tests, which are to be applied to the materials and workmanship.

The specification describes in details the work to be executed, the character and quality of materials and workmanship, and any special responsibilities of the constructor not covered by the conditions of contract. It may also describe
- the sequence of the site operations;
- a method of construction to be adopted; and
the details of any facilities to be offered to other constructors or subcontractors working on the site.

When drafting a specification, care should be exercised to avoid any possible conflict with the other contract documents. Where discrepancies do occur between the documents, the engineer will be requested to decide on the correct course of action to be followed. This may result in the issue of a variation under clause (52) of the conditions of contract.

"The specification describes what is to be furnished and how it is to be installed, the drawings designate where it should be placed. Specifications are made up of words and may be defined as a description of the quality of materials and equipment to be used on a project and their application or installation". Ayers (1975) and Jenses (1995) describes the different types of specifications available:

Descriptive Specifications

- Detailed description of properties of a product or materials.
- Workmanship required for installation.
- Proprietary names are not used.
- The specifier assumes the burden of performance.

Example: Concrete mix of four parts course aggregate, two parts fine aggregate, one part cement, with 0.5 water/cement ratio.

Performance Specifications

- Statement of required results.
- All desired end results must be spelled out.
- Criteria for verifying compliance must be included.
• Reference standards may include words used in a different context than those same words used in the General Conditions.
• Inappropriate provisions often appear in Reference Standards.

Proprietary Specifications
• Identification of product’s manufacturer, brand, model, type.

There are two types
a) Open Proprietary Specification:
• Allows substitutions.
• Named product defines described properties and uses any acceptable quality.
• Substitutions are reviewed and allowed if approved.

Example: Master spec. Language for an open specification is as follows:
“Subject to compliance with requirements, products which may be incorporated in the work include, but are not limited to, the following:”

b) Closed Proprietary Specifications:
• No substitution.
• May specify one product.
• May specify several products as options.

Example: Master spec. Language for a closed proprietary specification is as follows:
“Subject to compliance with requirements, provide one of the followings:”

Many problems and disputes between the parties involved in the construction contract are due to poor specifications. Some of the reasons for poor specifications
could be briefed as follows: Incomplete specification, vague and unclear specification, incorrect specification, wrong phrasing, unsuitable specification to the project, complexity in specification, inconsistent specification and no provision to settle the disputes, as specifications questionnaire survey results showed.

Drawings
This means the drawings referred to in the specification and any modification of such drawings approved in writing by the engineer and such other drawings may from time to time be furnished or approved in writing by the engineer. [ICE Clause 1 (g)].

The drawings will show the site location, the position of the works on the site, means of access to the site, plans, elevation, section, structural, mechanical and electrical designs. The inspection of these and other drawings is highly recommended since it may provide the opportunity for an informal discussion on the project with the designer. Each drawing should include the following.

- Name and address of the consultant.
- Drawing number, for reference and recording purposes.
- Scale, if more than one scale is used they should be of such dissimilar proportions that they are really distinguishable by sight.
- Title, which will indicate the scope of the work covered on the drawing.

Upon signing the contract, the contractor will be provided with further copies of the contract drawings. This may include copies of the drawing sent to the contractor with the invitation to tender, together with those drawings that have been used in the preparation of the bill of quantities and specification. The list of drawings will be included within the specification. It is usually necessary during the construction phase for the engineer to supply the constructor with additional
drawings and details. These may either explain and amplify the contract drawings, or, because of variations, identify and explain the changes from the original design Ashworth (1998).

The contract drawings must be the drawings on which the constructor tendered. It is not unusual for the architect to have made revisions on the original drawings, between the tender and the signing of the contract. The contract drawing must be carefully scrutinized before signing, and if such revisions are present, the architect must be asked to restore them to their previous condition Chappell (1995).

The Intermediate Form of Building Contract, 1984. (IFC 84) provides Four Options

- Contract drawing and specification prices by the constructor.
- Contract drawings and schedules of work priced by the constructor.
- Contract drawings and bills of quantities priced by the constructor.
- Contract drawings and the sum the constructor requires for carrying out the works.

Lack of attention to detail during the design stage and preparation of the working drawings and missing information and errors in the drawings affect the quality of the project, and the flow of information and coordination at the site. According to the British Research Establishment (BRE), (1987) “In achieving quality on building sites”. Two thirds of the 501 examples of poor quality observed on site were caused by design faults, 130 of these, were caused by unclear or missing project information. Other causes were lack of design co-ordination, poor construction ability and poor design. This demonstrates that the lack of sufficient flow and poor coordination between participants seriously affects quality in terms of design and construction faults.
Bill of Quantities

The Bill of Quantities comprises a list of work to be carried out, providing a brief description and the quantities of the finished work in the project. In conjunction with the other contract documents, it forms the basis on which the tenders are obtained. When priced it allows tenders to be compared. When the contract has been agreed, the rates in the bill of quantities are used to value the work for interim payments, and are used to price the actual quantities of work. The Bill of Quantities allows each constructor tendering for a project to price on the same information with minimum effort. The bill may include firm or approximate quantities, depending upon the completeness of the drawings and other information from which it was prepared. Ashworth (1998).

Seeley (1979) describes the process and purpose of the Bill of Quantities as follows:

The method of preparation of a Bill of Quantities can conveniently be broken into two processes.

- "Taking-off", in which the dimensions are scaled or read from drawings and entered in a recognized form on specially ruled paper, called 'dimensions paper'.
- "Working-up", which comprises squaring the dimensions, transferring the results' lengths, areas and volumes to the abstract, where they are arranged in a convenient order for billing and reduced to the recognised units of measurement. Finally the billing operation, where the various terms of work making up the complete job are listed in full, with the quantities involved in a suitable order under work section or elemental headings.
The purpose of Bill of Quantities

- It enables all constructors tendering for a contract to price on exactly the same information with a minimum of effort.
- It provides a basis for the evaluation of variations, which often occur during the progress of the work.
- It gives an itemised list of the component parts of the building, with a full description and quantity of each part, and this may assist the successful constructor in ordering materials and assessing the labour requirements for the contract.
- It provides a good basis for a cost analysis, which subsequently will be of use on future, contracts in cost planning work.

Tender Documents

Constructors should be sent the tender document comprising of the conditions of contract, specification, bill of quantities and drawings, together with the 'Instructions to Tenders'. These instructions outline the contractor's obligations, explain the format of the information to be submitted to the client, describe the terms of employment, working practices, procedures and methods of payments. The instructions should also attempt to minimize the submissions of qualifying bids and provide details of procedures, which should be adhered to in the event of problems occurring.

All information on the site and the ground conditions should be included in the tender or made available to contractors tendering. It is recommended in the guide that four weeks should be allowed for tendering or longer on a major or complex project, in practice the period allowed for the submission of bids varies between six and eighteen weeks. If any queries of any significance are received during the tender period the engineer's response should be circulated to all tenders. Keith Potts (1995).
The tenders are submitted to the employer or engineer, who will then make a recommendation as to the acceptance of a tender, the form of tender may state the employer Ashworth (1998).

- May not accept any tender.
- May not accept the lowest tender.
- Has no responsibility for the costs incurred in their preparation.

The form of tender may also state that the contractor

- Has examined the appropriate documents.
- Agrees to carry out the works in accordance with these documents.
- Undertakes to complete the works within the specified time.
- Will provide security for due performance.

Written Acceptance

The tender is submitted to the client in a form as specified in the invitation letter, arriving at the correct address at the right time. The constructor should keep all copies of the tender documents marking the drawings ‘used for tender’.

Once the constructor has made an agreeable offer, there must be an acceptance of it by the employer before a contract can be established. The acceptance of the offer must be communicated to the constructor in writing.

The written acceptance of the constructor's tender by the employer is considered part of the contract's documents.
Contract agreement

The basic responsibilities of the parties to most construction contracts are relatively clear. The constructor agrees to build the facility in a manner defined by the contract documents, the employer defined by the contract documents and the employer agrees to pay the constructor. A typical employer-constructor agreement easily covers these issues, usually with elaboration on how and when payments will be made, and a schedule of when the work is completed. The agreement must establish the lines of communication and administrations procedures, and protects each party's interests.

The agreement is the contract document which the employer and the constructor sign. Space is provided in the contract agreement for the:

- name of the Employer;
- name of the Constructor;
- name of the Consultant;
- date of signing the Contract;
- location and nature of work;
- list of contract drawings; and
- amount of the contract sum.

In some circumstances, it may be necessary or desirable to execute the contract under seal. This is often the case with local authorities and other public bodies. The spaces for signatures are then left blank and the seals are affixed in the appropriate spaces indicated. After scaling, the contract must be taken to the Department of Customs and Excise where, upon payment of stamp duty, a stamp will be impressed on the documents. Without this the contract will be unenforceable Ashworth (1998).
5.4 Information Technology in the Construction Industry

Information Technology (IT)

Information technology is the technology, which supports activities involving the creation, storage, manipulation and communication of information, together with their related method, management and application, therefore, information technology may be seen as the broadly based technology needed to support information systems French (1998).

Information System

Senn (1989) stated that information systems assist managers in decision-making and problem solving. The information systems draw on data stored as a result of transaction processing, but they may also use other information.

French (1998) defines information system as follows: "The term 'Information System' is normally used in situations where an organisation is being considered as a whole with respect to its information requirements and information utilisation. The 'information System' of an organisation is the total apparatus for handling information within the organisation in all respects".

In order to reach its objectives an organisation must be able to plan ahead, control, and coordinate its activities; the organisation must depend on the provision and communication of information. The information is used effectively, if it is seen as a resource, which needs to be exploited to the best advantage by the whole organisation and not just by its individual departments. The idea that "The whole can be more than the sum of its parts" lies behind this information system's view of organisation. Whether or not such a view is taken, the requirement of providing and communicating information remains. These requirements are met, at least in part, by the "Data Processing Systems" within the organisation.
The construction information manager

A new role emerging in construction among constructors, especially for large projects, is that of construction information manager. The function performed by the information manager include the following. Harris and McCaffer (2001)

- advise on an IT system for the project;
- develop an information management plan for the project;
- attend design co-ordination meetings;
- receive information from design team and distribute;
- receive all information from design sub-constructors and distribute;
- monitor and review the flow of information;
- inspect and comment on details, obtain project team’s input and relay back to designers;
- assist in the preparation of sub-contract enquiry packages;
- review sub-contract quotation for compliance with design;
- review design alternatives;
- prioritise and process information requests with designers;
- process comments and compliance with design;
- monitor and collate information for HSE file;
- co-ordinate design sub-constructor’s drawings;
- obtain design sub-constructor’s risk assessment;
- track information; and
- maintain project archives.

Data Processing (DP)

Data Processing is the collection and manipulation of terms of data to produce meaningful information French (1998). The term "data processing" is more commonly associated with specialist business tasks, such as sales order processing, purchase under processing and payroll processing. The methods of data
processing have involved electronic means, principally the computer. Any study of data processing must look at Electronic Data Processing (EDP), which is seen as one of the important areas of information technology (IT).

French (1998) distinguishes between "Data" and "Information" being long established convention in Data Processing as follows.

"Data" is the term used to describe facts about the activities of a business. Examples are: The number of hours worked by any employee on a particular machine, the amount and type of materials consumed in a particular process, the number of tons of finished product produced in a day or week.

"Information" is obtained by assembling terms of data into a meaningful form. Example: A financial statement or an efficiency report. Information can range from a simple report about routine operations up to a report required by top management to make strategic decisions.

Business Software
The following are some of the latest business software.

Operating Systems
A computer needs an operating system before any software will work. The operating system performs all the background tasks, such as entering information through the keyboard or displaying results on the screen or printer. The choice of operating system is vital because it limits the software that can be used. The most common operating system is MSDOS (Microsoft Disk Operating System). Microsoft has launched the "Windows" operating system extension that provides a more sophisticated environment whilst retaining backward compatibility.
Word Processing

The word processor is one of the simplest programmes but it is used more than any other. It allows the user to enter, edit, text, arrange and format. A typical construction application is the creation of preliminaries or specifications. The user can quickly insert or cut and paste sections. The positioning of text is manually carried out and there is limited maths capability. The current market leader is 'Word Perfect'; others include 'Microsoft Word' and 'Lotus Ami'. 'Desk-top publishing' is a superior form of word processor.

Spreadsheets

Spreadsheets are often the first application used by professionals; it allows the creation of maths models in a simple rows and columns format. The screen shows the result of 'what-if' calculations very quickly. Spreadsheets are ideal for single-page calculations of a one-off nature. Their strength and weaknesses, is their flexibility. Construction professionals can spend hours elaborating a simple spreadsheet and then corrupt the logic. A typical application would be a manhole schedule that calculates the length of formwork, area of brickwork and volume of concrete based on the internal dimensions. The current market leader is 'Lotus 1-2-3' with 'Microsoft Excel' and 'Borland Quattro' being strong contenders.

Databases

Databases are more difficult to get used to; databases are not nearly as intuitive as spreadsheets, however, they can be used to extract or sort data and quite sophisticated applications can be written. A typical example would be a Bill of Quantities. The market leader is 'Microsoft FoxBASE' with 'Microsoft Access' and 'Borland Paradox' as alternatives.
Graphics

Business graphics programmes can create excellent graphics that are attractive and informative. A bar chart or pie chart can simplify a mass of figures. The most common example is the cumulative cash flow graph comparing forecast expenditure against actual valuations. The current market leader is ‘Lotus Freelance’; ‘Corel Draw’ is better but more complicated.

Communications

The world wide web, also called simply “the web”, is a very large internet communication service. The internet offers a level of access to information that is unprecedented Khan and Logan (1996). Anyone with access to the world wide web has access to all the information published on it as well as the powerful tools for searching through the information on the web. The compelling feature of WWW documents is that they are linked to other documents by means of a technology known as hypertext. The hypertext allows the user to get from one related document to another by simply clicking the mouse to select a word or graphic that has been set-up as a link. A link is normally indicated by a word or a graphic set apart from the usual text by the use of a different colour or boldface text. Hypertext makes the web interactive when browsing web resources; the user can decide how to navigate through a specific document.

Web search engines do basically the same thing that the user do when using the web: they look at documents and follow links. The difference is that these technologies actually store the information about each link they go to. They build up databases that are searchable, and the user can do complex queries against those databases.

This ability to access information from all over the world as if it is in the users very own computers, is one of the features that makes the internet such a powerful tool for information exchange and communication.
Shami (2000) stated that the communication channel represents the part of the network that connects the sender with the receiver in Internet-based communication. Senders and receivers can be individuals or other electronic applications within the same or different organizations. The sender might work on a client or a server in a LAN or Internet within an organisation. Theoretically, communication channels can be understood as part of a relationship among communication objects, that is organizations, processes, sub-processes, and project databases.

The latest, and newest type of communication software is Electronic Mail. This normally runs on a network of connected personal computers and allows users to transfer messages or files. By using electronic mail a user can type a memo and then 'post it' on the electronic mail system to either an individual, a group or to all members of the project team. The software will tell each user that mail has arrived. The receivers can read the document on the screen and then save to disk, delete it, edit and return with comments, or print it.

Electronic and digital signatures
Electronic and digital signatures provides a sophisticated and innovative transaction systems for organisation looking for ways to increase profitability and gain competitive advantages by removing costly and time-consuming paper process from the workflow. It provides an electronic alternative to any paper processes. Users no longer need to print, sign; seal and deliver paper documents. The two signatures are defined as follow.

Electronic signature definition
According to State of Georgia (1997) Georgia Senate Bill 103 the electronic signature " means an electronic or digital method executed or adopted by a party with the
internet to be bound by or to authenticate a record, which is unique to the person using it, is capable of verification, is under the sole contract of the person using it, and is linked to data in such a manner that if the data are changed the electronic signature is invalidated”.

According to State of Oklahoma (1997) Home Bill 1690 the electronic signature means any letters, characters, or symbols, manifested by electronic or similar means, executed or adopted by a party with the intent to authenticate a writing. A writing is electronically signed if an electronic signature is logically associated with such writing.

**Digital signature**

Means a type of electronic signature that transforms a message using an asymmetric crypto system such that a person having the initial message and the signer’s public key can accurately determine whether the transformation was created using the private key that corresponds to the signer’s public key, and whether the initial message has made. A digital signature features are as follow.

- intended by the party using it to have same force and effect as the use of a manual signature;
- unique to the party using it;
- capable of verification;
- under the sole control of the party using it; and
- linked to data in such a manner that it is invalidated if the data is changed, and the electronic signature may be used to sign a writing and shall have the same force and effect as a manually written signature.
Construction Software
Most of the project management used in the construction industry have been overviewed in Chapter Seven. However, some of the functions used in the construction industry are mentioned here in general, and they are as follows.

- Project Management.
- Computer-Aided Design and Drafting.
- Computer-Aided Engineering Analysis.
- Bill of Quantities.
- Surveying.
- Quality Assurance.

Artificial Intelligence
Usage of artificial intelligence consists of knowledge acquisition, data acquisition, the effects of certain decisions, defining objectives, and suggesting methods for achieving these objectives.

There are three methods for the implementation of artificial intelligence in an organisation. The first method is the use of existing software and data (knowledge) bases. In such program packages knowledge can be partly modified to suit the needs of the user. Systems formed in this way are most efficient in solving widely spread problems or problems which do not depend on types of organisations or market.

The second method is to hire a professional artificial intelligence firm with experience in this field to form the system. In this method the organisation has to define the objectives of the system, the hired firm has to design the requested programmes and knowledge base as well as to carry out the training of organisation personnel.
The third method of introducing artificial intelligence system is the development of package software and knowledge base in research and development department of the organisation in question. An adequate software package or tool is used. The organisation experts are used as a source of expert knowledge and the role of the knowledge engineer id given to the members of the research and development department. This method suitable for solving problems in an organisation of market. This method is also used when necessary to achieve considerable technological improvement in comparison with the competition. In this way business secrets are kept within the company.

The aim for the use of the artificial intelligence is to increase speed and accuracy in preparing analysis for decision taking to achieve the organisation's objectives, and to form a system that will advise the project management in the organisation in everyday operational tasks.

**Project Management (PM)**

Project Management software can be used at many different levels of sophistication for controlling performance. It is used by the main constructor for ensuring that all necessary tasks are performed in the correct sequence and in time for the next operation. The project manager can use the software to ensure that the client, design team and constructor work together. The principles are simply identifying the tasks, and calculating the duration and the relationship between tasks. The software will then calculate the total duration and highlight the critical tasks that have no float. Examples of PM software include 'Pert Master', 'Microsoft Project', and 'Power Project'. Potts (1995).
Computer-Aided Design (CAD) and Visualisation

Computer-Aided design programmes are commonly used for architectural designs and computer-aided drafting. The drawing is constructed on the screen, basically being lines from one co-ordinate to another with a colour and style. A library of common objects can be built up, such as cars, trees, and toilets, and posted on to the drawing. The great advantage is the ease of editing. Most programmes will work in 2D or 3D models, the 3D models being the best. If a building is created in 3D then it can be viewed from any angle or sectioned at any point. In addition, it is possible to shade the planes with brick effects or others to produce artist’s impressions, and even to be able to ‘walk through’ the building on the screen. 3D programmes are essential for services drawings to migrate against collisions and obstructions. Examples include ‘Intergraph’, and ‘AutoCAD’ which has monopolized the PC market.

The latest development in Computer-Aided Design (CAD) is visualisation of the components of the design, where in architectural design the designer or client can visualise the inside of the designed project or building. The designer can walk through inside the design model, appreciating the elements, layout, spaces, utilization of areas and colors of the internal components of the design. This type of visualisation helps to appreciate the design more and also put “interior design a step a head in presentation of concepts, ideas and perspectives of the interior design through the use of computers.

Computer-Aided Engineering Analysis

Computer-aided engineering analysis programmes are usually used by those engineers who are working on the design of a project such as structural analysis, electrical power distribution and pipe layout. These programmes also have application on the job site, such as designing temporary facilities, designing
concrete formwork or checking stresses during the critical erection sequence. Examples of the types of applications include the following Paulson (1995).

- Structural design and dynamic analysis.
- Concrete form design.
- Pipe network layout and flow calculations.
- Soil mechanics and foundation engineering.
- Cofferdams and diversion tunnels.
- Crane and cableway cycles.
- Drill and blast computations.
- Design of screening and crushing plants.

**Bill of Quantities (BoQ)**

There are several BoQ programmes on the market designed specially for the British Construction Industry. In essence they are simple. The user selects a description from a standard library that has an ordinary code, attaches a quantity, sorts the items and prints them. The items are then priced, and the programme will extend the quantity and rate and collects subtotals to a grand summary. Examples of bill of quantities software include ‘CATO’ and ‘Master Bill’. Potts (1995).

**Surveying**

Construction surveying has benefited enormously from computer applications. Microprocessors integrated into electronic Theodolites and distance-measuring devices automatically record the data produced. Upon returning to the office, surveyors can transfer the recorded information to sophisticated computation and analysis software running on powerful microcomputers. Enhancements to surveying technology have led to some of the first practical applications of automated construction machines. Spinning laser beams guide field tasks from
setting footing forms at the beginning of the job to installing false ceilings at the finishing stage.

One of the latest surveying systems are the Global Positioning Systems (GPS) which are space-based radio positioning systems that provide 24 hours three-dimensional position, velocity and time information to suitably equipped users anywhere on or near the surface of the earth.

There are currently several levels of GPS units available, varying by accuracy and cost of the unit: (http://www.flatsurv.com/gps.htm) and they are as follow.

Navigational unit
Small hard held units at relatively low cost allow boaters and hikers to know their position within a few hundred meters. This accuracy is sufficient for recreational use.

Mapping
A hand held or similar unit at mid range price that is linked to a fixed broadcast base station. These units allow utility companies, municipalities and others to locate various items (telephone poles, waterlines, values) with a positional tolerance of several meters. This is suitable for geographical information systems (GIS) mapping purposes.

Real time Kinematic
Roving high precession units available at relatively high cost that are linked by radio to a fixed base station, allowing quick on-site gathering of data without the need for post-processing. These units are suitable for topographic mapping, construction layout, and other uses with a positional tolerance of centimetres.
Geodetic

For highly precise measuring of long baselines, or measuring between points in different terrain (across rivers, mountains, urban). These units use long observation times and off site post processing of data to obtain a sub-centimetre positional tolerance.

Quality Assurance

Quality Assurance can begin with online retrieval of specification, codes, and standards. Quality Assurance systems also assist in documenting procedures and testing requirements and in reporting test results and completion of administrative steps to various interested agencies and parties. Some of the most advanced applications involve not only administrative producers but also direct production control. For example, modern automated concrete batch plants enable the operator to call up any of several predefined mixes, the computer then operates the plant until the correct mix discharges into a waiting concrete truck, batch information is printed out and copies are given to the truck driver to take to the point of delivery for an inspector's confirmation and approval before the concrete goes into the pour. Copies are also attached to samples made at the pour site, and the loop closes following testing, when sample results are logged and sent back to the Quality Assurance department.

Hardware

The development of the hardware storage drives with very large volumes, modems, scanners, and back up devices has made the computer amenable to the storage and distribution of drawings and other data in electronic format. The evolution of servers, network cards, modems and routers have linked computers together providing a forum for community collaboration. For example, the newest versions of the CAD programs Autocad, and Micro-station include features that allow multiple users to post, view, mark up details on a drawing and collaborate
through the use of an internet based web browser. These technological advances have made possible a situation whereby design work can proceed on a 24-hour employing several design teams in different parts of the world. Design drawings are transfers from one time zone at the close of work to another time zone where the working day is about to commence. Harris and McCaffer (2001).

French (1998) have classified the computers hardware according to their use and according to their size as follow.

**Classification by use**

- A Home Computer is a low-cost microcomputer of limited capability designed for domestic use with programs that typically are used for such things as computer games or controlling family finances.

- A personal computer (pc) is a microcomputer designed for independent use by an individual at work or in the home mainly for business purposes. Some PCs are portable. Many can be connected to minicomputers and mainframe computers so that the PC user can also gain access to the facilities offered by the larger machine.

- Desktop computer is any computer design for use on a desk in an office environment. Therefore, home computers and PCs are types of Desktop computer.

- A workstation is another kind of desktop computer. Although larger more powerful PCs are sometimes called workstations the term is normally used to imply the presence of advance features not provided by all PCs. These include inbuilt capabilities for their interconnection and operation in conjunction with other computers, and for them to process pictorial data as well as that presented in the form of text.

- A lap-top and palm-top computers sufficiently small and light for their user comfortably to use it on the user lap or in the hand. A typical lap-top computer
operates on mains electricity or by rechargeable batteries and is small enough to fit inside a brief case. Lap-topes normally have in built disk drives and flat screens. The latter are commonly Liquid Crystal Display (LCDs).

Classification by size

- Mainframes. Large general purpose computers with extensive processing, storage and input/output capabilities. Conventional large scale. Data processing has traditionally been carried out on these machines.

- Minicomputers. Physically smaller computers compared with mainframes. They are used for special purposes or smaller scale general purpose work. Conventional medium scale data processing has traditionally been carried out on these machines.

- Microcomputers. These represent a further step in miniaturisation in which the various integrated circuits and elements of a computers are replaced by a single integrated circuits called a "chip". Their continuing and rapid technological development have had a major effect on the whole computer industry over the past twenty years.

Integration

When combining the permutations of computers, disk drive size, disk format, printers, operating systems, software types and versions, the user has a recipe for disaster. If all the above are not matched, the user will probably have difficulty in being able to read, edit and print the information. This is often a problem within one organisation; the problem will be even greater if it is communicated with another company.

The simple solution is to have exactly the same set-ups, but this is difficult to agree on and can be disruptive. Most companies work with many clients and
professionals, so it is impossible to match all the other parties. The only solution is to try to integrate different systems as much as possible.

Waring and Wainwright (2000) defined integration as the ability of computer hardware or software systems to work with incompatible systems. For technically able IT managers this definition conjures up images of computers, networks, protocols, clients/server architecture, hubs, routing and connectivity. The managers focus is on delivering the ‘right kit’ on time and within budget. Four critical recommendations are identified for the implementation of integration and they are as follow, identify the role of integration in the context of business objectives; derive appropriate measures of performance for the project; exercise effective project management throughout development; and evaluate system operation in an appropriate manner. Integration will provide the organisation with the following benefits, improved productivity; more efficiency; better control, lower costs; and less waste.

**Networking**

Originally computers were mainframes. These machines were very expensive and worked on the principle of one large central processor and storage that everybody shared. Everybody worked on the same data and used the same programmes. The personal computer was invented and suddenly computers were cheap and the end user could work in his own way using whatever software chosen. No data was shared; all information was re-entered on each machine, which is inefficient and technically inconsistent.

Networks were introduced that linked personal computers giving access to shared data, but still allowing local processing therefore, having the advantages of a mainframe with shared data whilst retaining the creativity of local personnel.
Potts (1995) describes the two different networks. There are two main types of networks, Local Area Networks (LANs) and Wide Area Networks (WANs). LANs consist of one central file server that stores all the common data and a cable running around a building with connection boxes at frequent intervals. An individual personal computer is connected to the network with its own cable to the socket. Once information is changed on the network it is available to everyone.

WANs connect LANs in different locations. The most common way is by having a dedicated data link, connecting the two file servers. This means users at both locations have access to the same information instantly.

5.5 Knowledge Management

The adjustment of demand and supply of knowledge is an important condition for the efficient performance of organisations. When there is a mismatch, this will lead to increased production times and production costs. For this reason, it is important for organisations to understand the role of knowledge in their production processes. A better understanding of these processes will also lead to an increased flexibility to react to changes in the environment. When demand and supply of knowledge are well adjusted, the quality of products and services will increase.

The Knowledge Management Network in the USA described on their web site the main goals for knowledge management as follows.

- To formulate the organisation-wide strategic policy for the development and application of knowledge.

- To implement knowledge strategies with the help of all relevant parties within an organisation or a network of organisations.
• The daily improvement of business processes in an organisation, with a focus on knowledge development and use.

• To monitor and evaluate the achievements of knowledge assets and to monitor and evaluate management activities in terms of knowledge.

Based on these main goals, several targets can be identified which must be addressed in daily knowledge management activities.

• The disclosure of knowledge. For example, lessons learned and best practices, so that all members of the organisation can use that knowledge in the context of their organisational roles.

• To ensure that knowledge is available at the location where it is most crucial for decision-making process, for example, the front office at the customer side.

• To ensure that knowledge is available when it is needed for the business processes (24 hours a day).

• To facilitate the effective and efficient development of new knowledge. For example: Research and development activities, learning on the basis of historical cases.

• To ensure that new knowledge is distributed to the people in the organisation who perform activities on the basis of this knowledge. For example: distribution of lessons learnt.

• To ensure that everybody in the organisation 'knows' where knowledge is available within the organisation or network of organisation.
5.6 The TQM framework, knowledge management and organizational learning

Davenport and Pursak (1998) defined knowledge as follows:

"Knowledge is a fluid mix of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms."

Organisational learning is simply any learning that takes place within an organisation. Learning in groups as part of an organisation is more complex than learning by individuals. Within groups, individuals must first learn to understand what others in the group mean by what they are saying. They then as a cognitive unit. They have to learn to understand the other person's meaning based on their own set of experiences. They must set up standards that become a common learning ground for the group, rather than learn it up to each individual and each individual's interpretation. Then the group must learn to respond to an ever changing world by learning quicker and applying the learning faster than their competitors.

Organisational learning is part of knowledge management. The principles for the application of knowledge management in the industry are for better competitive positioning and higher market place awareness through tough leadership, improving speed, cost and quality of client service. Smith (2000). In today's competitive environment, developing and leveraging knowledge is a key competitive success factor. Leading edge firms actively manage their knowledge in order to apply it for business success. In doing so they do not manage collaboration learning, innovation and sense as separate silos. In many cases they manage them
so they overlap and enhance each other. Knowledge management techniques enable this through sharing, codifying, making accessible, documenting and help disseminating both internal and external knowledge for positive knowledge enabled business outcomes.

The TQM framework in this research is achieved by developing the specification model of "PROMAN SYS" where in this model elements of TQM are implemented such as teamwork, effective communication, creation of a culture, continuous improvement and value engineering. The framework receives, stores, present, process, document and report informations of any number of activities in the constructions of a project, with a minimum ten design and construction team members involved in the use of the framework as the only tool of information system for the project. The knowledge, experiences, values, information and practices of every member in the design and construction teams are introduced in the framework of TQM. To help improve speed, cost, quality to clients service, competitiveness and decisions making in the process of constructing the project in hand, or for use in future projects. The TQM framework could be used efficiently in knowledge management and organisational learning, with the amount of knowledge, data, experiences, practices and information introduced to the framework.

Although the terms "information" and "knowledge" are often used interchangeably, there is a clear distinction between information and knowledge. Information is flow of messages or meanings, which might add to, restructure or change knowledge. Dretske (1981) offers the following definition of information. "Information is that commodity capable of yielding knowledge and what information a signal carries is what we can learn from it. Knowledge is identified with information- produced (or sustained) belief, but the information a person receives is relative to what he or she already knows about the possibilities at the source".
5.7 Expert System

Rembold, Naji, and Storr (1996) defined and explained the components of the expert system as follow.

"An Expert System is a software product, the development of which has a defined life cycle. People involved in building an expert system are the user, the expert and the knowledge engineer".

Basic Component of an Expert System

The builder of an expert system must have a model of the system for which a solution is being sought. The model describes the properties and behaviour of the system. Usually, an attempt is made to keep the model simple and to include only the important features of a process. The various models used for knowledge engineering are as follows.

- Informal symbolic model: that contains an informal textual description of the process.
- Diagram: that may show the flow of information or material through a process.
- Formal mathematical model: that describes the behaviour of the process with a set of mathematical equations.
- Heuristic Model: that describes the process with a set of rules.
- Pictorial model: that describes the process with symbols or pictures.

Building an Expert System:

There are five phases, which make up the expert system. These are: identification, conception, formalization, structuring and testing Rembold, Nnaji and Storr (1996).
Identification Phase

The following typical questions must be resolved.

- What are the aims of the system?
- What is the scope of the knowledge domain?
- What does the user expect from the system?
- How is the user going to apply the system?
- What is the required ergonomics from the various machine interfaces?
- How can the system be hierarchically structured?
- How can the system be expanded in the future?
- What do the interfaces to other manufacturing system components look like?
- What are the sources of knowledge (expert, books, manuals)?
- How much data is needed, and how should it be structured and stored?

Structuring Phase

At this stage the knowledge engineer will formalize the knowledge and prepare the data where the following factors must be considered.

- How is it possible to obtain relevant data?
- How can the most important features be represented with the available data?
- Is the data consistent and reliable to formulate the required knowledge?
- Is the planned level of effort justifiable to obtain the data?

Implementation Phase

During implementation, the development components are configured to a computer system. If this is the final implementation, it may be necessary to re-programme the system with a more efficient language to reduce computing time and memory requirements. Usually, the final system is a component of global planning and control system. In this case, all the required interfaces have to be combined to make the knowledge-based system part of the total system.
Test Phase

The final phase is necessary to assure that the system provides the specified requirements. Points of particular interest are efficiency, user friendliness, expendability and maintainability. A test will include the following questions.

- Is the system user-friendly?
- Can the user maintain the system?
- Are the interference rules consistent and complete?
- Are the answers of the system ambiguous or satisfactory?
- Are the test examples realistic?

If the system gives wrong answers, the interference rules must be investigated and it might be necessary to trace the operation of the interference process, step by step, to locate the problems. For this purpose, the system should be provided with an explanation component.

5.8 Summary

Technological developments in the last few decades have elevated the role that information plays in the management of companies, and is causing a re-think in the way organisations in general treat information, information systems and its associated technologies. Until the 1980s, managers in the construction industry generally did not concern themselves with how information was collected, processed and distributed within their organisations. The reliance on paper-based communication formed an essential part of the most construction organisations, and often got in the way of real productive work. The use of information within construction has seen a significant change from this position.
Traditional documents used in the construction industry comprises the following.

Conditions of Contract
The conditions of contract seek to establish the legal, framework, within which the construction work is to be undertaken. Although the clauses aim to be precise, explicit and concern any eventuality, disagreement in their interpretation does occur.

Specification
The specification describes in details the work to be executed, the character and quality of materials and workmanship, and any special responsibilities of the constructor not covered by the conditions of contract.

Drawings
The drawings form part of the contract documents, the contract drawings must be the drawings on which the constructor tendered. It is not unusual for the architect to have made revisions on the original drawings, between the tender and the signing of the contract.

Bill of Quantities
The bill of quantities comprises a list of work to be carried out, providing a brief description and the quantities of the finished work in the project. In conjunction with the other contract documents, it forms the basis on which the tenders are obtained.

Tender Documents
Constructors should be sent the tender document comprising of the conditions of contract, specifications, bill of quantities and drawings together with the
“Instruction to tenders”. They outline the constructor’s obligations, explain the format of the information to be submitted to the client, describe the terms of employment, working practices, procedures and methods of payments.

Written Acceptance
The constructor makes an offer submitted to the client in a form as specified in the invitation letter, arriving at the correct address at the right time.

Contract Agreement
The contract agreement is signed between the employer and the constructor. A typical employer-constructor agreement covers issues such as the names of the parties in the contract, a cope of works, method of payments and schedule of when the work is to be completed. The agreement must establish the lines of communication, administration procedures, and protect each party’s interests.

Information technology is the technology that supports activities involving the creation, storage, manipulation and communication of information, together with their related methods, management and application.

The business software is categorised as follows.
- Operating Systems.
- Word Processing.
- Spreadsheets.
- Database.
- Graphics.

The main construction software is categorised as follows.
- Project management.
- Computer-Aided Design and Drafting.
Computers are integrated by having the same set-ups and by matching the permutations of the computers, disk drive size, disk format, printers, operating systems and software type and versions.

Computer networking is achieved by two main types of networks, Local Area Networks (LANs), and Wide Area Networks (WANs). The advantage is that it gives access to shared data through the mainframe, but still allows local processing by individual computers.

It is important for organisations to understand the role of knowledge management and expert systems in their production process. A better understanding of these processes will lead to an increased flexibility to react to changes in the environment.

The proposed dynamic model “PROMANSYS” uses and implements most of the construction industry documentations and it technology. It creates an environment of flow of information between the project’s team members in all aspects and fields of the information. Which reflects the need for the implementation of “PROMANSYS” as a tool of information system and a framework to implement TQM.
CHAPTER SIX

ANALYSIS AND LIMITATIONS OF THE CONSTRUCTION SPECIFICATION USED IN BAHRAIN
CHAPTER SIX

ANALYSIS AND LIMITATIONS OF CONSTRUCTION SPECIFICATION USED IN BAHRAIN

6.1 Introduction

The architect and his support staff should draft specification. Some offices operate a system whereby a specification writer is employed solely to draft specifications. Such a person, to do the job, has to spend time studying the drawings to get a grasp of each scheme and probably take up the time of the architect, assistants or members of the whole design team; asking questions to get the information needed to write-up the specifications.

This method of writing specifications lacks the teamwork effect; it has many setbacks in the process of communication. Information might be missing from the specifications or may not be covered from the beginning. The architect is not qualified to write about items and clauses outside of his field, such as electrical and mechanical works specifications and even many of the civil works clauses. Each member of the design team must write the specifications that he is responsible for. This is where TQM steps in to be implemented in the method of writing specifications to get everybody working as a team, with an effective method of communication in a system that creates a culture for the project which is continuously improved and with the implementation of value engineering technique. This is what this research is aiming for.

This chapter discusses the concept of specifications in general analysing the purpose of specifications, the systems of writing specifications, with a comparison between the information in the drawings and in the specifications. The chapter also
analyses the present construction specifications in Bahrain, the source specifications with a discussion on the general practice in specification writing, the problems arising from the present situation and the need for improved specifications in Bahrain.

6.2 The Concept of specification

6.2.1 The Purpose of Specifications

Rosen (1999) stated that “specifications are one of the necessary constituent elements of the contract documents, it is imperative that practicing architects and engineers have a very good working knowledge of the role that specifications play”.

Willis and Willis (1997) described that specification may have three purposes, in each case in conjunction with the drawings:

- to be read by the constructor’s estimator as the only information available on which to prepare a competitive tender;
- to be read by the quantity surveyor to enable a bill of quantities to be prepared as a basis for such competitive tenders; and
- to be read by the clerk of works and the constructor’s agent during the progress of the contract as the architect’s instructions for carrying out the work.

Whether the specifications are written by a specifier in a large office or by the job architect and engineer in a small office, they are used by a diverse group of participants. To begin with, they are written for the constructor to describe how to construct, manage and direct the construction. They are also written for the estimator in the constructor’s office, who prepares the estimate based on the specifications. They are written for the resident project representative or inspector, who must be given a document that can aid this person in inspecting and
controlling the work. They are written for the owner, who would like to know what he is buying and is entitled to receive. They are written for the sub-constructors so that each can readily see the scope of his contract. They are written for the manufacturers of building materials and equipment so that the grade and type are clearly defined with respect to the many variations they may manufacture.

6.2.2 Systems of Writing Specifications

There are two basic approaches to writing specifications the method system and the result system.

1. When the method system is employed, the specifier describes in detail the materials, workmanship, installation and erection procedures to be used by the constructor in the conduct of his work operations in order to achieve the results expected. The method system can be best described as a descriptive specification.

2. When the specifier elects to use the results system the places on the constructor the responsibility for securing the desired results by whatever methods the constructor chooses to use. The results system is best described as a performance specification.

It is also possible that both the descriptive specification and the performance specification can be used together in the same project specification, each in its proper place, in order to achieve the prime objective.

The drawings and specifications are two documents represent a means of communication of information between the designers and the constructor, but each document uses a special form of communication: one pictorial and the other verbal. The following table shows the comparison between drawings and specifications.
Table 6.1: Comparison between drawings and specification

<table>
<thead>
<tr>
<th>No.</th>
<th>Drawings</th>
<th>No.</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extent, size, shape and location of component parts</td>
<td>1</td>
<td>Type and quality of materials, equipment and fixtures</td>
</tr>
<tr>
<td>2</td>
<td>Location of materials, equipment, and fixtures.</td>
<td>2</td>
<td>Quality of workmanship</td>
</tr>
<tr>
<td>3</td>
<td>Details and overall dimensions</td>
<td>3</td>
<td>Methods of fabrication, installation, and erection</td>
</tr>
<tr>
<td>4</td>
<td>Interrelation of materials, equipment and space</td>
<td>4</td>
<td>Test and Code requirement</td>
</tr>
<tr>
<td>5</td>
<td>Schedule of finishes, windows and doors</td>
<td>5</td>
<td>Gauges of manufacturer’s equipment</td>
</tr>
<tr>
<td>6</td>
<td>Sizes of equipment</td>
<td>6</td>
<td>Allowance and unit prices</td>
</tr>
<tr>
<td>7</td>
<td>Identification of class of any material at its location</td>
<td>7</td>
<td>Alternates and options</td>
</tr>
</tbody>
</table>

6.3 Source of Specifications in Bahrain

So far the majority of design offices in Bahrain and government authorities that are involved in the preparation of specifications and contract conditions, tend to copy from other previously used specifications as seen in the results of the specification questionnaire survey. The mistakes, discrepancies, inconsistencies and unclear wording are often repeated in new projects due to the copying of the clauses. Even the most commonly used specifications, which are considered as standard specifications in Bahrain, are published by the Public Works Directorate in the Government of Bahrain but are not tailored for the construction industry environment in Bahrain.
There is no establishment, body, or authority in Bahrain responsible for: the country's construction industry specifications; the development of new up-to-date techniques, methods of construction and products; or responsible for the inclusion of new solutions to the day-to-day problems arising on site. In other words documentation and improvement of specifications in the construction industry in Bahrain is very weak. The construction industry in Bahrain is still lacking the standard and quality of specifications that suites the country's hot climate; methods of construction adopted; level of workmanship; availability of raw material; and clients requirements in the design. The only body that is hoped to take on its shoulder the responsibility of preparing and issuing a master specification for the construction industry in Bahrain is Bahrain center for studies and research, which is still did not present any thing to do with the specification in the construction industry in Bahrain. Until such time, the necessity comes for this research and the work carried out in this thesis to produce "PROMANSYS" as a framework to implement TQM through specifications to improve performance in the construction industry in Bahrain.

There are conferences taking place from time to time with issues related to concrete deterioration and damage to concrete structures due to corrosion and sulphate attack. But the outcome of the conferences with regards to recommendations and proposed procedures as solutions to the problems end-up and diminish with the end of the conference. There is no committee to follow up with the recommendations, procedures, and solutions to the concrete problems, nor to implement and incorporate their experiences in the future specifications. The proceedings of the conference end-up on one of the library shelves of Bahrain Society of Engineers.

The Gulf Co-operation Council (GCC) has established a Committee from the Commerce Ministries in the region to set up standards of specifications for the
consumed goods and commodities that arrive in the Gulf region from abroad to suit these countries' requirements and specifications. But without giving any attention to the construction industry's specifications standards, requirements, material and codes of practice with regards to availability of modern technologies, climate, environment, local materials and implemented methods of construction. It is now time to establish a government task force to look at these issues if the quality concept is to be achieved and improved in the construction industry in Bahrain. By forming a joint committee from all the Gulf countries as members of a taskforce to put: objectives; plans; and strategies to prepare master specification for the Gulf countries.

6.4 The general practice of specification writing in Bahrain

In Bahrain, there are no personnel who specialise or academically qualified in specification writing. The Consultant (Designer) would be the person in charge for the preparation of the specifications, contract, conditions and tender documents. The designer can seek assistance from any member of the design team for information within their field to be incorporated in the specifications. The owner relies heavily on the designer to implement his requirements, objectives and design brief within the drawings and specifications, to obtain the standard of quality required within the allocated time and budget for the project.

The designers usually use old specifications from finished projects for the new project, with some modifications in certain clauses as the results of the questionnaire showed, for example the name of the owner, the budget of the project, the duration of the project, the name of the constructor, some finishing classes and some Prime Cost sums and items. Such specifications tend to be out-of-date with old information, techniques, and methods of fixing and old products. With many clauses conflicting with each other, duplicated and some clauses are not even related to the project in hand, these specifications lead to construction
disputes, delayed projects and unhappy clients. These facts were obtained from the interviews and the specifications questionnaire conducted at the data collection stage.

The designer preparing the specifications for the project in hand should always endeavour to be up-to-date with the latest industry information. The designers, who are not, will spend a lot of time talking to bidding constructors who must constantly call to obtain more information before bidding the project. They will spend time writing addenda to incorporate the corrections bidders call in, they will also spend time on construction disputes that arise out of the assumptions bidders made when reading the design documents.

6.5 Problems arising from the present situation

Many problems arise in the construction industry in Bahrain because of inadequate specifications. The following is a summary of some of the problems.

- Nearly all projects don't finish on time due to unclear specifications, variations and disputes.
- The allocated budgets are always raised due to changes and high cost of variations.
- Disputes arise due to unclear, vague or incorrect specifications. This is reflected by the high number of cases at the courts of justice between clients and constructors.
- The quality of the building is always compromised to finish the project, due to unclear specification of quality standards, specification of the wrong materials and methods of fixing.
- Penalties correspondence and time consuming instruction orders between the architect, the constructor and the owner, due to missing information in the specification.
At the end of the project there are always disputes and finger pointing between the architect and the owner, due to lack of information, inadequate or poorly prepared specifications and the low quality of the finished project.

6.6 Standardisation

Standard specifications in the United Kingdom can take two forms, Willis and Willis (1997) there are specifications such as the National Building Specification, which is primarily a library of clauses that can be used to build up a working specification. Careful coding of the clauses permits the writer to refer simply to the relevant number or code and the word processor operator can do the rest. The second form of standard specification is one prepared with plenty of space for alterations and additions and a number of copies can be duplicated to serve as the draft for each project. Government departments and local authorities do this where, for instance crown offices or schools are to be built in substantial numbers over several years, with similar methods of construction and general features. In using this form of standard specification, great care must be taken. It is easy for something inapplicable to be left in, which when duplicated into the individual specification leaves no indication of being an oversight and looks unprofessional.

The disadvantage of a standard specification to be adopted for each project is that it tends to make the brain lazy. Instead of the writer's mind being alert and on the job as it should be.

The British Standards Institution (BSI) publishes standards for a very wide range of materials. The BSI also has an obligation to publish British versions of European Standards and withdraw any conflicting British Standards or parts thereof. The BSI also publishes Codes of Practice relating to workmanship in various trades.
6.7 The Need for improved specification

As building grew more complex and materials and construction techniques became more involved, it became necessary to increase the number of technical sections as more portions of the work came under subcontract Rosen (1999). Today, the specification sections are designed essentially to permit general constructors, estimators, sub-constructors, manufacturers and material supplies to “take off” the items of their specific work for estimate during the bidding period.

Accuracy in estimating is in the best interest of building owners and architects alike. To ensure accuracy, the specifications should be divided into sections to permit the constructor’s estimator and the sub-constructors to prepare estimates quickly and precisely. The preparation of drawings and specifications takes considerable time, whereas bidding periods are generally of short duration. It is therefore evident that the quantity surveyor must have a specification separated by section or units of work so that he can list the materials and quantities, note the methods of their use and installation, secure prices and tabulate results, all within a three to four week bidding period. Such a system also permits the specification writer to organise his own material. It provides a method for organising the information on the drawings in a systematic, orderly and pre-arranged manner.

Whatever the method of improving the layout and sections of the specifications, there is still a need to revolutionise the method of specification writing. TQM is capable of doing that. The aim of this project is to implement it to specification writing and get every body producing effective, useful specifications. The proposed dynamic model in this research provides a package to do this with the elements of TQM to improve the standard of specifications.
6.8 Summary

Specifications are one of the necessary constituent elements of the contract documents; it is imperative that practicing architects and engineers have a very good working knowledge of the role that specifications play. Specifications must be written by all design members involved in designing the project, not only by the architect, the assistant or the specification writer.

There are two systems of writing specifications; the first one is the method system where the specifications describe in detail the material, workmanship, installation and fixing methods. The second system is the results system and the specifications specify results to be achieved and the constructor is responsible for achieving the desired results whatever the method the constructor chooses to use.

The preparation of specification and contract conditions practised in Bahrain is to often copy from other specifications that are made by somebody else earlier. Due to lack of skills and knowledge in specification writing. Whatever the mistakes and discrepancies, inconsistencies and unclear wording are repeated once again in a new project. Due to the poor standard of specifications the following problems arise from the present situation:

- Most of the projects do not finish on time.
- Allocated project’s budget is raised due to changes and variations.
- Disputes arise with unhappy clients ending up in court.
- Qualities of buildings are compromised to finish the project.
- High penalties with time consuming correspondences and instructions.
- Lost of trust and confidence between parties of the project with no future cooperation.

TQM is capable of improving the method of specification writing and the quality of specifications with the implementation of TQM elements of teamwork effective
communication, creation of culture, continuous improvement and value engineering. The level of specification will definitely improve by eliminating all those problems of the existing specifications used in Bahrain, through the proposed dynamic model in this research.

There is a need for an improved specification as building designs grew more complex and materials and construction techniques become more involved, it becomes necessary to increase the number of technical sections as more portions of the work came under sub-contract.

There also a need to review the application of different software packages in the construction industry, as it is one of this research objectives, which will be reviewed in the next chapter.
CHAPTER SEVEN

OVERVIEW OF THE APPLICATION OF DIFFERENT SOFTWARE PACKAGES IN THE CONSTRUCTION MANAGEMENT
CHAPTER SEVEN

OVERVIEW OF THE APPLICATION OF DIFFERENT SOFTWARE PACKAGES IN THE CONSTRUCTION MANAGEMENT

7.1 Introduction

The evolution of IT has been a major factor in boosting the efficiency of every profession both in practice and implementation of its specific rules, theories and principles. It would not have been possible to bring "PROMANSYS" to the efficiency level aimed for in the objectives of this thesis, without doing chapter five (the use of information technology in the construction industry) and this chapter. The purpose of this chapter is to overview and study most packages used in the construction industry with their advantages and disadvantages, and come-up with a software package that is serving the aim and objectives of this research; establish competitiveness between "PROMANSYS" and other packages available in the industry, assess the new features and techniques available in "PROMANSYS", and achieve uniqueness of the framework between other packages and at top of all with its advantages, features and effectiveness in improving performance in the construction industry through the implementation of TQM.

One of the professions that have benefited most from the advancement of IT is Construction Management. It provides the necessary tools for effective control and project management, the facility for budgeting planning and monitoring of the progress of each project.
Software packages are now available on the shelf to support professionals in their respective fields. Development tools are also available to customise or develop software based on specific user requirements.

In order to implement effective construction management, the use of these software packages is necessary, not only to save time, but to formulate guidelines on budget, planning and scheduling of activities.

There are many elements to be considered in selecting the right software for a specific profession. The first and possibly most important is the user interface specification. The software designer needs to follow certain steps and know proven procedures in order to produce a system that is fast, compact, easy to use, maintainable and works well with other systems. One of the requirements of this research is to do a comparison and an analysis of the configuration components and design of the most frequently used software packages in the construction industry in relation to the proposed dynamic model in this research. This chapter will describe seven of the most commonly used software packages, analysing their advantages and disadvantages. The information for this chapter has been obtained from working on some software packages; other information has been taken from the users' manuals and mostly, from the Internet.

### 7.2 Microsoft Project 2000

**Description**

Microsoft Project 2000 is the latest version of the Microsoft Project Management System. The application provides an effective planning tool to support scheduling, tracking project phases or tasks. It is regularly updated by Microsoft corporation to provide connectivity and centralisation of system utilising the Internet.
To utilise web application and remote connectivity, Microsoft Project 2000 introduces a companion module, MICROSOFT PROJECT CENTRAL, which enables collaborative planning among workgroup members, project managers and other users, using the facilities of the Internet.

Web-based project management allows the project team members equal and convenient access to project information. Using Microsoft project and e-mail, the user can incorporate feedback from the project staff; the project manager; and key contacts efficiently. Through web-based project management, the project manager can do the following:

- Communicate with project staff about a potential task assignment.
- Distribute notices automatically to project staff regarding schedule and assignment changes.
- Request status and work information from project staff.
- Incorporate status and work updates into the schedule.

The user can also save plans as html (hypertext markup language) files and post them on the web, where the team members can reviews and update. Users can also embed Gantt charts; calendars; resource sheets; and other information. (http://www.Microsoft.com/office/project/FAQ.htm).

Advantages

With the facility of the Internet, this application could handle multi-national firms, with remote or overseas branches. It provides the required functionalities to manage projects, from the time the project is created up to Task Costing and Scheduling.

It has a built-in scheduling engine that has an ONLINE effect to the rest of task schedules of the project. When a change or update takes effect in one work item, the IT impacts to the rest of project. Microsoft Project and Microsoft Project
Central, are designed under GUI (Graphical User Interface) or Windows environment, thus making it easier to learn as the menus and functions are similar to that of other Microsoft products.

Disadvantages
The application of Microsoft project 2000 in its design and function provides a comprehensive planning tool only in managing a project. It is not specification based, as is in "PROMANSYS". It does not get all the design team of the project working together with one tool, therefore not promoting teamwork. Microsoft Project 2000 concentrates mainly on the relation and inter-relation between the activity of the project in a certain timescale, with a focus on the resources of the project. Estimating and cash flow are not functions within Microsoft Project. The user of this package needs intensive training and through reading of the manual with long hours of practise on many projects to become expert in using Microsoft Project. The user needs time to learn how to use the software, as the stages of the implementation of the package are complicated. Especially when calculating the early and late start of activities with early and late finish dates of the same activities, bearing in mind the interrelation of the activities and the calculation of the float time and critical path of the project.

7.3 Primavera
Description
Primavera, a master system for multiple project management has introduced its latest version called PRIMAVERA EXPEDITION 7.0. It provides the required tools to manage projects for the construction industry, executing planning, budgeting and scheduling. It has a comprehensive feature of total contract management and administration, covering capture of contract information, drawings and relative submittals, meeting minutes and correspondence linked to
critical issues during the project duration. It also provides multiple project handling in multiple locations. (http://www.primavera.com/products/p3.html)

Advantages
This software was exclusively developed for construction management. The system was created, and has been revised to adapt to the real or actual requirements of the industry. It has the full features required to manage civil projects from the time of conceptualisation or estimating up to planning and costing. It is a portable system and could be utilised in a standard PC configuration and is available as a Windows based operating system. It has facilities to customise and capture changes made in the project, its causes and relative negotiations up to approval. Its feature provides Online or flow through effect in the project, for both its cost and time schedule factor. As changes or transactions are created, costing files are instantly updated, providing real-time project information for analysis, forecasting and better cost management decisions.

The introduction of Primavera Project Planner (P3) with interface to other Primavera products, the Primavera Expedition and Sure Track, has provided enhancements to the system as a whole, summarized as follows.

- Capability to control large and complex projects, with up to 100,000 activities per project, 24 activity codes, 16 custom data items, 10 project codes, 19 levels of sort, 28 levels of selection criteria and 31 activity calendars.
- Multiple projects in a multi-user environment.
Disadvantages

Primavera is basically a Project Management System. It is able to manage multi-site and major contracts. Its design and components are developed to handle large scale or major projects thus making it impractical for minor range projects. Whether the project phases are in one single site or more, the functions it provides are still the same. The procedures it observes to generate the required reports are tedious and time consuming for ordinary users.

In order to fully utilise the facilities of the system; Primavera segregated its product into three different sets, the Enterprise Edition, P3 and Sure Track Project Manager, which should be implemented separately. This requirement of the system provides the links or share of information from all the modules. This situation is therefore not practical for ordinary users, making the system more complicated to use.

### 7.4 Project Scheduler

**Description**

A PC based Project Management Software Tools, which provide functions to handle team planning, costing, and scheduling of projects. It is for general applications and could adapt to various lines of profession. It is intended for use in a Windows 95-environment or Windows NT.

(http://www.scitor.com/ps7/index.asp)

**Advantages**

Similar to the other systems previously mentioned in the study, Project Scheduler has the full features to handle a Project Management System. It is for general application and is not specific to any profession or field of practice. It provides a parameterised feature to adapt to various types of projects. It has full
compatibility with Microsoft Office 97 and works on a standard PC configuration.

It has add-on features which helps users in their day-to-day activities such as Tip of the Day, Multi level undo and redo, specific field level help facilities to interact with the user during utilization. It also provides a very useful facility to incorporate Resource Assignments, to locate and manage important resources of the project.

Disadvantages
It is purely a planning tool and the system's functions require thorough definitions and training to understand their usability. The menus, or set of functions provided are not intended for ordinary users. In order to fully utilise the system, the user should be aware of its modular or functional components, its specific output and formulation.

One of the functionalities that are not common, or abstract to user are the project schedule or the job of task scheduling. It has its own internal process and generates its own analysis of the schedule of activity. After this process the user should be aware of the next step to complete the system process, such as resource assignment, ordering, filtering and sorting.

Good communication and clean understanding of the timing and sequence of events is not handled well in Project Scheduler. In addition to that, the "ease of use" feature has not been taken into account on this software, this will reduce the number of users that will benefit from this project.
7.5 Timberline

Description
Timberline is an integrated estimating and accounting system for the construction industry. It is supported by sub-systems on the same platform, by the following:

- Timberline Gold Collection, a management tool to handle project accounting in construction or a leased-based system such as Property Management industry.
- Timberline Precision Collection, for estimating and budgeting of construction projects.
- It could be linked to CAD, Scheduling, bidding software, and more. It is a full pledge financial system, comprising of the following support modules.
  - Accounts Payable
  - Accounts Receivable and Contracts
  - Advance Retail
  - Billing
  - Equipment Cost
  - General Ledger
  - Information Assistant
  - Inquiry Designer
  - Job Cost
  - Payroll
  - Property Management

Advantages
Timberline software applications are designed for the construction industry. It is an integrated system, which works with full interface from both job and financial accounting, thus making it different from other software. It generates reports, from job estimation, planning, costing and scheduling up to general ledger and financial aspects. It works with standard platform, such as Windows 95, 98 and Windows NT, and could share information to other software packages such as Primavera, Sure Track and others. This feature is very important and useful, especially for transferring data from one software package to another instead of feeding the software with the data again.

Disadvantages
Timberline is a complete accounting and management system, which covers project handling, estimating, costing, scheduling, general accounting and financial reporting. It is basically intended for a well-organised construction establishment, with departmental and sectional activities. This means that, in order to utilise or apply the package, the users are required to be trained properly, specific to their line of responsibility. Options to customise or modify a module to adapt to the real environment are not available and therefore, it is difficult or impractical for a medium range industry to implement. It is an integrated system and requires parameterisation or set up prior to implementation. This creates a draw back to some establishments, as it is necessary for them to create an IT department internally to administer and supervise implementation.

The software package has nothing to do with the planning of activities, resources or specification. It is purely an estimating software intended to create and develop proper estimating systems for the construction industry. Its features and
functions are different from all other planning software; it is in line with estimating and taking-off packages in the construction industry.

7.6 Sure Track

Description
Sure Track is a project management software that helps to plan and control the project schedule, from planning the activities needed to complete the project, to tracking project progress and determining how quickly it can be completed. It is part of the Primavera software package. It is software for the planning of activities and resources in the construction industry.

- Sure Track enables the user to create new projects by adding and modifying activities, creating relationships between these activities and developing calendars for a project. This includes instructions for assigning resources, costs and revenues, building a schedule and defining the critical path for the project.
- Setting up the coding structure (breakdown structure and activities code), grouping and sorting activities; selecting activities by filter and summarising project data.
- Discuss the appearance of the project including instructions for controlling the activity columns, bar chart and PERT view.
- Create target dates for the project, update the activities progress and resources and costs, analyse resources using profiles and tables.
- Printing layouts and reports including graphics that communicate information about the project.

(http://www.primavera.com/products/st.html)
Advantages

- Multi-user considerations: When working with project groups and member projects, initial users can access different member projects of the same project group in Read Write mode.
- If upgrading from Microsoft Project, Sure Track makes the transition smart and easy because Sure Track has many features similar to those of Microsoft Project as well as features unique to Sure Track.
- If working in a concentric Project Management environment that includes using Primavera project planner (P3) in conjunction with Sure Track. Sure Track can open, save, backup, and restore the project in P3 format as well as in Sure Track.
- When needed to share project information with other organisations around the world, Sure Track can translate the language of the activities to another language you select using set language control.

Disadvantages

Sure Track is part of the Primavera series of packages. Therefore, it is in the same series of planning packages and tools. It is not a specification writing software, nor is it a cash flow and budgeting programme. It has no building rate library and nothing to do with value engineering. It is not a TQM tool or software package which implement the TQM elements such as teamwork, effective communication between members of the in both design and construction, teams it can not be continuously improved by the users and does not create a culture during the design and construction stages.

7.7 SAP/3

Description

SAP stand for “software, Applications, and products in Data processing”. The overall intention of the SAP R/3 system is to empower all normal business
processes while simplifying the task involved. SAP R/3 is divided into Sales and Distribution, Production Planning, Accounting, Human Resources and Material Management. The spectacular thing about this familiar division is it is done with precisely directed integration. The processes are normally linked within a business base. This provides real-time updating of information from one business area to the next. Better information leads to better decisions, which leads to better business. The integration of the modules within SAP R/3 are broken down into four high level work areas.

- Logistics
- Accounting
- Human resources
- Business tools

The first three are recognisable form their business function functionality. Business tools represents the system management of SAP R/3 this includes the configuration of the system, communication and administrative tools. Hiqet, Kelly and CCAI (1998)

Advantages of SAP R/3

- The user interface is simply a graphic user interface, which makes SAP easily adaptable by the user and a powerful interactive development tool.
- Integration in the data collection systems makes information easier to obtain and analyse. SAP/R3 is a powerful tool to collect and analyse information needed to guide a business.
- Quick accessing and accurate up-to-date information online.
- Better control of information, which leads to making the most of changes in the market place, and this leads to increased revenues, profits and opportunities.
Disadvantages of the SAP R/3

- Many users complained that the system was hard to work with and demanding time consuming for data input.
- To be customised with the system, the user needs thorough training.
- It is again a planning tool to control activities, resources and material of the project.
- It is not a teamwork package.
- It is not a specification writing method.

7.8 Construction Computer Software (CCS)

CCS Description

CCS is an integrated system specifically designed for the construction industry. The major components are estimating, valuations, planning and cash flow.

Estimating: an analytical, resource-based estimating system with powerful tools for producing tenders rapidly and accurately.

Valuations: on successful tenders the estimate is used as a basis certification, Budgeting and forecasting.

Planning: a versatile and easy to use construction planning system which links the estimate and cash flow, to produce forecasts of the estimate's cash and resources.

Cash flow: models the financial requirements of a construction project so that the cash flow can be optimised to maximize return on investment.

(http://www.ccsus.com/default.html)
Advantages

- It offers a comprehensive and integrated set of software tools to facilitate the management of construction projects, improving accuracy and increasing productivity.
- It combines much software into one software with regard to functions, such as estimating planning and cash flow.
- It has the full features required to manage construction projects from start to finish.
- The ability to print layouts and reports including graphics that communicate information about the project.

Disadvantages

- It lacks specification writing techniques, no library of any specification related to the activities of the projects, the software is not based on specification tool as the main link between all design and construction members of the project.
- It is merely a planning tool for the project in-hand with regard to activities planning, cash flow and estimating.
- It lacks value-engineering techniques as a method to go through the design or specification to control the quality, budget, time and life cycle of the project.
- The user needs prolonged training and seminars to become familiar with the package.
7.9 Summary

1. All the softwares that are commonly used in the construction management, such as the seven programmes overviewed in this chapter, are considered as planning tools to plan the activities of the project, allocate labour and plant resources and submit good reports and charts for the planning and control processes.

2. Some of the softwares add the cash flow and estimating features to the planning packages as a means of controlling the time and budget of the project.

3. The majority of the packages overviewed in this chapter are useful for large projects in the construction industry. The packages are time consuming to prepare, complicated and need long periods of training and experience for the user to become fully competent in implementing them to real life projects.

4. All the packages in this chapter are not specification oriented as in the dynamic model "PROMANSYS". They have no master library for specifications and building rates. The advantages of the dynamic model is its ability to be continuously improved by the users and to take into account all new materials, methods of construction and management systems that are up to date in the construction industry.

5. The packages in this chapter cannot be continuously improved by the users, only by the programme producers. This means that these packages can not be implemented as TQM tools for the construction industry became they lack one of the TQM elements and that is the ability to make continuous improvements to the package to satisfy the customers requirements and new trends in the construction industry.
6. The packages discussed lack the elements of value engineering, which adds a
great value to the project in hand when implemented in improving the
specification, the material and techniques used in the project, with great
savings in the total budget of the project, and an increase in the lifecycle of
the functionality of the project.

7. Web-based project management allows the project team members equal and
convenient access to project information. Using Microsoft project and e-mail,
the user can incorporate feedback from the project staff; the project manager;
and key contacts efficiently. Through web-based project management, the
project manager can do the following:

- Communicate with project staff about a potential task assignment.
- Distribute notices automatically to project staff regarding schedule and
  assignment changes.
- Request status and work information from project staff.
- Incorporate status and work updates into the schedule.

8. Teamwork is one of the main elements in the implementation of TQM.
“PROMANSYS” uses this element at great length during the preparation of
the project specification, B.o.Q, charts and reports. Due to the fact that the
project manager, architect, civil, planning, material, electrical, value and
mechanical engineers and quantity surveyor, are all using the package of the
dynamic model to form an effective teamwork effort. All other packages
available in the construction industry lack this element of teamwork, because
only a limited number of those mentioned above would be using the package.

This chapter overview the different packages in the construction industry while
next chapter focuses on the proposed dynamic model “PROMANSYS” alone.
CHAPTER EIGHT

QUESTIONNAIRE, RESULTS AND ANALYSIS
CHAPTER EIGHT

QUESTIONNAIRE, RESULTS AND ANALYSIS

8.1 INTRODUCTION

This chapter contains two sections of questionnaires, section one: specification questionnaire and section two: TQM questionnaire. The two questionnaires were aimed at the technical staff, engineers, architects and managers in the construction industry in Bahrain: in the public sector, mainly government technical offices and service-government authorities; and in the private sector to engineering offices, contractors, sub-constructors and suppliers. The aim of the questionnaire focused on the: appreciation and use of TQM in the construction industry in Bahrain. To measure the awareness and the level of implementation of TQM, the readiness of the construction industry in Bahrain to receive TQM, and through which framework should it be implemented. The aim of the specification questionnaire focused on the appreciation and use of specification in the construction industry in Bahrain. Analysis the current problems with specifications, the level of quality of the existing specifications, the problems arising from the current specifications in use, and how to improve specifications in the construction industry in Bahrain.

The software package used to analyse questionnaire's responses was Microsoft Excel, with the use of pie-chart method, for ease of categorization, colouring and, data writing on the chart and legend style was used below the chart. The overall questions, responses to the questions are analysed and presented in this chapter.
8.2 Questionnaire objectives

The objectives of the specification questionnaire focused on: the appreciation and use of specification in the construction industry in Bahrain; quality; size; standard; type of specification used; the problems of specifications; problems resulted from the use of the present specification; and what are the methods to use to improve the standard of specification. The objectives of the questionnaire focused on: the appreciation and use of TQM in the construction industry in Bahrain; effectiveness of communication in the industry; implementation of teamwork; commitment to training; recognition of the contribution and accomplishment of the employees; appreciation to customer satisfaction in the organisation; and coordination between the different departments in the organisation.

8.3 Questionnaire design

The questionnaire design and layout in their survey established using the procedures and recommended by Hoiville (1977), Fowler (1993) and Prescott (1993) as mentioned in Chapter Two.

The two types of questions that can be used in any questionnaire are open-ended questions and closed-ended questions. Most of the questions used in the questionnaires are closed-ended questions. Closed questions often require a short response in the form of yes or no, agree or disagree, important or not important. Closed-ended questions are easy to ask and quick to answer, they require no writing by respondent or interviewer, and their analysis is straightforward Nachmias and Nachmias (1996).
8.4 Sampling

The sample is of major government technical offices, constructors and engineering offices, who are involved in design and construction in the construction industry in Bahrain, who influence the methods and quality of the construction industry project and buildings.

A questionnaire survey (110 questionnaires) was posted and distributed to the Ministry of Housing (22), Ministry of Public Works (17), Central Municipal Council (16), Building Constructors (30) and Engineering Offices (25) questionnaires.

8.5 Response rate

The questionnaire (with 29 questions) contained two sections, section one: specification questionnaire having 11 questions and section two: TQM questionnaire having 18 questions. The total responses rate of the two sections were analysed based on the total questionnaire sent out which were 110 questionnaires, the total responses that were returned were 43 responses, giving an overall return rate of 39 percent. This is considered an accepted and reasonable response rate according to Fowler's assumption Fowler (1988) the response rate in excess of thirty percent is accepted.
8.6 Section One: specification questionnaire, results and analysis
Question 1

Do you write specifications for every project you do?

Analysis
Even though the questionnaire was mostly distributed to Government Departments, Ministries, and Technical offices, it was noted that 26 percent of the respondents don’t write specifications for every project they do. This shows that there is little appreciation of the purpose of specifications. This will always put the quality of the building materials used, quality of workmanship and quality of the method of construction used in question, with the life cycle, durability and feasibility of the project executed. The answers to this question might be related to the size of projects in hand, but still for the quality to be achieved in any job whether large or small, it has to be measured against pre-set standards of quality requirements for every new job designed especially if the design has unique features, to be used as a benchmark for the project. With the absence of the quality standards the finished job will always be in question, and conflicts in the job would be difficult to avoided.
Question 2

For new projects do you?

Analysis

Projects in the construction industry are often unique, and there is a need to write new specifications for each project. Eighty-seven percent of the respondents use old specifications from previous projects. This process could lead to conflicts and duplication of clauses, in many instances irrelevant clauses are found which have nothing to do with the new project. Many clauses also clash with each other, as the modification done to tailor the specifications to fit the new project, do not delete previous clauses used in the previous job, which often stated the opposite of the new modification. This is common practice in the construction industry in Bahrain. This practice emphasises the need to create and develop a master specification for the construction works by a government body, to keep improving these specifications from time to time, and to introduce new clauses to incorporate new materials, new techniques and methods of construction in the construction industry. These specifications could be divided into small, medium and large project's specifications.
Question 3

Do you have computerised specifications?

Analysis

It was noted that the direction of future specification is for the computerised specification. It was encouraging to see that seventy-seven percent of the respondents are already using computerised specification. Unfortunately, after conducting some interviews to investigate this matter, it was concluded that the answers to this question had been interpreted as referring to specifications that have been 'typed' or computed and saved on a floppy disk for use and modification of new projects. This has nothing to do with the creation of master specification, use of local material and solutions to existing concrete problems, standardisation, inclusion of up to date new material techniques and method. The respondents answers still reflected a desire to have the specification on computers and to move away from the manual method of specification writing. This is encouraging in the sense that any new methods package for specification writing in the construction industry would be welcomed and not rejected as a new trend in the industry.
Question 4

What do you think of your existing specifications?

Analysis

The survey indicates that the existing specifications used in the construction industry need to be modified by fifty-eight percent. Twenty-three percent agreed that they must be improved, making the total of eighty-one percent as the majority of the respondents are not happy with the existing specifications used in the construction industry, due to the problems faced at the job sites, difficulty of implementation and conflicts resulting from the use of the existing specifications. There are still nineteen percent of the respondents who think that their specifications are useable for all the projects they execute. This slice of the respondents reflects those who think that what they are familiar with is always the best and anything new is an extra cost for no reason. This slice objects to any calls for change. But the majority are calling for change and requesting an improvement in the present situation regarding specifications and this is encouraging.
Question 5

Your specification has a problem of?

Analysis

It was noted that there are many problems with the existing specifications. Seventy-two percent of the respondents replied that there are problems with specifications, twenty-six percent being incomplete, sixteen percent being not precise, four percent with problem of repetition in clauses, eight percent unclear and eight percent with conflict clauses. These results support the answers and replies in Question four emphasising the need to change existing specifications, and create new modern, up to date, clear and usable specifications. The responses to this question calls for an immediate change of the present situation. The continuation in using these inadequate specifications will result in poor quality buildings, more disputes and court cases and a waste of time and money. The problem is that no one is doing anything about it in either the private or the public sector. This is how the need for this research came about, and with the introduction of the new technique of specification writing in “PROMAN5YS” and the implementation of TQM to improve the performance in the construction industry through specification improvement.
Question 6

For the contract conditions in your specification do you use?

Analysis

The majority of the respondents use Federation International Des Ingenieurs-Conseils (FIDIC) and Joint Contracts Tribunal (JCT) conditions of contracts for standard specification of forty-five percent and forty-three percent respectively in their projects, showing that the European standards and quality levels of workmanship, legality clauses and the system of management running the sites. There are many conditions generally in the Gulf region and specifically in Bahrain, which impose a need for standard specification such as the conditions of a hot climate, the availability of the raw materials, the methods of construction at sites and the level of workmanship available in the region’s markets. Most of these conditions differ from the conditions mentioned in the Federation International Des Ingenieurs-Conseils (FIDIC) and Joint Contracts Tribunal (JCT) and Institution of Civil Engineers conditions of contract (ICT) clauses of the specifications.
Question 7

Your specification size is between?

Analysis

The responses of this question showed that the standard of specification is inadequate, as fifty-six percent of the respondents are using specifications of 10-100 pages only, which is usually not enough to cover contract conditions, general and particular specifications, electrical and mechanical. This weakness is reflected in the quality of the projects executed. Missing information creates conflict at job-sites and a large number of variations, increasing the budget set initially for the project, which damages the feasibility study and investment return of the project set at the initial stage of the project design. The introduction of master specification will unite most of the building projects to a similar size of specification, where all the clauses are saved on a cd and modified according to the project in hand, and that would mostly be in the finishing clauses as the civil, mechanical and electrical works often have the same standard of material, workmanship and methods of fixing.
Question 8

How long does it take you to prepare your specification?

Analysis

The majority sixty percent of the respondents prepare their specification for the project in a very short period, regardless of the size and complexity of the project. This shows that the answers for Question 2 is right, which means that specifications of new projects are used from previous jobs and changed in a short time wherever needed. This reflects the lack of appreciation of the purpose of specification and is done for the sake of completing the contract documents in a short time. There is no appreciation of the possible adverse outcomes such as conflicts in clauses, unclear specification, duplication in clauses and incomplete specifications. These problems would also be solved by the creation of master specifications for the construction industry, categorised according to the size and type of the project.
Question 9

What type of specification do you use?

Analysis

The majority of the respondents who answered this question indicated the use of the descriptive specification forty-five percent, then the performance specification thirty percent and only seven percent used both combined, and eighteen percent used only a proprietary specification. Unfortunately, during the interview stage, it was discovered that the majority really did not know the difference and the meaning of the different types of specifications. Which shows that they only assumed what type of specification they were using and selected one to the best of their knowledge. Even though the meaning of each type of specification was written in the questionnaire itself, to get precise answers to the question. This proves that the respondent to the question not only lack appreciation of the purpose of specification, as in the answers to Question 1; they are also not aware of the different types of specification in the construction industry in general, or when to use each type of specification.
Question 10

How often do you improve your specification?

Analysis

This question was designed for the purpose of confirming answers of previous questions, like Questions 2, 4, 6 and 8. It did confirm that twenty-four percent of the respondents don’t improve their specifications, but only use the same old specification. Thirty-two percent improve in a time period of every three years or more. Thirty-six percent improve their specifications within a three-year time period. Respondents did not take into account before executing their projects, the problem of construction, new techniques, new methods of construction and new materials of improved quality in the construction industry. This keeps them years behind in obtaining the quality standards required by clients, and holds their survival at stake.
Question 11

Do you prefer?

Analysis
The preference and the direction are towards computerised specifications rather than manual specifications, in order that they are easy to amend, change, improve and modify. It is an encouraging indication towards the improvement of the specification, and this shows the validity and necessity of this thesis, as improvement of specification writing is the focus of this research. This indicates that when the package "PROMANSYS" is introduced to the construction industry in Bahrain, it should be welcomed and appreciated as it is based on computerised specification and lead to the information of master specification to the Gulf region. The majority of the responses eighty-eight percent to this question show a need for computerised specification in its true meaning, not just clauses of conditions saved on diskette and re-copied. The computerised specifications shown link all design and construction team members, it should be continuously improved, should be an effective tool of communication, and get everybody to work as a team.
8.7 Section Two: TQM questionnaire, results and analysis
Question 1

How familiar are you with the TQM concept?

Analysis

The concept of TQM is still new to the construction industry in Bahrain and few organisations have used or implemented it yet. Thirteen percent of the respondents had never heard about it and do not know what it is. Sixty-nine percent of them have heard about it and do not know what it is. The remaining eighteen percent knew what it is and still have not implemented it. The interviews showed that the knowledge came through attending seminars, workshops, and short courses on how to be prepared to use it whenever they are requested to implement it. The overall results of the responses showed that TQM is a new concept. This emphasises the need to introduce TQM to the construction industry in Bahrain. The main objective of this research is to implement TQM to specifications to the construction industry in Bahrain to improve performance through specification improvement; it will take sometime to see the results. It might take five years or so, but better to start now than never.
Question 2

Did you participate in a TQM seminar or workshop?

Analysis

The responses to this question show the results obtained for Question 1. The majority of the responses eighty-two percent have not attended any seminars or workshops in TQM, but only eighteen percent attended. These seminars and workshops were organised by the Society of Engineers in Bahrain to educate the Bahraini engineers with all new concepts of construction management, new techniques, materials and methods of construction, because that is one of the society's objectives. This also shows the hard work is needed to change the percentage to a majority who are aware of the concept of TQM. The efforts should be shared by the private and the public sectors. The government bodies should take care of their employees; the engineering society and other technical institutions should provide equal chances to managers, engineers, supervisors and technical staff in the private sector.
Question 3

Does your organisation implement TQM?

Analysis

The design and purpose of this question is to confirm the result of question 1 and 2, to ensure if TQM is implemented, and the person replying to the questionnaire may or may not have been part of the team implementing TQM. The responses to this question showed that TQM is still a new concept to the respondents. In this case of hundred percent of the respondents had not implemented TQM, the process should start from top management with plans, policies and budgets which should be allocated to this process. The reason to start from top management is to learn from Deming's experience in the U.S.A as the TQM guru started with supervisors and seniors of technical staff. In Deming’s experience in Japan emphasised on starting TQM lectures with top management.
Question 4

Do you think that your organisation encourages teamwork?

Analysis

This question is about the encouragement of teamwork in the organisation. Senior management does not yet take this notion of teamwork seriously. The majority of the respondents are still not convinced that their organisation encourages teamwork, while their response to Question 5 is that the majority of respondents were encouraged to implement teamwork, which reflects the big difference between their willingness and their senior manager’s attitude. The lack of awareness towards teamwork of the senior manager in their methods and styles of management puts the organisation’s survival at risk. Teamwork is an essential element of TQM, without it any TQM programme will collapse. In “PROMANSYS” teamwork is the main feature of TQM elements implemented. As seen in the answer to the previous question, it is the top management that should be started with and not the technical staff of the organisation.
Question 5

Do you like to contribute in teamwork?

Analysis

The question is about employee's willingness to contribute in teamwork. The positive responses eighty-two percent reflect a very welcoming attitude encouraging to see the teamwork spirit among the respondents, which should be utilized and improved to achieve a standard of quality and customer satisfaction. Before starting any teamwork programmes the top management should be assured that the employees are aware of the meaning of teamwork. The interview took place after completing the questionnaire showed that some of the employees thought that teamwork is an official work group only, which is not the right meaning of teamwork. It should be understood that in any teamwork programme there must be shared responsibility, continuous co-ordination, shared beliefs, ideas and objectives, shared pooling of knowledge and experiences and commitment by all team members.
Question 6

Do you get enough information to do your job properly?

Analysis

This question is about the levels of information delivered to employees to perform their duties properly. The responses showed that only eighteen percent of the respondents confirmed that enough information is delivered to them to do their job properly. This reflects the weakness and ineffectiveness of the management of information system implemented, and the ineffective system of communication in the organisation. The respondents feel that either they do not get the right information from senior managers or feel that they are being isolated from important decisions. TQM is based on a good information system in any organisation, without it all TQM programmes will fail. The effectiveness, speed, value and the media of information are reflected in the services and products of any organisation. The organisation will be short lived and will struggle in its survival with a weak information system. The proposed dynamic model in this research “PROMANSYS”, emphasizes of the effectives of the TQM communication element as an essential part of the information system in the organization.
Question 7

Do you often put forward views for improving your work?

Analysis

This question is about employees' initiative to put forward views for improvement. The purpose of designing and putting this question in the questionnaire was to find out about the employee initiative in participating to improve the processes of the organisation and share in setting out the overall management policies of the organisation. The survey showed a great willingness and actual participation in the process of improvement seventy-eight percent of the respondents while others twenty-two percent still need encouragement and training to be able to participate fully in the process of improvement. This is part of the teamwork process, when the employees put their views and participate to improve their work; actually they work as a team to the benefit of the organisation and the end product or service. The responses to Question 5 showed that there is willingness from the employees to work as a team and the management should encourage this team spirit.
Question 8

Do your supervisors welcome your views for improvement?

Analysis

This question is about superiors' receptivity for views for improvement from their subordinates. It is interesting to note that only thirty-three percent of the respondents replied that their views are always welcomed and thirty-eight percent are mostly welcomed while twenty-two percent are rarely welcomed and seven percent never welcomed. This could be explained that either most of their views are not to the expected standard according to their superior's expectations or that the superiors were not precise in their perception. The minority might feel that they are being dictated as what to do with not much room for feedback. Not being receptive to subordinates' views and suggestions is again a problem for top management. In some good organisations, the management provides incentives or awards to the best idea for improvement as a means to encourage their employees to do their best and always give their best ideas for improvements. The employees would feel that they are actually part of the organisation and are sharing the achievement of their management.
Question 9

Do you think that your organisation adopts sufficient systems that are able to provide its customers with quality services?

Analysis

This question is about the sufficiency of systems and procedures to provide the customers with quality services. The responses to this question were not encouraging but were expected as only twenty-seven percent of the respondents always think that their organisation adopts sufficient systems to provide its customers with quality services, which indicates major shortcomings in the systems. This may impose the need to revise current systems and search for more modern ones that are capable of ensuring improved quality services to the customers. This reflects a loss of trust in the organisation by the employees, if this is the case with the employee, what about the trust of the customers in the organisation? This appear to be a major internal and external problem, and also reflects a diminished culture; the employees and the management do not share the same culture. In this case customers are never satisfied and TQM will never be implemented.
Question 10
Does your organisation have an effective management information system for decision-making?

Analysis
This question is about sufficiency of management information system for effective decision-making. The responses to this question were very discouraging as the majority of the respondents sixty-three percent agreed that their organisation does not have an effective management information system (MIS) and twenty-five percent mostly agreed that the management information system works for effective decision-making. This is a weak foundation to establish TQM in the organisation. The results reflect an existing inefficient communication system to take care of the flow of information up to the level of decision making. The responses to this question support and agree with the responses of Question 6 (to take and enforce a decision, the employees and their management both need a good information system to implement the organisation’s plans and strategy as set initially).
Question 11
Is there management commitment towards training?

Analysis
This question is about management commitment towards training. It is discouraging to see the responses to this question, a declining trend towards training. Only twenty-nine percent of the respondents showed commitment of the management towards training. The majority forty-one percent rarely receive training. The concept of training in the organisation of the construction industry in Bahrain means extra budget, and there are always limitations to the budget and to the overall expenses per annum. Training is still not appreciated in the organisation of the construction industry, as dependency of manpower is still not on the local technicians and workers. Once TQM elements are raised, the employee’s appreciation and work skills are increased and the quality of the end product is also raised. By this customer satisfaction is gained, the organisation’s turnover is improved and the organisation’s position to training resembles an organisation working forwards.
Question 12

Are your contributions and accomplishments recognised and appreciated by your superiors?

Analysis

This question is about recognition of employees' contributions and accomplishments. The responses to this question support and confirm the responses to Question 8 that only thirty percent of the respondents confirmed the recognition of their contribution and accomplishments and still twenty-nine percent do not see that their contributions recognized. This might be due to the fact that performance measures are relatively absent or not very clear. This also could be to the absence of effective communication and feedback. An employee's accomplishment without recognition is a depressed employee, killing the creativity and contribution to improvement not only in the employee who accomplishes and achieves something, but also in every employee in the organisation. The competition between all the employees to do better will be diminished due to the fact that their efforts are not appreciated.
Question 13
Is customer satisfaction of primary importance to you?
Analysis
This question is about the importance of customer satisfaction. It is interesting to see that the majority seventy-six percent and mostly eighteen percent totalling ninety-four percent of the respondents appreciate customer satisfaction, and are willing to achieve customer satisfaction, which is one of the TQM elements. This indicates that the basis is there for TQM implementation, but the other elements of TQM elements are still not appreciated. Due to the fact that the organisations have good teamwork and recognition of employees' good initiatives, all of these elements are the responsibilities of top management. If the employees, as the responses show that they are willing to change, improve and adopt TQM in the organisation, the top management should appreciate this willingness and use it to improve the performance of the organisation.
**Question 14**

Does your organisation try to perceive and respond to customer interest?

**Analysis**

The question is designed to determine whether employees see their organisation as really customer oriented. Only thirty percent of the respondents sees their organisation as customer oriented. A lot of effort and improvement still needs to be done to focus on customer satisfaction. Some organisations in the construction industry in Bahrain do not pay much attention to the customers' interests. It might be due to the old methods of management systems used, or due to the weak performance of senior managers running the organisation. Whatever the reasons mentioned above it is actually a lack of a TQM system in some organisations in the construction industry in Bahrain. This is why this research is done to provide a framework to implement TQM and improve performance in the construction industry in Bahrain, through the proposed dynamic model “PROMANSYS”.
Question 15

Is the understanding of customer requirements crucial in your organisation?

Analysis

This question is designed to determine the openness of organisations to understand the requirements of customers. This confirms the responses on Question 14 which still reflects a problem in understanding the concept of 'customer.' This is due to a lack of awareness of TQM and quality concept in general. Customer requirements, needs and feedback in any organisation are the benchmark to the whole production cycle in the organisation; in the construction industry or in any industries in the market. Without knowledge, research and studies to the client's requirement, any production plan is definitely a failure in any organisation. It is discouraging to see organisations, in the new millennium, still not focusing on customer satisfaction.
Question 16

Is coordination between the different departments clear and effective?

Analysis

This question is about the level of coordination between departments. The majority of the respondents seventy percent agreed that coordination between different departments is weak, and only 12 percent confirmed the effectiveness of coordination between departments. This could be due to the existing ineffective communication system in the organisation, of the respondents and to the implementation of bad teamwork policies by senior management in the organisation. Responses to Question 5 prove the willingness of the employees in the organisation towards teamwork, but the responses of the answers to this question proves that the management discourage teamwork. Without effective co-ordination between different departments, all the master plans set earlier in the organisations by senior management will fail. Clashes in the processes, methods, strategies and systems will result in loss of time and money with disturbances in the production line as the project manager tries to get everybody in tune to work towards organisational objectives.
Question 17

Do you think the communication system is effective in your organisation?

Analysis

This question is about the effectiveness and awareness of the benefits of communication between management and employees in the organisation. Only nineteen percent responded that their communication system is effective, as eighty-one percent are not sure about their communication system. This is due to the lack of awareness of the benefits of an effective communication system, which creates a large gap between the management and employees, and between the organisation and its customers. This might put the organisation's survival at risk. This situation will object to the implementation of TQM in the organisation, as effective communication is one of the main elements of TQM. Any information system no matter how effective it is will collapse with the existence of ineffective communication system in the organisation.
Question 18

Are you pleased with your job conditions?

Analysis

This question is designed to determine employees' satisfaction about job conditions. It is interesting to see fifty-nine percent of the respondents confirm their satisfaction about their job conditions and twenty-three percent are mostly satisfied. These results may be driven by psychological factors and job security conditions. It is worth mentioning that the responses of this question contradicted with the outcome of previous responses in Questions 8 and 12 with regards to lack of recognition, training and appreciation of accomplishments. In the interviews that took place after completing the questionnaire, it was noticed that a misunderstanding between the respondents to this question in the clarification to the meaning of job conditions. Some thought it was related to the working hours, job security, salary and their treatment by superiors. Forty-one percent who were not totally happy with their job conditions had problems with the explanations mentioned to this question.
8.8 Summary

The questionnaire contained two sections, section one: specification questionnaire (11 questions) and section two: TQM questions (18 questions), both Questionnaire were aimed at the technical staff, engineers, architects and managers in the construction industry in Bahrain: in the public sector, mainly government technical offices and service- government authorities; and in the private sector to engineering offices, constructors, sub-constructors and suppliers.

A questionnaire survey (110 questionnaires) was posted and distributed to the Ministry of Housing (22), Ministry of Public Works (17), Central Municipal Council (16), Building Contractors (30) and Engineering Offices (25) questionnaires.

The total responses rate of the two sections were analysed based on the total questionnaire sent out which were 110 questionnaires, the total responses that were returned were 43 responses, giving an overall return rate of 39 percent. This is considered an accepted and reasonable response rate according to Fowler’s assumption Fowler (1988) the response rate in excess of thirty percent is accepted.

The specification of the questionnaire results are as follows.

- The Majority in the construction industry do not write specifications for new projects.
- The Majority uses old specification and changes them wherever needed.
- Most existing specifications need modifications.
- Repetition, uncompleted, unclear, conflict in clauses and lack of precision are the features of the existing specification.
- The Majority uses FIDIC and JCT conditions of contract for the specifications.
- Common size of existing specification is between 10-100 pages and takes less than a month to prepare.
Descriptive and performance specifications are the common type of specifications used.

The Majority prefer computerised specifications.

Total Quality Management Questionnaire results are as follow:

- The concept of TQM is new to many people in the field of construction in Bahrain.

- Teamwork is an important concept of TQM. Most top management still not giving it much attention, while staff and employees have the willingness to contribute in teamwork.

- The flow of information from management to employees is not sufficient, therefore, the employees initiative in participating to improve the process in the organisations has not yet been explored.

- Many organisations do not adopt sufficient systems to provide their customers with quality service.

- The majority organisations do not have an effective management information system for decision-making.

- There is weak management commitment towards training.

- The majority do not get recognition of their contribution and accomplishment at work.

- The majority of top management in the construction industry organisations do not invest in customer satisfaction due to lack of appreciation to the importance of customer satisfaction. While the majority of respondents in the organisation showed more willingness to achieve customer satisfaction.

- lack of awareness to the benefits of effective communication system in the organisation, create a large gap between management and employees, and between different departments in the organisation.
CHAPTER NINE

THE PROPOSED DYNAMIC MODEL: DEVELOPMENT; TESTING; AND VALIDATION
CHAPTER NINE

THE PROPOSED DYNAMIC MODEL: DEVELOPMENT; TESTING; AND VALIDATION

9.1 INTRODUCTION

The idea behind the proposed dynamic model "PROMANSYS" came as a means to implement TQM to the construction industry in Bahrain through specification writing. It is a tool used to develop a framework for TQM for the construction industry. "PROMANSYS" created master specification, master building rates and gathered all the project team members to work within one tool. Enhancing teamwork effective communication, creating a culture and providing continuous improvement to the system, (which has been explained in more detail in Chapter Ten).

This chapter describes the development of the system of "PROMANSYS" model, the software and hardware requirements and the characteristics of the model. Full description is given to the functional flow and data hierarchy of the model. The case study consists of a small extension of a bedroom, dressing area and a bathroom with details shown, with the implementation of a "PROMANSYS" model inputs, screens, and model outputs which consist of reports, charts and graphs. The dynamic model and software have been validated through presentations and questionnaires. Being presented to five architects and five civil engineers at the same time validated the model in this research. A questionnaire was distributed to everybody individually with twelve questions covering the validation requirements such as ease of learning, user-friendly, usefulness to the industry, improving processing speed, implementation of TQM, comparison with other packages, reduction of errors and
ability to be continuously improved. The results of the validation and questionnaire analysis are also presented at the end of this chapter.

9.2 Development of “PROMANSYS”

The development process of PROMANSYS had to go through the following stages:

1. Model objectives;
2. model layout;
3. model formation;
4. model characteristic;
5. model functional flow and data hierarchy;
6. model inputs;
7. model outputs;
8. model testing;
9. model screens;
10. model as an information system; and
11. model validation; questionnaire; and analysis.

9.2.1 Model objectives

The objectives of the model PROMANSYS in this research include the following.

- Improved specification writing techniques;
- A framework to implement TQM;
- Involve the maximum number of design and construction teams members in the use of the model to achieve teamwork;
- Involve the maximum number of activities and functions in the model to create a culture of unified aims; objectives; and beliefs;
- Provide an efficient flow of information for the project to achieve an effective communication between project team members.
9.2.2 The model layout

The model is based on the method of specification writing, where the project specifications are entered with other information such as the activity's quantities, material, plan, labour rates, date starting and ending for the activities are all entered, through a library of information or by the user directory. From these, inputs reports and charts are obtained such as specification manual, bill of quantity, planning and others.
control charts, material control charts, budget control charts and others with the implementation of the value engineering technique.

9.2.3 The formation of the PROMANSYS model

The Project Management System is a computerized information, budget control and reporting system for the construction industry based on the specification writing method. The design and formation of the system is based on the construction principles and the stages the project will undergo which are interpreted as functional modules of the computerized system. These modules are referred to as functions that capture, maintain and generate the following.

- The Clients and Project Master Details.
- Standard of Project Phases, Costing and Specifications.
- Project Scheduling, Planning and Quantities.
- Charts, Graphs and Reports.

The query, tables, forms and reports utilised the features of the Windows based operating system and characteristics of a Graphical User Interface (GUI), and can be deployed in a PC under the Pentium Range with standard configuration and Windows Operating Systems. An advice was needed from a professional computer programmer in some of the points during the formation stage.

The system is an independent application in itself with its sets of environment requiring libraries (DLL: Dynamic Link Library) and can be installed with a built in database engine, Microsoft JET and have a full connectivity and interface with most Microsoft Application Packages.

PLATFORM

Windows 95, Windows 98, Windows 2000 and Windows NT
DATABASE
Microsoft Jet

DEVELOPMENT TOOLS
Visual Basic 5 Enterprise Edition
Crystal Reports
Visual Data

HARDWARE REQUIREMENTS
Pentium I, or Higher
At Least 64 MB RAM
266 MHZ Speed or Higher
Requires 20 MB Hard Disk Storage Allocation
SVGA Monitor

9.2.4 Characteristics of PROMANSYS

The success of any software depends on the intended user. In general, the system should comply with the required elements of software design, summarised as follows.

- Ease of use;
- Speed and responsiveness;
- Size and compactness;
- Maintainability;
- Packaging; and
- Web-based model.

PROMANSYS as a customised system, under Windows Operating System, satisfies the above criteria, not only in the design of its functions which are based on actual
users' requirements, but also to the components of the system which provides the standards of Graphical User Interface (GUI).

GUI refers to the users' interface in the system using Graphics, which is easier to understand instead of Text that the previous generations of software used.

Programmes that are difficult to learn or operate are normally considered short lived simply because the user does not have the time to learn complex procedures, read a range of complex manuals or attend long and boring training lectures. Additionally, complex or difficult programmes encourage errors, causing fatigue and a waste of human effort.

9.2.4.1 Ease of Use

PROMANSYS, has the attributes of an easy-to-use software, it is:

- simple to operate;
- simple to learn, because the concept is based on common and well known procedures;
- consistent as the system does what the user expects;
- convenient, as the system does all that it can to serve the user, without causing misunderstanding; and
- efficient as the system minimises the user's effort.

9.2.4.2 Speed and Responsiveness

Speed and responsiveness is one of the vital attributes of software packages. It refers to the system performance on user's required outputs, and the speed of its responses especially on inquiries and reporting. PROMANSYS was carefully designed and developed with these attributes and thoroughly tested to satisfy quick and easy reporting. GUI contributes to this facility, as the user uses the mouse to
select options in one screen, with multiple functions such as selecting a project in a list box, and details of the project will be shown at the same time, on the same screen. An icon or image is also available to select and generate the required output, such as "Printer" for a hardcopy, "Window" for screen display, and e-mail, connection through the Internet.

9.2.4.3 Size and Compactness

A novice system user, although technically experienced, can measure size and compactness. It can be checked and verified using common and simple commands in the computer. It refers to the size of memory required to run the system, and measured in RAM and Disk Memory. It affects the performance of the system as the same is always loaded in the memory while the system is still running, and works in conjunction with internal Data Structures, Systems resources, file buffers and the data file itself which the storage space increases as new information is entered or captured. Disk memory can be a major factor in the design of an application as well, because such simple operations like sorting can greatly increase the amount of disk space required.

9.2.4.4 Maintainability

The availability of Software Tools and the new approach of systems’ development greatly affect the choice of Software. PROMANSYS is a customised system developed using Microsoft Standards. It falls under RAD (Rapid Application Development) and uses GUI, objects and built-in codes as its components.

The source code is available and open for enhancement or modification, as the situation requires. It uses Microsoft JET database engine to have full connectivity to other Microsoft products.
It gives peace of mind considering that the system could expand its functions, correct or update deficient modules, and incorporate other reports as situations requires. Unlike on-the-shelf packages, which are sometimes proprietary and protected so that even file formats cannot be modified. Documents and files are always available for analysis, can be preserved, and can be easily transferred or re-installed in any computer which uses Windows platform.

9.2.4.5 Packaging

Packaging is one of the important attributes of a successful system and refers to the design and development aspects of the software. It is the capability of the system to interface work with other applications, for further analysis or processing. It also refers to its adaptability or workability with common and standard operating systems.

PROMANSYS, as previously elaborated, operates in Windows, which has become the standard or most widely used operating system. Pentium I, with Windows 95, Pentium II with Windows 98 and Pentium III with Windows 2000 and multi-user under Windows NT, without limitations, as the system works well on all the mentioned hardware and operating systems.

After installing PROMANSYS, the user can create an ICON to Windows NT/Windows 95 Start up Screen or DESKTOP. Similar to other Window-based applications the user can run the system by selecting and double clicking the assigned Project Management System icon. An internal Login Screen will appear to identify and plug in the level of user authorisation. Through a valid password, the Systems Menu will appear and will be open for utilisation.
9.2.4.6 Web-based model

The model has the capability to be linked to the internet through a button at the bottom of the model screen. This improves project communication and flow of the project information to the design and construction members when connected to the World Wide Web.

Table 9.1: The keyboard functions

<table>
<thead>
<tr>
<th>The key</th>
<th>The function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt</td>
<td>To activate/highlight items in the menu.</td>
</tr>
<tr>
<td>Enter</td>
<td>To display submenu per main menu item or run a highlighted/selected menu item.</td>
</tr>
<tr>
<td>↑ ↑ ↓ ↓</td>
<td>Up and down arrow keys to select item in each submenu or combo selection boxes in case of data entry screens. It is also applicable to scroll or select cells in tables and data entry, worksheets or grid.</td>
</tr>
<tr>
<td>← →</td>
<td>Right and left arrow keys to navigate and select other submenu items. It is also applicable to scroll or select cells in tables and data entry, worksheets or grid.</td>
</tr>
<tr>
<td>Esc</td>
<td>Terminate or return to previous Text, Entry or Command Boxes and Buttons.</td>
</tr>
<tr>
<td>Tab</td>
<td>To navigate/select Text, Entry, Command Boxes and Buttons.</td>
</tr>
</tbody>
</table>

Using the mouse

Standard characteristics of GUI/Window based System where the mouse is utilised to Drag, Pull, Point and Click to select functions in the system. It is applicable to Menu, Data Entry Screens, Tables, Worksheets and Grids.
Figure 9.2: Project management system functional flow and data file hierarchy
9.2.5  PROMANSYS Functional Flow and Data File Hierarchy

As shown in Figure (9.2)
The following are the functional flow and data file hierarchy.

9.2.5.1 Processes (□)
The process in the functional flow includes the following.

- Creating and maintaining of client details.
- Creating and maintaining of project details.
- Creating and maintaining of project works phases.
- Creating and maintaining of general works, item cost and specification.

9.2.5.2 Data Files (□)
The data files in the functional flow include the following.

- Client master that is inter-related to project master.
- Planned activity per project and item, which consists of Work schedule; Item costing; and Costing.

9.2.5.3 Process (□)
The process in the functional flow includes the following.

- Generate charts, graphs and reports per project, and present it in a hard copy.

9.2.5.4 Hard Copy (□)
The hard copy in the functional flow includes the following.
• S-curve: which shows the budget of the project, calculates the budgeted at the pre-contract stage and then plots the actual budget post-contract to check the loss and profit situations.
• Material planning charts showing each activity material requirements and the cost of each activity and duration.
• Labour planning chart showing each activity labour requirements and the cost of each activity labour requirements for that activity.
• Plant planning charts showing each activity plant requirement and the cost of each activity plant requirement for that activity.
• Total activity material, labour, plant requirements and cost of that activity.
• Bill of quantity for each activity with regard to material, labour and plant for each activity.
• Specification of each activity and requirements of each activity with regard to the design and construction requirements of each activity.

9.2.6 Model inputs

9.2.6.1 Clients File

The client's file includes the following.
• Client's code.
• Client's name.
• Address.
• Telephone and fax.
• Email.
• Contact person and position.
• Index according to coding.
9.2.6.2 Project Master File
The project master file includes the following.
- Project Number. (coding).
- Client name and coding.
- Project location.
- Index of Projects according to coding.

9.2.6.3 Project Phase Master
The project phase master file includes the following.
- Phases civil (c), Electrical and Mechanical( E and F), and Finishing(F).

9.2.6.4 Specifications
The specification file includes the following.
- Activity (item Number.) Coding.
- Full Specification of the activity.
- Index of activity specifications according to coding of activities.

9.2.6.5 Planning and Costing
The planning and costing file includes the following.
- Project Number.
- Client name.
- Phase Number.
- Item (activity) Number.
- Full specification of activity.
- Duration of activity.
- Starting date of activity.
- Completion date of activity.
• Quantity of activity.
• Material, labour and plant rates of the activity
• Total cost of activity.
• Value engineers for the activity.
• Index of activities by Project Number.
• Phase Number and activity Number.

9.2.6.6 Project Reports and Charts

The project reports and charts file includes the following.
• Project Number.
• Project name.
• Client code.
• Project location.
• Index of all products by Project Number.

9.2.7 Model outputs

9.2.7.1 Project Planning Bar Chart

The project planning bar chart includes the following.
• Activity name.
• Duration (from/to).
• Days.
• Bar chart.

9.2.7.2 Material Planning Chart

The material planning chart includes the following.
• Activity name
• Quantity of the activity.
• Cost of the activity.
- Total cost of all activities.
- Bar chart for activity material.
- Requirements in chart.

9.2.7.3 Labour Planning Chart

The labour planning chart includes the following.

- Activity name.
- Number of labourers for the activity.
- Cost of labour for each activity.
- Bar chart for activity.
- Labour requirements in chart.
- Total cost of labourers for all activities.

9.2.7.4 Plant Planning Chart

The plant-planning chart includes the following.

- Activity name.
- Number of plants.
- Cost of plant for each activity.
- Bar chart for activity plant.
- Requirement in chart.
- Total cost of plants for all activities.

9.2.7.5 Cumulative Budget Chart for all Materials, Labourers and Plant for each activity

The cumulative budget chart for all materials, labourers and plant for each activity includes the following.

- Activity name
- Total cost of each activity (Material; Plant and Labour)
• Bar chart for activity (Material; Plant and Labour)
• Requirements in chart
• Total cost of all activities (Material; Plant and Labour) for all activities

9.2.7.6 S-Curve (Cumulative Budget Cost)
The S-curve (cumulative budget cost) includes the following.
• Total cost of activities in each month, for the whole duration of the project as an S-Curve relating time to cost, cumulative.

9.2.7.7 Bill of Quantities
The bill of quantity includes the following.
• Project Number.
• Project name.
• Item.
• Activity.
• Specification.
• Quantity.
• Material rate, labour rate and plant rate.
• Total activity cost.
• Total cost of all activities cumulated.

9.2.7.8 Specifications
The specification file includes the following.
• Project Number.
• Project name.
• Item (activity) code.
• Name of activity.
• Specification of activity.
• List of all activities in the project.

9.2.7.9 Material Budget Graph Chart

The material budget graph chart includes the following.
• Project Number.
• Project name.
• Client name.
• Total budget needed for each activity per month, for the whole duration of the project, relating time to cost, not cumulative.

9.2.7.10 Labour Budget Graph Chart

The labour budget graph chart includes the following.
• Project Number.
• Project name.
• Client name.
• Total budget needed for each activity per month, for the whole duration of the project, relating time to cost, not cumulative.

9.2.7.11 Plant Budget Graph Chart

The plant budget graph chart includes the following.
• Project Number.
• Project name.
• Client name.
• Total budget needed for each activity per month, for the whole duration of the project, relating time to cost, not cumulative.
9.2.8 Model testing

The model had to be tested to prove its efficiency as a dynamic model, and prove that the aim and objectives set prior to the development and formation of the model are met after the completion of the model. Also to prove that "PROMANSYS" is different than other packages in its performance, productivity, inputs and outputs of the model.

A case study project designed specially for the testing of the model, the case study project comprised of a bedroom, a dressing area and a "bathroom". The area of the project is 36m², 6m wide by 6m long, and the height of the structure is 3.0m. the structure design of the project is done on a strip footing with load-bearing walls, pre-cast slabs for the roof, plastered and painted walls.

The data shown on the case study drawings were used to test "PROMANSYS" through the following activities: excavation; foundation; block work; pre-cast slabs; plastering; electrical; plumbing; painting; tile work; gypsum ceiling works; and aluminium works.

These twelve activities are used to test the proposed dynamic model "PROMANSYS" with regard to specification writing; bill of quantities; project planning bar chart; material planning chart; labour planning chart; plant planning chart; cumulative budget chart for material, labours and plant; S-curve chart; individual material, labours and plant budget graph.

The case study complete drawings with details and results of the test are shown in printout format in Appendix E.
9.2.9 Model screens

9.2.9.1 Login password

To maintain security and protect the system from unauthorized utilization, the system provides a log on screen to enter User Name and Password for the system to validate.
With valid user code and password, the System Menu will be displayed with the following functionalities.

- **Client File**, to maintain client details
- **Project Master**, to allocate and maintain project code, project name and its owner or client code.
- **Project Phase**, to organize the project into major work phases such as Mechanical, Civil, Electrical and finishing.
- **Specification**, to standardize and register quality specifications of jobs.
- **Planning and Costing**, to enter and maintain planned activities of each project in relation to its project plans, items, its schedule and quantities.
- **Reports and Charts**, support module to generate reports and charts required for the project management.
- **Sign Off**, an exit command to quit the system.
9.2.9.3 Customer master

The display form as shown is divided into three parts.

a. the relevant information or data of the client or customer;

b. the list box, where the user can choose the client record; and

c. the command boxes in the bottom of the form to select the option available such as New, Delete.

To edit and correct a record, point to the required field and correct the information. The system enables the user to point and click on the save command to implement the change.
9.2.9.4 Project master file

Similar to Client form, the above Project Master form comprises of three parts:

a. the project, project name, client and location;

b. the list box of active project; and

c. command boxes to select the option required by the user.

To edit and correct a record, point to the required field and correct the information. The system enables the user to point and click on the save command to implement the change.
9.2.9.5 Project phase master

Similar to Client form, the above Project Phase Master form comprises of three parts

a. The phase description;

b. The list box to active project phases; and

c. The command box to select the option required by the user.
9.2.9.6 General work, material and budget item

General Work, Material and Budget Item form is similar to other forms except in the characteristics of the specification entry box, where multi-line on memo field entries are accepted by the system. The Project Item Query List Box allows the user to scroll, browse and select the project items in relation to its Standard Specification Material Labour and Plant Hire Budget Rate.

The save command is used to edit and correct the system. To add a new item the user should fill the project item query list box followed by the specification part, it is then saved by the save command.
9.2.9.7 Planed activity and work details

Based on General Works Material and Budget Items form, the Planned Activity and Work Details is activated by incorporating each item to the budgeted or planned project activities.

The Query List Box displays the budgeted items by project code, project phase, and project items.

Once selected or scrolled, the details of the project item is displayed with its relevant master information, project, client, phase, item and the budgeted values for material, labour, plant, subcontractor and other expense headings.

The user should:

- click SAVE for editing and changing; and
- click NEW to add a new item.
9.2.9.8 Project Wise Query and Reports

Project Wise Query and Reports. The above form allows the user to choose a project and generate the required reports in sequence as displayed.
9.2.10 PROMANSYS as an information system

The proposed dynamic model "PROMANSYS" uses and implements most of the construction industry documentations. It creates an environment of information flow between the projects team member in all aspects and fields of the project information. The system receives the information entered by the project's team members and designers. It allows them to have the information used and processed in many ways, retrieves the information at any time and then presents it in a professional manner, with the ability of the information being stored and continuously improved.

"PROMANSYS" gathers most of the construction industry documentations in one information system as the sole tool of communication to be used by the project team members. The architect, structural, mechanical and electrical engineer enter specifications on the specification page. The quantity surveyors enter each activity quantity, material, plant and labour rates. The planning engineer enters the duration of each activity and allocates the resources needed for each activity. These informations are all processed in "PROMANSYS" as an information system then presented in a well documented manner in the form of specifications manual, bill of quantity sheets, activity planning charts, material, plant and labour control charts, and ash flow charts.

"PROMANSYS" makes the decision making process easier and more effective for the management in all stages of the projects, either at the pre-contract or post-contract stage. A culture is created when "PROMANSYS" as an information system is used where it provides a sharing environment of information to the management and users of the dynamic model. A sense and feeling of the quality level is shared and approved by all members. Achieving the aim and objectives of the project enable it to become easier and quicker without any waste of time or money.
For any information system to survive it must have the ability to be improved, "PROMANSYS" has the ability to be continuously improved through its master data library. The user can easily introduce any new material, techniques, methods and tools used in the construction industry. The data can be updated and improved at any stage even during the construction of the project. The presentation of the documentation can also be improved to cope with any development improvement in managerial skills and project requirements.

9.2.11 Model validation, questionnaire, results and analysis

The model was validated to establish its competitiveness to other packages, and assess the models new features and techniques. There were certain elements that had to be tested in the model to prove these points, such as: Is it easy to use? Is it fast in production time? Is it useful to the industry? Does it implement TQM? Is it well documented? A questionnaire was prepared following the guidelines in Chapter Two.

The case study project structure had a size of 6.0m X 6.0m with a height of 3.0m, comprising of a bedroom, dressing area and a bathroom. The project had: excavation works; foundations work; block works; pre-cast slabs; plastering; electrical works; plumbing works; painting works; gypsum ceiling work; and aluminium works.

The case study data were fed into the model and presented the model with its input, output and the model characteristics to five architects and five civil engineers, totalling a sample of ten people. Then the questionnaire was given to the architects and engineers to complete and provide feedback. A thorough discussion took place before the presentation and after. The purpose of the discussion was to give some information on TQM to those who had no knowledge of TQM, and to describe the purpose of the research and its aim and objectives.
The following tables, figures, and analysis reflect the outcome of the questionnaire's answers. A Copy of the dynamic model validation questionnaire is show in Appendix D.

9.2.11.1 Q1: Is the package easy to use?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier to use than other packages</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Similar to other packages</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Difficult to use</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

The majority of the response fifty percent in favour of the first answer was that the package was easier to use than other packages. Even though forty percent of responses were that the model is similar to other packages in the ease of use, and not less than other packages, ten percent of the answers did not know the difference as they had no experience of the construction industry packages. It was very important to conclude from the answers of this question that the package is easy to use, otherwise the benefits that could be obtained for the use of "PROMAN SYS" will be short lived and the objectives of implementing TQM will collapse.

9.2.11.2 Q2: What is the data production time?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow data production time</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Normal production time</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Fast production time</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The responses to this question were divided into answers fifty percent each. Fifty percent of the responses agreed that the model has a fast production time and the other fifty percent agreed that the production time of the model is the same as other packages but definitely not slower. The entries of the data and information in PROMANSYS are either from the stored library such as the specifications of the activities and the building material, labour and plant rates. The design team of the project gives the rest of the information. The efficiency of the model is that at the same time the data are entered, it is immediately processed and presented in reports and charts on other screens of the model.

9.2.11.3 Q3: What is the cost of the package with regard to human resources and material use?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheaper to use than other packages</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Normal to use to other packages</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>More Expensive to use than other packages</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>2</td>
<td>20</td>
</tr>
</tbody>
</table>

The majority fifty percent agreed that due to the fact that the model is getting everybody in the design team working with one tool, therefore there is less time wasted by working individually. The risk of errors is less, thus, there is no duplication of work and no redoing. Thirty percent of the answers agreed that the model is normal in its cost with regard to human resources and material use compared to other packages in the construction industry. Twenty percent of the
responses did not know the difference, as they do not have any experience with regard to cost of human resources and material use in other packages. All agreed that the model is not expensive to use and operate.

9.2.11.4 Q4: How useful is the package to the construction industry?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful to the construction industry</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Similar to other packages in the industry</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Useless to the industry</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The confidence in the model will reflect on its usefulness to the industry. The majority ninety percent of the responses agreed that the "PROMANSYS" model would be useful to the construction industry. This large percentage reflects the facility and features the model has and what impact and advantages it will bring as a tool to implement TQM and as an information system to the industry. All the advantages presented in the model are concluded in the agreement of the first answer with a rate of ninety percent of the responses.

9.2.11.5 Q5: What is the learning time of the package?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short time to learn</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Normal time to learn</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Long time to learn</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
In order for the model to be successful it has to be learnt in relatively a short time. The user will not be happy to go through long training hours, complicated procedures and long lectures on a difficult model to use. A model with these features will be short lived. Fifty percent of the answers agreed that "PROMANSYS" could be learnt in a short time, due to the ease of use of the model screens and method of inputting and outputting the data and reports. Forty percent of the answers that the learning time of "PROMANSYS" is normal. This is still an advantage to the model as long as it does not need long hours and complex procedures to learn the model and then implement it to reach its objectives.

9.2.11.6 Q6: How well is TQM is implemented in the package?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TQM is well implemented</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>Nothing new</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TQM is not well implemented</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The essence of this research is to implement TQM to the construction industry in Bahrain by developing a framework for its implementation to TQM. "PROMANSYS" was the tool and system to implement TQM throughout the construction industry. Therefore, it was important to have feedback from the respondents that the "PROMANSYS" model actually implements TQM well and that it succeeded in using the elements of TQM (teamwork, effective communication, creation of culture and continues improvement). Eighty percent of the answers agreed that TQM is well implemented in the model. This was an achievement in itself to consider that "PROMANSYS" is a TQM tool. Twenty percent of the answers did not agree that TQM is well implemented. This is to the fact that not everybody has knowledge of TQM. An introduction of TQM was given.
to keep the respondents informed about its tools, techniques, principles and objectives before the presentation.

9.2.11.7 Q7: Will the package improve quality?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will not improve quality</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No change in quality</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very much will improve quality</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

The purpose of this question was to give a chance to those who did not know what TQM is and could not answer Question 6, at least they would know what quality is, and whether it is reflected in the model or not. Fortunately, the rate of responses was very close, eighty percent to TQM in Question 6 and ninety percent to this question. Which proves that TQM is implemented and the quality is actually improved by using "PROMANSYS" in the construction industry. Again ten percent did not know whether quality would be improved or not due to the fact that they lack knowledge of TQM. Full analysis is given in chapter six for the awareness of TQM in the construction industry in Bahrain.

9.2.11.8 Q8: How well is the package documented?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not much documented</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>No change in documentation</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Well documented</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The project management in any project is interested in good documentation for any project to maintain the quality standard, the budget of the project and duration to handover of the project. Any model is successful with the correct method of presenting its data, charts and reports. The better it is presented, the more the project management is effective. The majority sixty percent of the answers agreed that the model is well documented. The final reports given in the model such as specification manual and bill of quantities are presented in a different way to the traditional method of presentation. The specification and BoQ thirty percent of the answers agreed that the documentation given by "PROMANSYS" is not different to other packages. Ten percent did not think that the model was well documented.

9.2.11.9 Q9: Is the software similar to other software?

<table>
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<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Don't know</td>
<td>2</td>
<td>20</td>
</tr>
</tbody>
</table>

One of the important aspects of proposing the dynamic model is that it is not just a repeated model, like any other models in the construction industry. The challenge in the preparation and proposing "PROMANSYS" model was to implement TQM, be competitive, easy to use, fast and useful to the industry compared to other packages. Fortunately the responses sixty percent agreed that the model is not similar to other packages. This may be due to the fact that it has planning control charts and, resource charts similar to other packages. But the fact remain that "PROMANSYS" is a specification-based software with bill quantities and then control charts implementing TQM, and not just control charts and graphs.
9.2.11.10 Q.10: Does it improve specification writing?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

Specification writing is the essence of “PROMANSYS” where a master specification is created and continuously improved for the library of the model. Poor specification is a source of many problems and conflicts in the construction industry, it is the tool that every team member of the project uses to maintain quality, methods of forming and materials selected for the project. That is why the dynamic model had to choose specification to implement TQM to the industry and improve its performance. All of the respondents hundred percent agreed that the model would improve specification in the construction industry. There was no doubt, from the presentation given that the input and output have shown that the model will definitely improve the method of specification writing and implementation of TQM.

9.2.11.11 Q11: Will the package reduce errors?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will reduce errors</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>No change</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Will not reduce errors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

One of the objectives of improving the method of writing specification was to reduce errors in writing the specification in the construction industry. Reduction of errors
means reduction of conflicts, less time and money wasted in variation and disputes. Again, all respondents agreed that the model would actually reduce errors in the construction industry. This is another success for the “PROMANSYS” model due to clarity of the information provided in the model and the ease of retrieving and processing the data in the input and output stages of the model. The detailed reports, charts and graphs given in the model will help manage the project in a smooth way without misunderstandings in the method of presentation or technical language of the model.

9.2.11.12 Q12: Could the package be improved continuously?

<table>
<thead>
<tr>
<th>Answers</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could be improved continuously</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Limited improvement</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not possible to be improved</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

One of the TQM elements is that continuous improvement is implemented in the system in-hand. Any model if it is to survive in the competitive market must have the ability to continuously make proper improvements to the system; otherwise the system will be short lived. "PROMANSYS" has the ability to be improved in many aspects, the library of master specification, building rates, the introduction of new techniques, materials and systems in the construction industry and in the presentation method and techniques of the reports, charts and graphs. Ninety percent of the answers agreed that the model could be improved continuously. This was a great success for the model with regard to the implementation of TQM and to its competitiveness with other packages in the construction industry.
9.3 Summary

Project Management System (PROMANSYS) is a computerised information system based on specification writing techniques, with budget control, material control, planning control and a reporting system for the construction industry implementing TQM.

The design of the system interprets the stages the project will undergo as functional modules referred to as functions that capture, maintain and generate the following.

- the client and project master details;
- standard of projects phases, specifications and costing;
- project scheduling, planning and quantities; and
- reports, charts and graphs.

"PROMANSYS" is a customised system under the Windows operating system, the design of the system satisfies the actual user's requirements and provides the Standards of Graphical User Interface (GUI) the characteristics of the "PROMANSYS" model can be summarised as follows.

- ease of use;
- speed and responsiveness;
- size and compactness;
- maintainability;
- packaging; and
- Web-based model.

Project management system functional flow and data file hierarchy comprising of inputs, process and outputs.
The inputs are.

- client and project master file;
- activities and phases;
- specifications;
- material quantities labour and plants rates;
- date starting and date ending of the activities; and
- value engineering techniques.

The outputs are.

- specification manual;
- bill of quantities;
- planning control charts;
- material labour, and plant control and budget charts;
- S-curve and cash flow charts; and
- creation of specification master and building rates master.

"PROMANSYS" as an information system is the only tool of communication to be used by the management for effective decision making, where all the projects documentation are presented well in the system such as, manual specification, bill of quantities, planning, material plants, labour and cash flow charts.

For any information system to survive it must have the ability to be improved otherwise it will be short lived. "PROMANSYS" has the ability to be continuously improved through its master data library. The user can easily introduce any new material, techniques, methods and tools used in the construction industry.
The PROMANSYS model is validated by presentation and questionnaire. The overall results of the validations proved that the model has the following qualities.

- ease of use;
- has reasonable production time;
- is cheaper to use than other packages;
- useful to the construction industry;
- has short time to learn;
- TQM is well implemented in the model;
- will greatly improve quality;
- well documented;
- not similar to other packages;
- the model improves specification writing;
- the package will reduce errors; and
- the package can be continuously improved.

This chapter links all chapters together, as the outcomes of the literature reviews; the data collected; the analysis and discussions, all pool in the proposed dynamic model "PROMANMSYS" to form the framework for implementing TQM to the construction industry through specifications.
CHAPTER TEN

DISCUSSION: THE IMPLEMENTATION OF TQM TO THE CONSTRUCTION SPECIFICATION USING THE DYNAMIC MODEL
CHAPTER TEN

DISCUSSION: THE IMPLEMENTATION OF TQM TO THE CONSTRUCTION SPECIFICATION USING THE DYNAMIC MODEL

10.1 Introduction

The method of writing specifications has not improved much over the years, definitely not at the same pace of other fields in design and construction software packages such as AutoCAD (Computer aided Design) in architecture and the design and analysis packages in the structured engineering fields.

"PROMANSYS" the proposed dynamic model in this research takes the method of writing specifications a step ahead through the implementation of TQM, introducing teamwork, creating a culture, improving communication, implementing value engineering and providing a continuous improvement to the system.

Many organisations trying to create a new philosophy based on teamwork fail to recognise that the employees do not know which teams to form, or how they should function as teams. People's behaviour is determined largely by the roles they have to play. A new situation will develop which will change the culture when the management create new responsibilities, team roles and a process driven environment. In "PROMANSYS", as a tool to implement TQM, the project manager will take the leadership to ensure distribution of responsibilities, team roles, tasks and coordinate between all team member to create a teamwork spirit and create a new culture with all members of the team sharing the same aims, objectives, values and beliefs to the benefit of the project in hand.
In this chapter, the implementation of TQM through the dynamic model is discussed along with an explanation of the concept of teamwork, culture, communication, value engineering, and continuous improvement. How to achieve TQM through "PROMANSYS" is also discussed, by getting all the project team members working together through one tool “PROMANSYS” at the pre-contract and post-contract stages of the project.

10.2 Introducing teamwork

10.2.1 Teamwork
Total quality is achieved through teamwork when a group of individuals work together to achieve a shared aim to the benefit of all parties connected with the project. Teamwork can apply to specific project activities and specific groups of people or to a whole range of processes and activities in the project. Most large projects will contain many teams, involving the customer, constructor, subcontractor and suppliers. Teams will be established both on and off site and will involve all categories of project staff ECI (1996).

10.2.2 Benefits of teamwork
The benefits of teamwork are as follow.

- better solutions through the pooling of ideas and knowledge;
- cooperation, so less time wasted in non-productive conflict;
- more commitment by members or decisions made by the team;
- even distribution of work, responsibilities, effort and stress; and
- more productive working by utilizing the particular skills of the individuals that make up the team.

Teamwork throughout any organisation is an essential component of the implementation of TQM, for it builds trust, improves communications and
develops interdependence. The use of the face-to-face interaction method of communication with a common goal develops over time the sense of dependence on each other. This forms a key part of any quality improvement process and provides a methodology to employ recognition and participation, through active encouragement in-group activities. Teamwork provides an environment in which people can grow and use all the resources effectively and efficiently to make continuous improvement. As individuals grow, the organisation grows.

**Figure 10.1: Independence to inter-independence through teamwork**

Source: John Oakland 1995
10.2.3 The Need for teamwork

Oakland (1995) stated that the complexity of most processes that are operated in industry, commerce and the services, places them beyond the control of any one individual. The only efficient way to tackle process improvement or problems is through the use of some form of teamwork. The use of the teamwork approach to problem solving has many advantages over allowing individuals to work separately. These advantages include the following.

- A greater variety of complex problems may be tackled - those beyond the capability of any one individual or even one department by the pooling of expertise and resources.
- Problems are exposed to a greater diversity of knowledge, skill, experience, and are solved more efficiently.
- The approach is more satisfying to team members, and boosts morale and ownership through participation in problem solving and decision-making.
- Problems that cross-departmental or functional boundaries can be dealt with more easily, and the potential/actual conflicts are more likely to be identified and solved.
- The recommendations are more likely to be implemented than individual suggestions, as the quality of decision-making in good teams is high.

10.2.4 Setting up a team

Getting the right team is important. The ability of the team to produce results will bear testimony to how well the team was set-up. Dale and Bidden (1994) provide the characteristics of an effective team and useful guidelines to assist in building a successful team.

1. Every member is an active and willing participant.
2. The relationships are good.
3. There is trust and respect among members.
4. All ideas are welcome.
5. There is commitment to the working/principles of the team.

Guidelines to assist in building a successful team are as follows.

1. Those who will be affected by the results of the team are included in the team activity.
2. All members are aware of and educated about quality management, particularly the use of improvement tools.
3. Every person is clear about the aims and objectives of the team.
4. There is discipline and adherence to agreed rules.
5. All members should regularly attend.
6. Periodic reports to senior management should be encouraged (this will recognize the worth of the team).
7. There is regular evaluation during and after the team’s life to review what feedback can be obtained. This will be useful information to other teams.

10.2.5 Stages in team development

Tuckman and Jensen (1977) suggested that there are four stages in the development of a team.

1. Forming: aims to make everyone aware of what are required, getting people to conform and understand each other.
2. Storming: is the stage where conflict is likely. This conflict has to be dealt with in order to make any progress.
3. Norming: is where the group will start to gel, and cooperation will occur, the team will start to display confidence, trust each other, have clarification...
about their purpose, an ability to think about problem solving, and consideration of how improvements can be achieved.

4. Performing: is the stage where productivity is characterized by flexibility, leadership decided by situation not by protocol, everyone's energies utilized, and basic principles and social aspects of the organisation's decisions considered.

10.2.6 Leadership and teamwork

John Adair (1987) developed a model for teamwork and leadership, Adair brought out clearly that for any group or team, big or small, to respond to leadership, they need a clearly defined task, and the response and achievement of that task are interrelated to the needs of the team and the separate needs of the individual members of the team. The value of the overlapping circles is that it emphasises the unity of leadership and the interdependence and multifunctional reaction to single decisions affecting any of the three areas.

![Adair's Model](image)

**Figure 10.2: Adair's Model**

*Source: John Oakland, 1995*
10.2.7 Implementing teamwork for quality improvement—the ‘DRIVE’ model

John Oakland (1995) developed a model for a structured approach to problem solving in teams, the DRIVE model. It provides landmarks to help the team on track and in the right direction, the model comprises the following four steps.

Define: The problem—output: written definition of the task and its Success criteria.

Review: The information—output: presentation of known data and Action plan for further data.

Investigate: The problem—output: documented proposals for Improvement and action plan.

Verify: The solution—output: proposed improvements that meet Success criteria.

Execute: The change—output: task achieved and improved process Documented.

Latham (1994) stated in the Constructing the Team Report, that “Teamwork cannot be achieved unless all sections of the process are committed to it”. Which must include the following.

1. Clients, who vary in their interest. Some, including some government departments, display no discernible interest in subcontractors. Other clients take an intense interest in all participants on and off site.
2. Consultants, on whatever basis they are retained and under whatever procurement route, especially as they often seek to transfer responsibility for detailed design to specialists.

3. Main constructors, whose role in pulling together the performance of the contract is crucial. Some have argued that main constructors no longer have a necessary role in the modern construction industry or even that their influence is malign. They remain the most effective mobilisers and coordinators of resources. They are responsible for the smooth running of the whole site throughout its operation, and for the performance and quality of the work of all their domestic subcontractors.

4. Specialist/trade constructors, many of whom (particularly specialists) also employ sub-sub constructors. Some are of the smallest sub-constructors, including those at the very end of the construction process such as landscape companies.

10.3 Teamwork in the proposed dynamic model for TQM

The PROMANSYS dynamic model provides a framework for implementing TQM (Teamwork) in both stages of pre-contract and post-contract of any project. The two stages are discussed as follow.

10.3.1 Pre-contract stage

1. Project engineer

   A team leader is appointed by the client and leads a large number of architects, engineers and technicians. The following team members are all required to pool their knowledge, expertise and information in the dynamic mode to complete it, to give the desired reports, charts and data as mentioned in Chapter Nine.
2. Client
The client will provide the project manager with the design brief and requirements to the design of the project, his vision, budget limits, size of project and the standard quality as the main issue and input from his side will find a benchmark for all team members to establish and always refer to, when each member submits his input of information to the project.

3. Architect
In "PROMANSYS" the architect will be responsible for providing all the information required to complete the specifications data required with regards to the use of finishing materials, sizes, colours, brands and shapes to reach the design requirements, functionalities, appearance and economy.

4. Civil engineer
Inputs in the specifications of the project all the structural design requirements to complete the structural drawings, and the construction requirements. All information related to type of soil, depth of excavation, bearing capacity of the soil, methods of supervision and specification with regard to building materials and processes.

5. Electrical engineer
Part of the specification requirements is the electrical design, materials and methods standards and criteria requirements to the project main design, with regard to writing, conducting, electrical loading and connections.

6. Mechanical engineer
The mechanical design is only completed by providing the technical specifications in the specifications writings of the project, with regard to
plumbing works, air conditioning, lift requirement, fire fighting, escalators and other mechanical works related to the project.

7. Material engineer
The material engineer gives the type of material, the time needed of those materials and the technical information of the materials required for the project, with the method of testing and custody of the material at site. The selection of the material and methods of testing are done in cooperation with the architect of the project.

8. Quantity surveyor
The rates, prices and all costs related to the budget of the project with the quantities of all related activities of the project are set, processed and controlled by the quantity surveyor. The data are input in the "PROMANSYS" after finishing all the specifications writing of each activity. The bill of all the quantities of the materials of the project are only obtained after the quantity surveyor has finished the input of his data in the "PROMANSYS."

9. Planning engineer
In the parallel line with the specifications writing and quantity surveyor work, the planning engineer provides all the information regarding the activity duration and the relations between the activities of all the project, with the allocation of human resources of each activity and plant requirements. The duration of the project is obtained after putting all the data of the planning engineer. The quantity surveyor uses the planning engineer to relate the cost of material requirements of each activity that the human resources and plant requires to achieve the total budget of the project.
10. Value engineer

After all the information and data are given by the architect, engineers and quantity surveyor, (with regard to material selection, cost and methods), the value engineer scrolls through all pages of the specifications activity by activity, studying and judging the requirements of each activity. The value engineer proposes new material, with new costs and new methods as alternatives to the ones selected earlier aiming to reduce the cost of the project, reduce the time needed to finish the project and give a long life cycle to all the materials selected to the project. Minimising the maintenance cost and giving more durability, better functionality with less cost, without affecting the quality standards and requirements of the project.

All these team members must have an input at one stage or another to the information required for the dynamic model. The project manager is the facilitator or team leader who will be in charge of putting the client's objectives and requirements into action and achieve them to the standard expected from the client through the team members.

10.3.2 Post-contract stage

The project manager will use all the data given by the team members in the "PROMANSYS," through the reports, charts and graphs given as an output of the project planning and control tools. Charts such as the planning chart (Gant Chart) or bar chart of all the activities and duration are used at the site to monitor and control the activities to avoid any delay. Human resources and plants are used to allocate labourers to the activities and plants for each activity to achieve teamwork at any stage of the project maintaining team spirit and effort.
The cash flow of the project is monitored through the S-Curve and planning budget charts to control the budget of the project and keep it within the allowed limits to reduce any losses in the project.

All these tools (charts, reports and graphs) are all produced through "PROMANSYS" to get the team members of the project sitting together around a table and working together as one team with real team spirit monitoring, controlling and achieving the quality of the project keeping TQM as the main target objective of the project. All these efforts are reflected in the projects in all aspects of design, construction, project's budget and quality.

The benefits of teamwork are achieved when all the team members are working under the project manager (team leader) through the "PROMANSYS" model as the main input tool of an individual project for all the team members. Achieving better solutions through the pooling of ideas, knowledge and cooperation, (so less time is wasted in non-productive conflict), commitment by the team members, even distribution of work, responsibilities, effort and stress, and more productive working by utilising the particular skills of the individuals makes up the team.

10.4 Creating a culture

Creating a TQM culture within an organisation is one of the biggest challenges of a TQM programme. An organisation's survival may depend on how it adapts its culture to a rapidly changing business environment, and to the demand of its customers.

Culture derives from people's belief and ideas, and in turn this determines their attitudes and behaviours. In TQM, cultural attitudes are of paramount importance and should characterise everybody involved in the construction project, from the project director through to each member of the workforce ECI (1996).
ECI (1996) described the attitudes to be fostered, which include: customer focus, empowerment, knowledge sharing, and no blame, as discussed below.

- **Customer focus:** The customer's needs are met as far as contractual and commercial realities will allow; satisfying the customer is a primary objective in everything done on the project; there is a non-adversarial approach to problem solving. There are both internal as well as external customers. This means that those people that are provided with a service in the organisation should be regarded as customers.

- **Empowerment:** Each member of the project work force is empowered to be responsible and accountable for their own actions and is encouraged by management to use their skills, knowledge and creative talents to the full for the benefit of the project as a whole.

- **Knowledge sharing:** Everybody actively and generously communicates and shares knowledge and information with all other relevant parties on the project.

- **No Blame:** There is no blame. Open, honest attitude to errors and mistakes with a view to swift correction and avoidance of blame. There is recognition that when mistakes occur, scapegoats should not be sought and the management has a responsibility to the workforce to examine what changes may be needed in working processes to avoid re-occurrence.

Distinctive cultural attitudes often exist on sites, where the workforce has a large transitory component. Special care needs to be taken to develop a TQ culture that bridges, not reinforces, the divide between head office and site.
10.4.1 Definition of a culture

Culture is a social construction: The elements of culture, such as values, benefits, and understanding are held in common by all group members.

Bounds, Yorks, Adams and Ranney (1994) defined culture as follows. “Culture as a pattern of artefacts, behaviours, values, beliefs and assumptions that a group develops as it learns to cope with internal and external problems of survival and prosperity”.

Peter and Waterman (1982) provided a list of seven basic values that are found in the best American Companies. These two management writers present corporate culture as a recipe for success in which quality is one of the seven essential beliefs. These basic values are defined as follows.

1. A belief in being the ‘best’.
2. A belief in the importance of the details of execution, the nuts and bolts of doing the job well.
3. A belief in the importance of people as individuals.
4. A belief in superior quality and service.
5. A belief that most members of the organisation should be innovators, and its corollary, the willingness to support failure.
6. A belief in the importance of informality to enhance communication.
7. Explicit belief in, and recognition of, the importance of economic growth and profits.
10.5 Culture in the proposed dynamic model for TQM

"PROMANSYS" unites all members of the project as the one and only tool for the project, which is the dynamic model, where every member of the design and construction teams has the same objectives to be achieved, resulting in unified values, benefits and understanding.

It is mainly the duty of the project manager to get everybody thinking and behaving in the same way since the team unites and works for this project and to the duration of the project only. This is if the team members are not all from the same organisations, but from many different firms. The job of creating a culture is much easier if all the team members are all from the same firm and under the supervision of the same project manager for many projects previously undertaken. The situation would be more difficult to create a culture if the team members are from different firms, where the project manager will use the client’s briefs, aims and objectives of the project and formulate them into certain beliefs, ideas, values and understanding to create a social environment to all team members to work on the same wavelength.

"PROMANSYS" will greatly help to create that culture, and the project manager would find it a very helpful tool to get everybody working on the same model uniting all members to the same beliefs, benefits, values and objectives.

Creating a culture usually takes a long time if the team members of the project do not share the same beliefs, common objectives and values. Using "PROMANSYS" repetitively for many different projects will shorten the duration needed to create the desired culture. The more "PROMANSYS" is used the more the project members get to the point where the aims benefits and ideas of the project are met.
The project members when working with the same beliefs and values, will share certain essential beliefs and basics such as, the importance of the details of the execution when doing the job, superior quality and services, the importance of informality to enhance communication, the importance of people as individuals, recognition of the importance of economic growth and profits and believing in being the best.

10.6 Improving communication

Effective communication of information for all activities and at all levels is vital for a construction project. Considering the amount of information (drawings, specifications, procedures, contract details), and also the number of interfaces (client – constructors - supplier, design - construction - commissioning, manager - foreman-worker) that typify the industry with up to twenty five percent of man-hours being spent exchanging information (meetings, conversations, instructions, reports) effective communication is the key. Information must be clear, complete and accurate, conveyed concisely and in understandable language (ECI, 1996).

![Effective communication channels](source: ECI (1996))

Figure 9.3 shows that effective communication must be up, down and across the project organisation; including design, manufacturing and site. Communication in the construction industry can be viewed from the following three aspects.
- Firstly: as a means of gathering information to certain needs of the employer and architect.

- Secondly: as a necessary tool of management to integrate the functions of departments and specialist sections within an organisation.

- Thirdly: as a vital link between manager and subordinate to get the job done using person-to-person communication.

10.6.1 Communication principle

Communication can be defined as the act of passing information Davis (1982). The act of passing information can be used to transfer ideas, relay instructions, give orders, tender advice and explain facts.

The first requirement of effective communication is that, what is intended is understood. Secondly, that the understanding should induce the action which was the objective of the communication. Thirdly, the lines of communication should be as short as possible and simplified.

Effective communications should initially require a purpose or objective for the transferring of information. The information to be transferred should be properly prepared and in the most suitable form to suit the receiver.

10.6.2 Barriers to communication

Rosemary Stewart (1979) describes the barriers to downward, upward and horizontal communication. Difficulties in downward communication can arise from misunderstanding. The manager should realize that what he is saying is often
misunderstood, due to a different use of language or use of technical jargon, especially when people have different backgrounds.

The other barrier in downward communication is caused by distrust, often leading to a wrong interpretation of what is said where there is an atmosphere of suspicion, and even the simplest remark and the most straightforward instruction will be examined for hidden meanings.

The barrier to upward communication is the lack of opportunities, either formal or informal, for employees to say what they are thinking and feeling. The management, when it wishes to explain its views and policies, does so via notice boards, letters and special meetings. Workers often have only their union, which may confine itself to wage claims and grievances.

Difficulties in horizontal communication arise from poor coordination and cooperation between the departments of the organisation. Top management should therefore try to encourage communication between departments at all levels by the use of interdepartmental committees. It can also try and foster informal contact by giving managers opportunities to get to know those in other parts of the business.

10.6.3 Open communication

The proposed dynamic model in this thesis is a good example for open communication.

Open communication is a necessity for an effective management improvement process. The job-site management teams must be able to clearly communicate their needs and concerns throughout the project from design to construction. All related project information must be available to all team members on an immediate basis to
allow decisions to be made promptly, particularly when these decisions can impact overall project quality.

Methods of effective open communication among team member include using project-computerised database. This allows all team members to access all related project information, instructions, correspondence, submittal information, and other project data whenever required. Paper trials are eliminated and owners can receive an entire project's archives on a disk for use as necessary in the future.

10.6.4 TQM and communication

TQM will significantly change the way many organisations operate. This change will require direct and clear communication from the top management to all staff and employees, to explain the need to focus on processes. Everyone will need to know their roles in understanding processes and improving their performance.

Whether a strategy is developed by top management for the direction of the organisation as a whole, or specifically for the introduction of TQM, is only half the battle. An early implementation step must be the clear widespread communication of the strategy. An excellent way to accomplish this first step is to issue a total quality message that clearly states top management's commitment to TQM and outlines the role everyone must play.

TQM will clearly have a profound effect on all tasks, activities, and processes throughout the organisation. It should change management style and integrate the process input of information, people, machines and materials. One aspect of the communication process worthy of particular attention is that between departments or functions.
The language used between departmental or functional groups will need attention in many organisations. Reducing the complexity and jargon in written and spoken communications will facilitate comprehension. When written business communications cannot be read or understood easily, they receive only cursory glances, rather than the detailed study they require. Simplicity and briefness must be the guiding principles Oakland (1995).

All levels of management should introduce and stress 'open' methods of communication, by maintaining open offices, being accessible to staff and employees and taking part in day-to-day interactions and the detailed processes. This will lay the foundation for improved interactions between staff and employees, which is essential for information flow and process improvement.

Opening up lines of communication through a previously closed system will aid the process. Change can be exciting if employees start to share this and participate by creating the most appropriate communication systems, development, growth, suggestions, and questions. Managements must encourage the key medium for motivating the employees and gaining their commitment to TQM by face-to-face communication and visible management commitment. Much is written and spoken about leadership, but its mainly involves communication. If people are good leaders, they are invariably good communicators. Leadership is a human interaction depending on the communications between the leaders and the followers Oakland (1995).

10.7 Improving communication in the proposed dynamic model for TQM

"PROMANSYS" relies on the open method of communication, where all the project team members can communicate their needs, information and data throughout the project stages from design to construction. "PROMANSYS" is the tool of
communication that holds all the strings of the project, which makes communication so effective, productive and short.

The communication barriers are almost removed in "PROMAN SYS" to avoid any misunderstanding, wrong interpretation, duplication and any unnecessary middle media.

The information in the model is open and available to all members of the project team to look at, study, and discuss through all stages of the project to achieve the best possible methods and quality standards to the benefit of the project.

TQM messages, objectives, strategies, tools and techniques are shared and unified to all the project members, who will give feedback to everybody related. The project manager will have "PROMAN SYS" as a tool to pass all the information related to the project to all the project members. An excellent way to accomplish the implementation of TQM is to issue a total quality message that clearly states top management commitment to TQM, and outlines the roles that the project members must play. This can be in the form of a quality policy of a specific statement about the objectives, aims and standards to integrate TQM into the project.

Once the project team members understand the strategy, aims, objectives and quality standard of the project with the budget allocated the project manager must establish the infrastructure. The required levels of individual commitment is only likely to be achieved if everyone understands the aims and benefits of TQM, the role they must play and how they can implement process improvements. For this understanding, a constant flow of information is necessary, including:

- when and how each member of the project will be involved;
- what the process requires; and
- the success and benefits achieved.
"PROMANSYS" can provide the project with interpersonal skills of every project member, which will be required for good and effective communication around the processes and stages of the project, to implement and obtain the best results of TQM.

10.8 Implementing value engineering

Value engineering with the aid of its tools and techniques may be applied in two stages. The first stage is during or immediately after the completion of the plans specifications and prior to their release to constructors. The second stage for value engineering study is after a contract is awarded for the construction of the project. The maximum cost savings is achieved in the first stage, where the plans of the building are modified with the use of the functional analysis techniques to concentrate on the needs and ignores the desires to give the optimum functional building system and the use of material without affecting the quality and at the lowest cost of the project.

10.8.1 Cost reduction areas when implementing value engineering

Prior to the Design Stage

During the clients briefing stage to the consultant, a figure for the project budget is given by the client and allocated to the whole project, based on the clients feasibility study at the conceptual stage. Usually, the client sets a low cost goal or budget by setting this goal, a mark is established for all team members to work toward. With this technique the design team will be committed to give a design meeting the client’s request and maintaining the quality needed for the project.
At the preliminary design

With the application of functional analysis on the plans and by adjusting, modifying, relocating and finding workable alternatives for the design, value engineering gives careful consideration to the methods and equipment that may be used to construct the project. Requirement, which increases the cost without commensurate benefits, would be eliminated. The ultimate decisions of the engineer should be based on a reasonable knowledge of construction methods and costs.

During the final design

During the final design, the client will ask the job construction management team to perform a formal value engineering evaluation on the whole design and specifications. They will look at all the plans and specifications and recommend changes to the design to save construction cost wherever reasonable. The specified quality of workmanship and methods of construction have considerable influence on the amount and class of labour required and the cost of labour. Complicated concrete structures are relatively easy to design, but they may be extremely difficult to build. A high-grade concrete finish may be justified for exposed surfaces in a fine building, but the same quality of workmanship is not justified for a warehouse. The quality of workmanship should be in keeping with the type of project.

At the tendering stage

Invitation or the nomination of the appropriate constructors is extremely important for the project, as the constructor should be capable financially and technically for the project otherwise project cost will be increased by delays, mistakes and conflicts. In addition, the timing of tendering is also a cost saving strategy, such as adjusting the timing of bids to avoid conflicts with other large projects packaging of
the construction contracts to allow the clients to obtain the lowest possible prices, partnering with construction constructors to minimise or eliminate claims and optimising environmental mitigation to perform the required mitigation in the most cost-effective manner.

**During construction**

At this stage the value engineering evaluation is made by the constructor under the direction of his own value engineer or under the direction of a professional value engineer engaged by the constructor. He is invited to submit detailed statements to the owner describing the modifications, with estimates showing the anticipated reductions in costs. A constructor, who does not keep informed on new equipment and methods, will soon discover that the competitors are under-bidding him, and will take a longer time to finish a project compared with other advanced and modern constructors.

**10.8.2 Value engineering techniques**

1. **Making a value engineering study**

A value engineering study should be made by one or more persons, who are thoroughly versed in methods of construction and the materials to be used in the project. As means of implementing the study, certain questions, such as the following should be asked regarding the project Period (1979).

1. What is its purpose?
2. What does it cost?
3. What modifications are possible?
4. What will such modifications cost?
5. What effect, if any, will the modifications have?
6. What is the time required to complete the project?
An application of each of these questions to each phase of the project may reveal that certain reductions in costs are possible without sacrificing the quality of function of the project. With the approval of the owner, these modifications can then be adopted.

2. Life-Cycle Costing (LCC)

The LCC approach is to treat design decisions as investments in building and their components. The amounts of future benefits must be established to assess costs to be made. The future benefits from the higher cost alternatives must be how much investment is justified when design alternatives at different capital are established and evaluated to justify the expense giving value of money over time.

3. Objectives in using life cycle costing

Life cycle costing provides visibility to all cost factors included in an analysis. Its broad objectives are:

- to provide a clearly defined methodical framework within which alternative solutions can be logically and fairly appraised;
- to derive the optimum economic solution to facilitate design problems from all available alternatives;
- to require design assumptions to be stated explicitly rather than intuitively;
- to provide an analytical tool that can establish the interaction between planning and design decisions and long-term costs; and
- to promote inter-disciplinary cooperation.

4. Functional analysis method

The analytical description of function has two apparently unrelated sources Kelly and Male (1993). The first can be traced to the operational research technique of
objectives hierarchies, and the second to functional analysis diagramming developed within the framework of value management.

Functional analysis diagramming is attributed to the developing techniques of value management within the manufacturing industry. The techniques have been transferred to the construction industry with mixed success. In a functional analysis the function of each component is examined in the project by asking the question 'What does it do?' In a value management exercise, the next question would be 'How else can this be achieved?' A brainstorming exercise is held and other technical solutions generated. However, once the problem is solved, one major fact should not be ignored, and that is the scale of the savings in time and money that may flow from the idea.

10.9 Implementing value engineering in the proposed dynamic model for TQM

"PROMANSYS" elevated from the level of other packages available in construction management with its performance, and especially with the introduction of Value Engineering. Value engineers can be implemented through many stages, at the preliminary design, during the final design, at the tendering stage and during construction. In "PROMANSYS" value engineering is implemented during the final design stage.

To obtain the best results of the materials used and methods of construction used in the project, value engineering must be implemented bearing in mind the Life Cycle Costing of each material and each activity and method used. To achieve TQM, value engineering must be used to analyse the designed building features, systems equipment, and material selections for the purpose of achieving essential functions at the lowest life cycle cost, consistent with required performance, quality, reliability and safety.
In "PROMANSYS" when all the materials of the project selection is finished and entered in the "specifications" entry forms and also the methods of fixing and construction selected, (with all the rates and quantities). At this stage, every member of the project will have put the information needed by them and no more entries are done in "PROMANSYS." The value engineer will look and study all the materials selected and methods used, to find alternates to the materials selected, perform the design requirements and save in construction cost wherever reasonable. Taking into consideration the Life Cycle Cost of every material used, the amount of future benefits must be established to assess how much investment is justified. When design alternatives at different capital costs are to be made, the future benefits from the higher cost alternates must be established and evaluated to justify the expense.

The value engineer will have to click on the box of value engineering in "PROMANSYS" to start changing the specifications and suggest alternatives. To enter the changes the value engineer must enter the password, so that no one else other than the value engineer will have the ability to enter and change the specifications for security reasons.

10.10 Continuous improvement

10.10.1 Objective of continuous improvements

To keep pace with the changes in the external environment, managers have to change the organisation. With rates of change increasing in the external environment, managers must improve differently and more frequently than in the past. Managers must pursue continuous improvement, which is a constant striving to change and make things better.
The objective of quality improvement is to continuously improve quality by eliminating non-conformance in every activity throughout the organisation. The benefits which can be gained from the implementation of a successful quality improvement programme are enormous: Improved customer satisfaction, elimination of error and waste; reduction in operating costs, increased motivation and commitment of employees; increased profitability and competitiveness and survival of the organisation.

10.10.2 Commitment to continuous improvement

Implementation of a quality improvement programme is not a step to be undertaken lightly. It demands absolute commitment from everyone, starting with senior management, if it is to succeed. It frequently requires a change in company culture and a radical rethink of every activity being performed in the organisation. The commitment of senior management is the most important factor in ensuring the success of the programme, and is also the most difficult to achieve. There is no easy method for achieving this commitment. It requires constant attention, persuasion and powerful evidence of the benefits that can be gained from quality improvement.

10.10.3 Principles of continuous improvement

The never-ending improvement cycle ensures that the organisation learns from results, standardises what it does well in a documented quality management system, and improves operations and outputs from which it learns. But the emphasis must be that this is done in a planned, systematic, and conscientious way to create a climate, a way of life that permeates the whole organisation Oakland (1995). There are three basic principles of never-ending improvement:

- focusing on the customer;
- understanding the process; and
all employees are committed to quality.

Focusing on the Customer
An organisation must recognise, throughout its ranks, that the purpose of all work and all efforts to make improvements is to serve the customers better. This means that it must always know how well its outputs are performing, in the eyes of the customer, through measurement and feedback. The most important customers are the external ones, but the quality chains can break down at any point in the flows of work. Internal customers therefore must also be well served if the external ones are to be satisfied.

Understanding the Process
In the successful operation of any process it is essential to understand what determines its performance and outputs. This means intense focus on the design and control of the inputs, working closely with suppliers, and understanding process flows to eliminate bottlenecks and reduce waste. It is not possible to stand aside and manage in never-ending improvement. TQM in an organisation means that everyone has the determination to use their detailed knowledge of the processes and make improvements, and use appropriate statistical methods to analyse and create action plans.

Employees are committed to quality
Everyone in the organisation, from top to bottom, from offices to technical services, from headquarters to local sites, must play their part. People are the source of ideas and innovation, and their expertise, experience, knowledge, and cooperation have to be harnessed to get those ideas implemented.

The first step is to convince everybody of their own role in total quality. Employers and managers must of course take the lead, and the most senior executive has a
personal responsibility for quality. The degree of management’s enthusiasm and drive will determine the ease with which the whole workforce is motivated.

10.10.4 Methods of achieving improvement

Steven McCabe (1998), described two areas of methods of achieving improvement and they are as follows:

- partnering;
- benchmarking; and

Partnering

An important aspect of the overall change brought about by a TQM approach is a changed relationship with suppliers. Dale, Lascelles and Lloyd (1994) provided a description of what they call “supply chain management” (another name for partnering). The concept is defined as a situation of ‘working together towards a common goal’. It leads to ‘benefit through cooperation, rather than pursuing self-interest’. The typical features are as follows.

1. Long-term contracts based on:
   - common aims, particularly to continuously improve the product or service;
   - shared desire to work together;
   - mutual trust;
   - cooperation;
   - honesty; and
   - open declaration of problems.

2. Willingness between both parties to learn more about each other. This may involve members of supplier’s and client’s organisations working at other offices or sites.
3. A constant interchange of information, including all financial matters.
4. Cooperation on the design and methods of production at the earliest opportunity.
5. Joint problem solving to achieve best practice.
6. A reduction in the size of the supplier base.

Partnering arrangements usually work better with fewer supplies. Otherwise adequate communication and a relationship built on trust cannot occur. Dale, Lacelles, and Lloyd, (1994) suggested the probable benefits of reducing the number of suppliers as being:

- less variation in product characteristics;
- more time for QA needs of vendor (buyer);
- simple and better communication with vendors;
- less paperwork; and
- less handling and inspection.

**Benchmarking**

Benchmarking is a useful part of any TQM process; it aims to identify the 'best practice' in other organisations, particularly those regarded as the best, so that 'objective comparisons' can be made with what the organisation is doing. Steven McCabe (1998) describes the three main types of benchmarking:

1. internal benchmarking;
2. competitive benchmarking; and
3. functional or generic benchmarking.
1. **Internal benchmarking**

Internal benchmarking compares all the operations within an organisation. It can be achieved in the early stages of TQM when one department, office or site has made extremely good progress. Other parts of the organisation seek to emulate this progress, and will visit the location to see what has been done, and how. Internal benchmarking seldom has problems with access, a distinct advantage.

2. **Competitive benchmarking**

This involves making a comparison with those organisations that operate in the same area or sector. As a result they are likely to be competitors. It is also called reverse engineering or tear down. This is because in the manufacturing industry, if the competitors come up with a new or radically improved product, the most obvious way to investigate is to buy one and pull it apart. This will allow seeing what components are used.

3. **Functional or generic benchmarking**

Functional or generic benchmarking is regarded as the purest form of benchmarking. It involves the comparison of a function, or indeed the whole organisation, against another organisation regarded as a superior in its field. The objective is not to copy but to be inspired. Non-competitor organisations are more likely to release information of their processes. Many organisations have provided revealing information on how they were able to achieve radical transformation. This was traditionally held as a commercial secret, guarded at all costs. This newfound freedom of access indicates that many organisations believe they are a long way ahead and they are likely to remain at the front because their improvement effort will be continuous.
10.10.5 Types of accomplishment for continuous improvement

Accomplishment for improvement (breakthrough, incrementalism, and standardisation) has been described by Bounds, York, Adams and Ranney (1994) as follows.

**Breakthrough**

Breakthrough means a big improvement in accomplished through radical departure from past practices. A breakthrough may come through creativity, when an old system is disregarded or scrapped. Creators synthesize and develop ideal systems with a clean slate. Because of this fresh approach, the creators can overcome the old prejudices, limitations, and intractable problems of existing systems. Pure creativity is probably never achieved, but just approached. In creating a new system, it is very difficult to discard the old completely and quickly, due to the new requirements of the new system, such as hardware, training and machinery and budget. Most managerial breakthrough is the result of innovation. In innovation, existing technologies, processes, or components of existing systems are recombined and re-assimilated in novel ways. The innovated system as a whole fundamentally differs from that which existed before.

**Incrementalism**

In incrementalism, small improvements are accomplished. Incrementalism may result from creativity or innovation. Often it results when existing systems are adjusted and modified by slight alterations. The accumulation of a number of relatively small incremental improvements can have a tremendous impact. Breakthrough or incremental improvements are not accomplished unless proposed changes are put in place. This requires standardisation.
Standardisation

The term "standardisation" is not limited to meaning imposed standards such as specifications, protocols, rules, and procedures, or the uniformity of materials. Standards are an important part of standardisation, but they must be considered in a broader context. In standardisation, managers verify the performance of new systems before releasing them for use. Standardisation requires the manager to transmit information about the systems' purpose and architecture, educate people who work with the systems and demonstrate that the system works as intended. The resulting standardised system displays the right strategic focus, statistical capability, and predictability for stable, on-target system performance.

Ishikawa (1985) stated "If a person determines a method, he must standardise it and move it into a regulation, and then incorporate it into the company's technology and property (the method) must be useful to everyone and free of difficulty".

10.11 Continuous improvement in the proposed dynamic model for TQM

"PROMANSYS" has the ability to improve in many aspects such as in the writing of specification, building and material rates, presentation of charts and reports and in the over all development of the whole package.

Any material that has been introduced in the market, any new method of construction and any new techniques and technology that has been introduced to the construction industry, could very easily be introduced in "PROMANSYS" library of data, also the fluctuation of prices of material in the market could also very easily be incorporated in "PROMANSYS".

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Every team member has full freedom to introduce any new material and techniques in their field, whenever it is needed. Each member is responsible to continuously improve their field accordingly. Every team member must keep pace with the changes in the external environment to the benefits of the project in hand. The objective of quality improvement is to continuously improve quality by eliminating non-conformance in every activity throughout the project phases and activity. This will improve the client satisfaction, eliminate errors and waste, will reduce operating costs, and will motivate and result in the commitment of all project team members.

The projects team members must ensure that in a never-ending improvement cycle, they learn from results, standardise what they do well in a documented quality management system, and improve operations and outputs from what they learn, this must be done in a planned, and systematic way.

There are a lot of experiences learnt from the conceptual phases of the project, preliminary stages, final design stage, tendering stages, and the process of construction as a whole. The learning cycle in these processes could be incorporated in the proposed dynamic model. Partnering with the suppliers in the provision of materials and plants will create improved standards, that could be incorporated in “PROMANYSYS” to provide TQM in its best results, performance and standards, to gain the satisfaction of the clients to create a loyal customer to the organisation.
10.12 Improvement of the framework on the traditional procurement system.

The traditional procurement method of organizing construction work starts with appointing a consultant designer, usually an architect or engineer, or both. Other specialists may be needed, in particular, a quality surveyor is appointed to provide cost information, prepare bill of quantity, compare bids and maintain financial management during construction.

The construction industry has experienced significant changes in the way in which contracts are managed. In some cases constructors have been brought in at an early stage as full members of the design team, in other clients have appointed project managers to act on their behalf. Clients have become increasingly concerned about problems such as poor design, inadequate supervision, delays and increased costs.

Because of the increasing complexity of buildings, the need for a greater degree of financial planning, and a desire to reduce both design and construction time, there have been numerous attempts to find new ways to plan and control the building process. A 'design-construct' contract, 'package deal' or 'turnkey' contract is intended to bridge the gap which normally separates design from execution. The constructor is appointed directly by the client and assumes responsibility for the whole process from initial briefing to the production of the completed building. In addition to talking on the role of 'leader of the team', the builder also contributes his own unique experience of construction materials, methods and costs.

The framework proposed in this research will improve the traditional procurement method of organizing construction work greatly. The client is involved at every stage of the project from the pre-contract stage (when writing the project's specification to tending appointment of main constructors and sub-constructors, and at the post-contract stage to hand-over of the project. The achievement of the
clients objectives and satisfying his expectations with cost and time, are the main target of the design and construction team. This is achieved by the framework as follow.

1. The quality: with the implementation of the TQM framework, the clients quality standards are taken as the main guidelines to writing-up the project's specifications, through the collaboration of all the design and construction team, when writing-up the project's specifications and implemented during the construction of the projects through the projects manager using "PROMANSYS" model with teamwork effort of all projects members including the value engineer and the main constructor.

2. The time: the project manager leading the design and construction teams, through the use of "PROMANSYS" tools of charts, graphs, bill of qualities and specification manual produced by "PROMANSYS" will achieve a commitment by the main constructor, sub-structor accepting more responsibility for meeting completion dates, and designs being more aware of the importance of complete information in "PROMANSYS" well in advance of work on site.

3. The budget: the value engineer, with the effort of the quality surveyor to produce, specifications on bill quantities will balance between the contract allocated budget and the quality standard needed by the client, by achieving realistic cost estimates and tenders which reflect the final cost, through the use of the best alternative material, methods and systems of construction for the minimum life cycle maintenance cost, and the most appropriate building rates available, reducing risk of contractual claims stemming from poor documentation and late receipt of information, and avoiding delays which can cause loss of revenue and costly funding arrangements.
10.13 Summary

Teamwork is an essential component in the implementation of TQM, in terms of bringing about change, for better communication, better solutions through the pooling of ideas, more commitment by members of the team, more cooperation, even distribution of the work and more productive work environment by utilizing the particular skills of the individuals.

In "PROMANSYS", teamwork as a main element of TQM is implemented in two stages, the pre-contract stage and post-contract stage. During the pre-contract stage the project manager leads all the project team, and they are: client, architect, civil engineer, electrical engineer, mechanical engineer, material engineer, quantity surveyor, planning engineer, and value engineer. The project manager's job is to ensure that all the team members share the same aims and objectives of the project and share the same values, beliefs and pace during the execution of the design of the project with team spirit to accomplish the design requirements including budget, time and quality standards. At the post-contract stage, the project manager uses the "PROMANSYS" tools such as charts, reports and diagrams to control the project through teamwork effort and coordination between all parties involved in the post-contract stage.

Creating a TQM culture to any system, group or an organisation is one of the biggest challenges of a TQM programme. An organisation's survival may depend on how it adapts its culture to a rapidly changing business environment and to the demand of its customers.

"PROMANSYS" unites all members of the project as the one and only tool for the project, where every member of the design and construction teams have the same objectives to be achieved, resulting in unified values, benefits and understanding.
The project members when working with the same beliefs and values, share certain essential beliefs and basics such as, the importance of execution details when doing the job, superior quality and services, the importance of informality to enhance communication, the importance of people as individuals, recognition of the importance of economic growth and profits, and believing in being the best. At that stage a culture is created.

Achieving TQM will require direct and clear communication from the top management to all staff and team members, to explain the need to focus on processes. Everyone will need to focus on processes. Everyone will need to know their roles in understanding processes and improving their performance. Effective communication is the key. Information must be clear, complete, accurate, conveyed concisely and in an understandable language.

"PROMANSYS" relies on the open method of communication, where all the project team members can communicate their needs, information and data throughout the project stages from design to construction. "PROMANSYS" is the only tool of communication that holds all the strings of the project together, which makes the communication so effective, productive and short.

Value engineering is important to any project in the construction industry in order to produce the project at the lowest cost and longer life cycle. It is an organised effort directed at analysing designed building features, systems, equipment, and material selections for the purpose of achieving essential functions at the lowest life cycle cost, consistent with required performance, quality, reliability and safety.

In "PROMANSYS" when all the material of the project selection is finished and entered in the specifications, entry forms and also the methods of fixing and construction selected with all the rates, quality and quantities. At this stage every
member of the project will have put the information needed by him and no more entries are done in "PROMANYSYS." The value engineer will look and study all the materials selected and methods used to find alternatives to the materials selected, perform the design requirement and save in construction cost whenever reasonable. Taking into consideration the Life Cycle Cost of every material used the amount of future benefits must be established to assess how much investment is justified. When design alternatives at different capital costs are to be made, the future benefits from the higher cost alternates must be established and evaluated to justify the expense.

Continuous improvement is the most powerful concept to guide management and for the organisation to survive. It is a term not well understood in many organisations. It is necessary to understand and be dedicated to the pursuit of continuous improvement in meeting external and internal customer needs. The objective of quality is eliminating non-conformance in every activity throughout the organisation. The benefits are enormous: Improved customer satisfaction, elimination of errors and waste; reduction in operating costs; increased motivation and commitment of employees; increased profitability; and competitiveness and survival of the organisation.

All parts of "PROMANYSYS" are continuously improvable, such as Master File, Projects Master Details, projects Phases, Specifications, Planning and Costing, Reports and Charts. In all these parts the projects team members must ensure that in a never-ending improvement cycle, they learn from results, standardise what they do well in a documented quality management system and improve operations and outputs from which they learn. This must be done in a planned and systematic way.
"PROMANSYS" has the ability to improve in many aspects, such as: in the writing of specifications, in the building and material rates; in the presentation of charts and reports; and development of the whole package.

- If any of these elements are missing, TQM programme will fail and the change process will collapse.
CHAPTER ELEVEN

CONCLUSIONS, RECOMMENDATIONS

AND FURTHER RESEARCH
CHAPTER ELEVEN

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

11.1 Introduction

This research has been devoted to the development of a framework for TQM in the construction industry in Bahrain by developing a specification model, which should help to improve performance in the construction industry. The research has sought to analyse the current status of the construction industry in Bahrain, with an analysis on the limitations of the construction specification used in Bahrain, as seen in Chapters 3 and 6.

The research discusses the concept of TQM, first in general followed by its relation to the construction industry, with an analysis of the traditional and modern construction documentation and the application of information technology system as seen in Chapters 4 and 5. An overview of the application of different software packages in construction management with a focus on the proposed dynamic model, is presented in Chapters 7 and 9. Chapter 6 discussed the implementation of TQM to the construction industry through the dynamic model, focusing on the main elements of TQM, teamwork, communication, culture, continuous improvement and value engineering. In this research there are three questionnaires analysed and discussed with results given on specification, Total Quality Management and validation of the proposed dynamic model “PROMANSYS”. 
11.2 CONCLUSIONS

The current status of the construction industry in Bahrain

The construction industry in Bahrain has yet to take its place in the development process of the country. There is a great need to control costs and to demand and achieve a higher quality of performance. Rapid development of Bahrain has focused attention on the problems that have been associated with the construction. The widely prevalent deterioration of concrete structures in Bahrain is caused by cumulatively interactive effect of environmental severity, incorrect specification, and bad workmanship, absence of engineering supervision and defective construction practices.

The survey results showed a lack of awareness for the purpose of specifications and the use of TQM in the construction industry in Bahrain. Level of awareness must be raised through authorities technical offices, technical institutions, engineering and managerial societies and through the media. To improve the level of quality of building in every phase of the construction process of the project until handover to client, to full satisfaction.

Achieving the objectives of the implementation of the framework in this research to the construction industry in Bahrain should work parallel with the raising of the awareness to the importance of specifications and TQM to the construction industry as a whole. This can only be achieved by the joint contribution of the private and public sectors together through all different channels in the construction industry in Bahrain. Like any other quality systems results are achieved with a certain period in time, for TQM program result usually achieved within three to five years in the construction industry organisations.
Defective workmanship in the construction industry in Bahrain come from errors in structural design, lack of attention to detail design, incorrect, inadequate or incompatible specifications, errors in construction methods and a lack of quality assurance programmes in design offices and sites. Projects in Bahrain can be categorised into three types namely large, medium and small projects. Most of the clients in the small, medium, and some of the large projects want to spend the lowest budget for a maximum investment return, without thinking of the effects of lowest prices on quality issues.

Barriers to implement TQM to the construction industry in Bahrain are briefed in the following points:

- lack of awareness of TQM;
- existence of mixed culture;
- lack of awareness to productivity;
- time scale needed to implement TQM; and
- resistance of managers to change.

The study of Total Quality Management concept with its relation to the construction industry.

Chapter 8 is devoted to the study of TQM, defining TQM and describing the principal tools and techniques of TQM with its application to implement TQM to the construction industry, a TQM questionnaire, with discussion and results given in this chapter.

The evolution of TQM changed its function with the passage of time from inspection, quality control, quality assurance, and quality circles to Total Quality Management from the years 1910 to 1980. This era produced many gurus who have contributed to the training and practice of the quality improvement movement in
two ways. Some of them concentrated on the philosophical aspects of quality improvement and others concentrated on the tools of quality. These gurus are categorised into three categories, the early Americans, the Japanese gurus and the Western gurus (their names and achievements are mentioned in chapter 4).

The gurus have set down points of wisdom in management and leadership and many organisations use these to establish a policy based on quality. These points have been distilled and modified to ten points for senior management to adopt.

1. The organisation needs long-term commitment to construct improvement.
2. Adopt the philosophy of Zero errors/defects to change the culture to right first time.
3. Train the people to understand the customer-supplier relationship.
4. Do not buy products or service on price alone-look at the total cost.
5. Recognise that improvement of the systems needs to be managed.
7. Eliminate barriers between departments by managing the process - improve communication and teamwork.
8. Eliminate the following.
   • Arbitrary goals without methods
   • All standards based only on numbers
   • Barriers to pride of workmanship
   • Fiction. Get facts by using the right tools.
9. Constantly educate and retrain - develop the experts in the business.
10. Develop a systematic approach to manage the implementation of TQM.

TQM still has obstacles and barriers for its implementation in the construction industry; there are general and specific obstacles. The general obstacles relate to the type and nature of the product and the method of construction. While the specific
obstacles refer to the background of different parties involved in the construction of a project, with regard to the ways of implementing TQM. These obstacles are described in detail in chapter 4.

This chapter describes recent research and developments in the quality of the construction industry, which includes:

- Department of Trade and Industry (DTI) : using £22 million a year innovation and research budget to help improve the competitiveness, quality and performance of the UK Construction Industry.
- Latham Report: Constructing the Team. Several recommendations were made in the final report including a cost reduction target of 30 percent.
- Egan Report: Rethinking Construction. Where a challenge was put to the industry, raising issues such as teamwork, buildability, culture, partnering, safety, cost and quality.
- Adams Associate in the United States of America introduced six sigma plus, which specializes in synergistic combination of strategic planning, leadership and total quality management TQM.

The six-sigma objective is to achieve a world-class performance, a key element of which is customer loyalty. It seeks to develop customer loyalty to the point that even when approached by a competitor with new benefits, low prices, better delivery and additional features, the customer remains loyal.

Six sigma is a methodology for working on projects utilising specific phases, these are: define; measure; analyse; improve and control. When six sigma is used to
describe a project. It is the application of these different steps for a specific project. The goal of the project is 3.4 parts per million defectives or less.

Analysis and objective of the information technology in the construction industry.

The traditional and modern documentation methods used in the construction industry are all discussed and analysed individually in this chapter. The main construction software used in the construction industry is categorised and discussed, including word processing database, graphics, computer-aided design and drafting, bill of quantity, surveying and quality assurance software, hardware requirements, networking local area network (LANs) and wide area networks (WANs). The purpose of this chapter is to give an understanding of the construction documentations presently used in the construction industry and the application of information technology systems, by analysing the field of construction documentation as it relates to managerial end users and the fundamental system concepts used in information technology systems. For managerial end users, the information system function represents a major source of information and support needed to promote effective decision making by managers. This is an important factor affecting operational efficiency, employee productivity and morale, customer service and satisfaction and is an important ingredient in developing competitive products and services that give an organisation strategic advantages in the global market place. The evolution of IT has been a major factor in boosting the efficiency of every profession both in practice and implementation of its specific rules, theories and principles. It would not have been possible to bring "PROMANSYS" to the efficiency level aimed for in the objectives of this thesis, without doing this chapter.
Analysis and limitations of the construction specifications used in Bahrain.

There are no specifications tailored for the construction industry in Bahrain or any of the Gulf countries. Consultants have developed a general specification for concrete works with the intention of applying it to all projects that they are engaged on. However, there are cases where the specification does not cover a particular type of work being carried out, yet provides a bulk of unwanted material that is of no use and just makes the document more difficult to use.

The preparation of specification and contract conditions is done in Bahrain by copying from other specifications, which were made by somebody else earlier due to lack of skill and knowledge in specification writing. Mistakes, discrepancies, inconsistencies and unclear wording are repeated once again in a new project. Due to the poor standard of specifications the following problems arise from the present situation.

- Most of the projects are not finished on time.
- Allocated project's budgets raised due to changes and variations.
- Disputes arise with unhappy clients ending up in court.
- Quality of buildings compromised to finish the project.
- High penalties with time consuming correspondences and instructions.
- Loss of trust and confidence between parties of the project with no future cooperation.

TQM is capable of improving the method of writing specifications and the quality of specification with the implementation of the TQM elements of teamwork, effective communication, creation of culture, continuous improvement and value engineering. The level of specification will definitely improve eliminating all problems of the existing used specifications in Bahrain through the proposed dynamic model in this research.
Overview of the application of different software packages in the construction management

The software packages that are commonly used in the construction industry are: Microsoft Project 2000, Primavera, Project Scheduler, Timberline, Sure track and Sap R/3 are overviewed in this chapter. They are all considered as planning tools packages, to plan the activities of the project, allocate labour and plant resources and submit good reports and charts for the planning and control processes of the projects.

The following points are the conclusions of the overview and analysis of the commonly used packages in the construction management, with a comparison to the proposed dynamic model in this research.

1. The majority of the projects overviewed in this chapter are useful for large projects in the construction industry. The packages are time consuming to prepare, complicated and need long seminars, training lectures and experience for the user to be fully qualified to implement them to real life projects.

2. All the packages in this chapter are not based on specification writing techniques as in the dynamic proposed model PROMANSYS. They have no master library for specifications and building rates. This gives advantages to the dynamic model, which has the ability to be continuously improved by the users and take into account all new materials, methods of construction, and management systems that are up to date in the construction industry.

3. The packages overviewed in this chapter cannot be continuously improved by the users and will have to be improved by the source of the packages producers. This means that these packages cannot implement TQM to the construction industry because it lacks one of the TQM elements and that is continuous
improvements to satisfy the customer's organisations and new trends in the construction industry. As the improvement done by package producer is done as a general improvement and not specific improvement for the requirement organisation using the package.

4. The packages discussed, lack the element of value engineering, which adds great value to the project in hand when implemented in improving the specification, the material and techniques used in the project, with great savings in the total budget of the project and an increase in the lifecycle of the functionality of the project.

5. Teamwork is one of the main elements in the implementation of TQM; "PROMANSYS" uses this element at great length during the preparation of the project specification, Bill of Quantity charts and reports. Due to the fact that the project manager, client, architect, quantity surveyor and the civil, planning, material, electrical, mechanical and value engineers all use the package of the dynamic model to form an effective teamwork effort. All other packages available in the construction industry lack this element of teamwork, because only a limited number of those mentioned above would be using the package.

**Analysis and results of specification and TQM questionnaire**

The questionnaire contained two sections, section one: specification questionnaire (11 questions) and section two: TQM questions (18 questions), both Questionnaires were aimed at the technical staff, engineers, architects and managers in the construction industry in Bahrain: in the public sector, mainly government technical offices and service- government authorities; and in the private sector to engineering offices, constructors, sub-constructors and suppliers.
A questionnaire survey (110 questionnaires) was posted and distributed to the Ministry of Housing (22), Ministry of Public Works (17), Central Municipal Council (16), Building Constructors (30) and Engineering Offices (25) questionnaires.

The total responses rate of the two sections were analysed based on the total questionnaire sent out which were 110 questionnaires, the total responses that were returned were 43 responses, giving an overall return rate of 39 percent. This is considered an accepted and reasonable response rate according to Fowler's assumption Fowler (1988) the response rate in excess of thirty percent is accepted.

Specification questionnaire results are as follows.

- The Majority in the construction industry do not write specifications for new projects.
- The Majority uses old specification and changes them wherever needed.
- Most existing specifications need modifications.
- Repetition, uncompleted, unclear, conflict in clauses and lack of precision are the features of the existing specification.
- The Majority uses FIDIC and JCT conditions of contract for the specifications.
- Common size of existing specification is between 10-100 pages and takes less than a month to prepare.
- Descriptive and performance specifications are the common type of specifications used.
- The Majority prefer computerised specifications.

Total Quality Management Questionnaire results are as follow.

- The concept of TQM is new to many people to many people in the field of construction in Bahrain.
• Teamwork is an important concept of TQM. Most top management still not giving it much attention, while staff and employees have the willingness to contribute in teamwork.

• The flow of information from management to employees is not sufficient, therefore, the employees initiative in participating to improve the process in the organisations has not yet been explored.

• Many organisations do not adopt sufficient systems to provide their customers with quality service.

• The majority organisations do not have an effective management information system for decision-making.

• There is weak management commitment towards training.

• The majority do not get recognition of their contribution and accomplishment at work.

• The majority of top management in the construction industry organisations do not invest in customer satisfaction due to lack of appreciation to the importance of customer satisfaction. While the majority of respondents in the organisation showed more willingness to achieve customer satisfaction.

• lack of awareness to the benefits of effective communication system in the organisation, create a large gap between management and employees, and between different departments in the organisation.

The proposed dynamic model and model validation

The following are the main features of the proposed dynamic model "PROMANSYS", and the results of the model validation. The characteristics of the model are explained in more detail in chapter nine.

• Project Management System (PROMANSYS) is a computerised information system based on specification writing technique, with budget control,
material control, planning control and reporting system for the construction industry implementing TQM.

- The design of the system interprets the stages the project will undergo as functional modules are referred to as functions that capture, maintain and generate the following:
  - the client and project master details;
  - standard of projects phases, specifications and costing;
  - project scheduling, planning and quantities; and
  - reports, charts and graphs.

- "PROMANSYS" is a customised system under Windows Operating System, the design of the system satisfies the actual users' requirements and provide the standards of Graphical User Interface (GUI). The characteristics of "PROMANSYS" model are summarised as follows:
  - ease of use;
  - speed and responsiveness;
  - size and compactness;
  - maintainability; and
  - packaging.

- Project management system functional flow and data file hierarchy consist of inputs, process and outputs.

  The inputs are.
  - Client and project master file.
  - Activities and phases.
  - Specifications.
  - Material quantities, labour and plant rates.
  - Date starting and date ending of the activities.
  - Value engineering techniques.

  The outputs are.
- Bill of quantities.
- Planning control charts.
- Material, labour, and plant control and budget charts.
- S-curve and cash flow charts.
- Creation of specification master and building rates master.

A description and analysis of "PROMANSYS" as an information technology system is provided where the proposed dynamic model "PROMANSYS" uses and implements most of the construction industry documentations. It creates an environment of flow of information between the project’s team members in all aspects and fields of the information.

"PROMANSYS" as an information system is the only tool of communication to be used by the management for effective decision making, where all the project’s documentation is well presented in the system such as specification manual, bill of quantities, planning, material, plants, labour and cash flow charts.

For any information system to survive it must have the ability to be improved otherwise it will be short lived. "PROMANSYS" has the ability to be continuously improved through its master data library. Users can easily introduce any new material, techniques, methods and tools used in the construction industry.

- The PROMANSYS model is validated by presentation and questionnaire. The overall results of the validations were that the model is.
  - Easy to use.
  - Has reasonable production time.
  - Cheaper to use than other packages.
  - Useful to the construction industry.
  - Has short time to learn.
- TQM is well implemented in the model.
- Will greatly improve quality.
- Well documented.
- Not similar to other packages.
- The model improves specification writing.
- The package will reduce errors.
- The package can be continuously improved.

The implementation of TQM to the construction specification using the dynamic model.

This chapter discusses how Total Quality Management is implemented through the proposed dynamic model, explaining the concept of Teamwork, Culture, Communication, Value Engineering and Continuous Improvements. Also discussing how TQM is achieved through "PROMANSYS", by getting all the project team members working together through one tool "PROMANSYS" at the pre-contract and post-contract stages of the project.

Teamwork

Teamwork is an essential component in the implementation of TQM, in terms of bringing about change, for better communication, better solutions through the pooling of ideas, more commitment by members of the team, more cooperation, even distribution of work and creating a more productive work environment by utilising the particular skills of the individuals.

In "PROMANSYS" Teamwork as a main element of TQM is implemented in two stages, pre-contract stage and post-contract stage. In the pre-contract stage the project manager leads all the project team, (client, architect, civil engineer, electrical engineer, mechanical engineer, material engineer, quantity surveyor, planning engineer, and value engineer). The project manager's job is to ensure that all the
team members share the same aims and objectives of the project and share the same values and beliefs during the execution of the design of the project, with team spirit to accomplish the design requirements including budget, time and quality standards. At the post-contract stage, the project manager uses the tools of "PROMANSYS" such as, charts, reports and diagrams to control the project through teamwork effort and coordination between all parties involved in the post-contract stage.

Culture
Creating a TQM culture to any system, group or an organisation is one of the biggest challenges of a TQM programme. An organisation’s survival may depend on how it adapts its culture to a rapidly changing business environment, and to the demands of its customers.

"PROMAN SYS" unites all members of the project, where every member of the design and construction teams have the same objectives to be achieved, resulting in unified values, believes and understanding. The project members when working with the same beliefs and values, share certain essential basics such as, the importance of execution details when doing the job, superior quality and services, the importance of informality to enhance communication, the importance of people as individuals, recognition of the importance of economic growth and profits, and believing in being the best. At this stage, a culture is created.

Effective communication
Achieving TQM will require direct and clear communication from the top management to all staff and team members, to explain plans, objectives and policies. Everyone needs to know their roles in understanding processes and improve their performance. Effective communication is the key. Information must
be clear; complete; accurate; conveyed concisely and in an understandable language.

"PROMANSYS" relies on the open method of communication, where all the project team members can communicate their needs, information and data throughout the project stages from design to construction. "PROMANSYS" is the only tool of communication that holds all the strings of the project together, which makes the communication so effective, productive and short.

Value engineering

Value Engineering is important to any project in the construction industry, to produce the project at the lowest cost and longer life-cycle. It is an organised effort directed at analysing designed building features, systems, equipment, and material selections for the purpose of achieving essential functions at the lowest life-cycle cost, consistent with required performance, quality, reliability and safety.

In "PROMANSYS" when all the material of the project selection is finished and entered in the specifications, at that stage every member of the project will have put the information needed and no more entries are done in "PROMANSYS." The value engineer will look and study all the materials selected and methods used to find alternatives to the materials selected, satisfying the design requirements, and saving in construction cost wherever reasonable. Taking into consideration the Life Cycle Cost of every material used, the amount of future benefits must be established to assess how much investment is justified. When design alternatives at different capital costs are to be made, the future benefits from the higher cost alternatives must be established and evaluated to justify the expense.
Continuous improvement
Continuous improvement is the most powerful concept to guide management and for the organisation to survive. It is a term not well understood in many organisations. It is necessary to understand and be dedicated to the pursuit of continuous improvement in meeting external and internal customer needs. The objective of quality is to eliminate non-conformance in every activity throughout the organisation. The benefits are enormous: Improved customer satisfaction; elimination of errors and waste; reduction in operating costs; increased motivation and commitment of employees; increased profitability and competitiveness and survival of the organisation.

All parts of "PROMANSYS" are continuously improvable, such as Master File, Projects Master Details, Projects Phases, Specifications, Planning, Costing, Reports and Charts. In all these parts the project’s team members must ensure that in a never-ending improvement cycle, they learn from results, standardise what they can in a documented quality management system, and improve operations and output from which they learn. This must be done in a planned and, systematic way.

"PROMANSYS" has the ability to improve in many aspects, such as the writing of specifications, building and material rates, in the presentation of charts, reports and development of the whole package.

11.3 Recommendations
The construction industry in Bahrain suffers badly from the old useless systems of construction management and quality of specification presently in use in the construction industry. This research develops a framework to implement Total Quality Management to improve performance, raise the level of quality of buildings produced, reduce disputes and satisfy the internal and external customer in the industry. The proposed dynamic model is introduced to solve these
problems. The model calls for a total rethinking of the existing working practices in the construction industry in Bahrain. Therefore, it is highly recommended to implement the model proposed in this research to the construction industry to improve performance in every phase of any construction project in the construction industry, with the introduction of teamwork, effective communication and the creation of culture with continuous improvement of the system.

The government authority in Bahrain is requested to form a taskforce for the improvement of performance in the construction industry, following the lead of the United Kingdom carried out by Latham and Egan. To analyse, discuss, investigate and recommend methods of improving the performance in the construction industry in Bahrain. One of the outcomes to be expected from this proposed taskforce is to develop the dynamic model proposed in this research to create and introduce the first master construction specification with a strong recommendation to implement TQM not only in specification, but also in every field of the construction industry in Bahrain.

The results of the survey analysis in this research showed a lack of awareness of the purpose of specification and the use of TQM in the construction industry in Bahrain. It is highly recommended to raise the level of awareness in these fields at the technical institutions, the society of engineers, and the authorities offices, to improve the level of quality of buildings in every phase of the construction process of the project until handover to client, to full satisfaction.

Information technology has never been a priority in the construction industry in Bahrain. Lack of awareness to the need, purpose and use of information technology has put the construction industry in Bahrain many years behind. It is recommended to introduce information technology to most of the construction industry fields. The proposed dynamic model in this research is considered an information system for
the industry; it is to be improved and developed to be used more efficiently in the construction industry to cope with everyday changes in information technology.

11.4 Further research

There are several recommendations for further research desired from this study. These have been summarised below.

1. The proposed dynamic model has introduced some planning and control charts that have been tailored to suit this model. Further research is recommended to integrate other packages such as Auto-Cad, quantity surveying, critical path method, and Primavera software to the dynamic model in this research for more comprehensive beneficial results from the model when implemented in any construction project.

2. The proposed dynamic model is based on specification as the main element of the package, which connects and interrelates many aspects of the project together with the main elements, such as B.o.Q, cash flow, material, labour, plant control and planning charts with the element of specification. Further studies should be conducted to investigate the feasibility of the proposed model "PROMAN SYS" by implementing it to other fields of the process of construction such as tendering and contractual procedure, feasibility study and quality control programmes.

3. This research has proposed a framework to implement TQM to the construction industry in Bahrain to improve performance in the construction industry. A trial was conducted on a small case study project. A complete implementation on a large-scale project should be the subject of further research so that the developed system can be further validated and evaluated.
4. This research focuses on specification writing with the creation of a large library of construction industry specifications. Further research should be undertaken to create master specifications for the construction industry in Bahrain or for the whole Gulf region. This master specification should categorise the projects into small, medium and large projects, or normal, complex and specialised projects, taking into account the methods of construction used in the construction industry in Bahrain, the level of workmanship, the availability of raw materials and the construction in a hot climate.

5. The proposed dynamic model implemented the main elements of TQM. These elements are teamwork, effective communication, culture, continuous improvement and value engineering. There are other elements that are not implemented such as benchmarking and leadership. The statistical charts, diagrams, matrix data analysis and other TQM tools are not used in the proposed dynamic model. Further research should be undertaken to develop a model using all the old and new tools of TQM.


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REFERENCES


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APPENDIX A

Workshops, seminars and conferences attended during the research period
<table>
<thead>
<tr>
<th>NO</th>
<th>WORKSHOP / SEMINAR / CONFERENCE ORGANISERS</th>
<th>WORKSHOP / SEMINAR / CONFERENCE TITLE</th>
<th>DATE</th>
<th>VENUE</th>
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<tbody>
<tr>
<td>1</td>
<td>Bahrain Society Of Engineers</td>
<td>Second Regional Concrete Conference on Concrete Durability In the Arabian Gulf</td>
<td>19-21 Mar 1995</td>
<td>Gulf Hotel</td>
</tr>
<tr>
<td>2</td>
<td>Bahrain Society Of Engineers</td>
<td>The Third Middle East International Quality Assurance Conference</td>
<td>24-26 Apr 1995</td>
<td>Gulf Hotel</td>
</tr>
<tr>
<td>3</td>
<td>Bahrain Society Of Engineers</td>
<td>First International Conference on Computers in Industry</td>
<td>12-14 Nov 1995</td>
<td>Holiday Inn</td>
</tr>
<tr>
<td>4</td>
<td>Bahrain Society Of Engineers</td>
<td>Seventh Middle East Corrosion Conference</td>
<td>26-28 Feb 1996</td>
<td>Gulf Hotel</td>
</tr>
<tr>
<td>5</td>
<td>Bahrain Society Of Engineers</td>
<td>Fourth Middle East International Quality Conference</td>
<td>28-30 Apr 1997</td>
<td>Sheraton Hotel</td>
</tr>
<tr>
<td>6</td>
<td>Bahrain Society Of Engineers</td>
<td>Fifth International Conference on Deterioration and Repair of Reinforced Concrete in the Arabian Gulf</td>
<td>27-29 Oct 1997</td>
<td>Gulf Hotel</td>
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<td>7</td>
<td>Bahrain Society Of Engineers</td>
<td>Eight Middle East Corrosion Conference</td>
<td>26-28 Oct 1998</td>
<td>Gulf Hotel</td>
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<td>8</td>
<td>Bahrain Society Of Engineers</td>
<td>First Gulf International Quality Conference</td>
<td>10-12 Apr 2000</td>
<td>Gulf Hotel</td>
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<td>9</td>
<td>Bahrain Society Of Engineers</td>
<td>Two Days Intensive Course on Quality Assurance Internal Auditor</td>
<td>29-30 Apr 1997</td>
<td>Bahrain Society Of Engineers</td>
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APPENDIX B

Questionnaire covering letter
Dear Sir,


Attached with this letter a national survey questionnaire which is part of my part time Ph.D. research into the development of a framework to implement Total Quality Management into the Construction Industry in Bahrain, by developing a dynamic specification model. The programme is being supervised by A.D.F. Price and Professor Ronald McCaffer in the department of civil and building engineering at Loughborough University in the United Kingdom.

The objective of this questionnaire is to investigate and analyse the level of the present specification used in the construction industry in Bahrain, and the second part of the questionnaire is to measure the awareness, and investigate the feasibility of implementing total quality management to the construction industry in Bahrain.

I have kept the questionnaire as simple as possible to minimize the time required to complete it. I would like to assure you that any information provided will be treated in the strictest confidence and Individual company responses will not be identified.

I would be most grateful if you could spare a few minutes to complete the enclosed questionnaire and return it in the envelope provided. I would be pleased to send you a copy of the survey results after they have been analysed.

Should you have any queries with respect to this questionnaire please do not hesitate to contact me on 530054 / 9603388.

Thank you for your assistance with this survey. I look forward to hearing from you in due course.

Yours Faithfully,

J.A. Al-Sehali
APPENDIX C

Specifications and Total Quality Management questionnaire
SECTION ONE: CONSTRUCTION SPECIFICATIONS

1. DO YOU WRITE SPECIFICATION FOR EVERY JOB YOU DO?
   - [ ] YES
   - [ ] NO

2. FOR NEW PROJECTS DO YOU?
   - [ ] WRITE NEW SPECIFICATION
   - [ ] USE THE SAME OLD SPECIFICATION
   - [ ] USE OLD SPECIFICATION AND CHANGE WHENEVER NEEDED

3. DO YOU HAVE COMPUTERIZED SPECIFICATIONS?
   - [ ] YES
   - [ ] NO

4. WHAT DO YOU THINK OF YOUR EXISTING SPECIFICATION?
   - [ ] USEABLE FOR ALL MY JOBS
   - [ ] NEED SOME MODIFICATIONS
   - [ ] MUST BE IMPROVED
5. YOUR SPECIFICATION HAS A PROBLEM OF:
(YOU CAN TICK MORE THAN ONE)

- REPETITION
- INCOMPLETE SPECIFICATION
- NOT PRECISE
- UNCLEAR
- CONFLICT IN CLAUSES
- NONE

6. FOR THE CONTRACT CONDITIONS IN YOUR SPECIFICATION DO YOU USE?

- FIDIC (Federation International des Ingenieurs -Conseils)
- JCT (Joint Contracts Tribunal -Standard Form of Building Contract)
- ICT (Institution of Civil Engineers Conditions of Contract)
- OTHERS (SPECIFY

7. YOUR SPECIFICATIONS SIZE IS BETWEEN

- 10 - 50 PAGES
- 50 - 100 PAGES
- 100-200 PAGES
- MORE
8. HOW LONG DOES IT TAKE YOU TO PREPARE YOUR SPECIFICATION?

☐ LESS THAN A WEEK
☐ LESS THAN A MONTH
☐ TWO - THREE MONTHS
☐ MORE

9. WHAT TYPE OF SPECIFICATION DO YOU USE?

☐ DESCRIPTIVE SPECIFICATIONS
   (A Description of the properties of a product only)

☐ PERFORMANCE SPECIFICATIONS
   (The Result of the Product Rather than the Product itself)

☐ PROPRIETARY SPECIFICATIONS
   (Identification to product, manufacturer, brand name, model, type ..etc)

OTHERS (SPECIFY ____________________________)

10. HOW OFTEN DO YOU IMPROVE YOUR SPECIFICATIONS?

☐ EVERY SIX MONSHTS
☐ EVERY YEAR
☐ EVERY TWO
☐ EVERY THREE YEARS
☐ MORE
☐ DONOT IMPROVE

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11. DO YOU PREFER

☐ MANUAL SPECIFICATIONS

☐ COMPUTERIZED SPECIFICATIONS

WHY: ____________________________________________

________________________________________________________________________

12. HOW DO YOU THINK WE CAN IMPROVE THE SPECIFICATION QUALITY:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

TO CONTACT CALL: 9603388
Section two: Total Quality Management

1. HOW FAMILIAR ARE YOU WITH THE TQM CONCEPT?
   - □ FAMILIAR WITH IT AND IMPLEMENTED IT
   - □ FAMILIAR WITH IT BUT NEVER IMPLEMENTED IT
   - □ HEARD OF IT
   - □ NEVER HEARD OF IT

2. DID YOU PARTICIPATE IN TQM SEMINAR OR WORKSHOP?
   - □ YES
   - □ NO

3. DOES YOUR ORGANIZATION IMPLEMENT TQM?
   - □ YES
   - □ NO

4. DO YOU THINK THAT YOUR ORGANIZATION ENCOURAGES TEAMWORK?
   - □ ALWAYS
   - □ MOSTLY
   - □ RARELY
   - □ NEVER

5. DO YOU LIKE TO CONTRIBUTE IN TEAMWORK?
   - □ ALWAYS

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6. DO YOU GET ENOUGH INFORMATION TO DO YOUR JOB PROPERLY?
   - ALWAYS
   - MOSTLY
   - RARELY
   - NEVER

7. DO YOU OFTEN PUT FORWARD VIEWS FOR IMPROVING YOUR WORK?
   - ALWAYS
   - MOSTLY
   - RARELY
   - NEVER

8. DO YOUR SUPERIORS WELCOME YOUR VIEWS FOR IMPROVEMENT?
   - ALWAYS
   - MOSTLY
   - RARELY
   - NEVER
9. **DO YOU THINK THAT YOUR ORGANIZATION ADOPTS SUFFICIENT SYSTEMS THAT ARE ABLE TO PROVIDE ITS CUSTOMERS WITH QUALITY SERVICES?**

- Always
- Mostly
- Rarely
- Never

10. **DOES YOUR ORGANIZATION HAVE AN EFFECTIVE MANAGEMENT INFORMATION SYSTEM FOR DECISION MAKING?**

- Always
- Mostly
- Rarely
- Never

11. **IS THERE MANAGEMENT COMMITMENT TOWARDS TRAINING?**

- Always
- Mostly
- Rarely
- Never

12. **ARE YOUR CONTRIBUTIONS AND ACCOMPLISHMENTS RECOGNIZED AND APPRECIATED BY YOUR SUPERIORS?**

- Always
13. IS CUSTOMER SATISFACTION OF PRIMARY IMPORTANCE TO YOU?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER

14. DOES YOUR ORGANIZATION TRY TO PERCEIVE AND RESPOND TO CUSTOMER INTEREST?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER

15. IS THE UNDERSTANDING OF CUSTOMER REQUIREMENTS CRUCIAL IN YOUR ORGANIZATION?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER
16. IS CO-ORDINATION BETWEEN THE DIFFERENT DEPARTMENTS CLEAR AND EFFECTIVE?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER

17. DO YOU THINK THE COMMUNICATION SYSTEM IS EFFECTIVE IN YOUR ORGANIZATION?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER

18. ARE YOU PLEASED WITH YOUR JOB CONDITIONS?

☐ ALWAYS
☐ MOSTLY
☐ RARELY
☐ NEVER
APPENDIX D

Proposed dynamic model validation questionnaire
THE PROPOSED DYNAMIC
MODEL VALIDATION QUESTIONNAIRE

1. Is the package easy to use?
   ☐ Easier to use than other packages.
   ☐ Similar to other packages.
   ☐ Difficult to use.
   ☐ Don't know.

2. What is the data production time?
   ☐ Slow data production time.
   ☐ Normal production time.
   ☐ Fast production time.
   ☐ Don't know.

3. What is the cost of the package with regard to human resources and
   material use?
   ☐ Cheaper to me than other packages with regard to human resources and
     material use.
   ☐ Normal to use than others with regard to human resorts and material use.
   ☐ Expensive to me than others with regard to human resorts and material
     use.
   ☐ Don't know.

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4. **How useful is the package to the Industry?**

- [ ] Useful to the industry.
- [ ] Similar to other package in the market.
- [ ] Useless to the industry.
- [ ] Don't know.

5. **What is the learning time of the package?**

- [ ] Short time to learn.
- [ ] Normal timing to learn.
- [ ] Long time to learn.
- [ ] Don't know.

6. **How well T.Q.M is implemented in the package?**

- [ ] T.Q.M is well implemented.
- [ ] Nothing new.
- [ ] T.Q.M is not well implement.
- [ ] Don't know.

7. **Will the package improve quality?**

- [ ] Will not improve quality.
- [ ] No change in quality.
- [ ] Very much will improve quality.
- [ ] Don't know.
8. How well the package is documented?
   - [ ] Not much documented
   - [ ] No change in documentation.
   - [ ] Well documented.
   - [ ] Don't know.

9. Is the software similar to other softwares?
   - [ ] Yes.
   - [ ] No.
   - [ ] Don't know.
   - Which software.

10. Does it improve specification writing?
    - [ ] Yes.
    - [ ] No.
    - [ ] Don't know.

11. How will the package reduce errors?
    - [ ] Will reduce errors.
    - [ ] No change.
    - [ ] Will not reduce errors.
    - [ ] Don't know.
12. Could the package be improved continuously?

- Could be improved continuously.
- Limited improvement.
- Not possible to improve.
- Don't know.

Name: ______________________________

Company: __________________________

Position: ___________________________
APPENDIX E

Case study drawings
Case study project

The case study project comprised of a bedroom, a dressing area and a "bathroom". The area of the project is 36m², 6m wide by 6m long, and the height of the structure is 3.0m. The structure design of the project is done on a strip footing with load-bearing walls, pre-cast slabs for the roof, plastered and painted walls.

The data in the drawings were used for the following activity works in the proposed dynamic model "PROMANSYS".

- excavation works;
- foundation works;
- block works;
- pre-cast slabs;
- plastering works;
- electrical works;
- plumbing works;
- painting works;
- tile works;
- gypsum ceiling works;
- wooden works; and
- aluminum works.

These twelve activities are used to test the proposed dynamic model "PROMANSYS" with regard to specification writing; bill of quantities; project planning bar chart; material planning chart; labour planning chart; plant planning chart; cumulative budget chart for material, labours and plant; S-curve chart; individual material, labours and plant budget graph.
PLAN FOR PROPOSED EXTENSION

HEIGHT = 3m
DOORS & OPENING = 2.1m x 1m
WINDOWS = 1.6m x 1.2m
ELEVATION FOR PROPOSED EXTENSION

SECTION FOR PROPOSED EXTENSION
ELECTRICAL FOR PROPOSED EXTENSION

ELECTRICAL LEGEND

⊙ CEILING MOUNTED LIGHT
⊙ ⊗ CEILING LIGHT WATERPROOF
⊙ ⊠ WALL LIGHT
⊙ ⌂ MIRROR LIGHT
⊙ ⌊ SWITCH POINT
⊙ ⌊ EXHAUST FAN
⊙ ⌊ 13 AMP SOCKET WITH SWITCH
⊙ ⌊ T.V. ANTENNAE
⊙ ⌊ A/C UNIT SPLIT TYPE
⊙ ⌊ A/C SOCKET WITH SWITCH
⊙ ⊠ CEILING FAN
APPENDIX F

Proposed dynamic model case study
reports, charts, graphs printout
### PROJECT NO. 123-4-2000
### PROJECT: JOHN SMITH EXTENSION
### SPECIFICATION LIST

<table>
<thead>
<tr>
<th>Item Code</th>
<th>Heading</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.01</td>
<td>EXCAVATION</td>
<td>Constructor should excavate according to the level shown on the drawings and must allow for excavating in rock or any other type of soil or whatsoever nature encountered. Then grading to make up level and filling with imported approved materials, fillings must be made in layers of 200mm with each layer being compacted at least 98% of maximum dry density prior to placing subsequent layer.</td>
</tr>
<tr>
<td>C.02</td>
<td>FOUNDATIONS</td>
<td>All concrete uses in foundations works must be ready mix concrete with a compressive strength of 45 N/mm², and should be tested with cube test from an approved lab. Sulphate resisting cement should be used, nominal size of aggregate is 20mm, and maximum water cement ratio shall be 0.45 and maximum cement content to be 370 kg/m³. Foundations must have a minimum concrete cover of 75 mm. All concrete works shall be vibrated using mechanical vibrator.</td>
</tr>
<tr>
<td>C.04</td>
<td>BLOCK WORKS</td>
<td>Concrete hollow blocks 200, 150 or 100 mm thick as per drawing shall be having compressive strength 7N/mm², for load bearing walls otherwise, 5N/mm² for framed structures with sulphate resistant cement. The blocks shall be only from approved supplies and shall be tested at an approved laboratory. Cement and sand motor shall be mixed in the proportion 1:3 mix. Block walls shall be built in stretcher bond. All joints between blocks shall be solidly filled to a general thickness by 10 mm at no point more than 15 mm.</td>
</tr>
<tr>
<td>C.05</td>
<td>PRE-CAST SLABS</td>
<td>Pre-cast slabs 150 mm for the typical floors and roof slabs, to be designed to carry the required floor and roof imposed loads as BS. 6399 part (1). The pre-cast slabs should be from an approved supplies. The design and calculations to be approved by the consultant prior to placing the pre-cast at site.</td>
</tr>
<tr>
<td>C.06</td>
<td>PLASTERING</td>
<td>All internal walls, columns and other areas except wash, kitchen and toilets to be finished in smooth to receive paint. Walls of wash, kitchen and toilets areas to be plastered but rough to receive tiles. Internal and external pastering shall be done with cement mortar 1:3 one coat 15 mm thick. The mortar shall be prepared only in concrete mixer machine with approved cement plasticiser. The maximum horizontal and vertical tolerances for plaster shall be (+/-) 3 mm.</td>
</tr>
<tr>
<td>EM.02</td>
<td>ELECTRICAL WIRING</td>
<td>All wires and cables are to comply with BS specifications and codes of practice. no cable with conductor smaller than 1.5 mm² shall be used in the installation. Cables shall be colour coded for identification. Black shall be used for neutral only. Green/Yellow shall be for the earth conductors and Red/Blue for phase conductors. Flexible cables used for lighting fittings shall be of 250 V grade with strands copper conductors, high temperature cables.</td>
</tr>
<tr>
<td>EM.07</td>
<td>PLUMBING</td>
<td>All hot and cold water pipe work shall be in half hard condition pvc pipes. Fittings shall be capillary type according to BS 864 part 2 in general. All hot water pipework to be concealed and exposed and shall be insulated with sectional fiberglass insulation. Provide ground water tank, and two water tanks at roof level made of fiberglass. all water supply and plumbing installation work in connection with the contract shall be executed in strict accordance with British standards.</td>
</tr>
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</table>

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## PROJECT: JOHN SMITH EXTENSION

### SPECIFICATION LIST

<table>
<thead>
<tr>
<th>Heading</th>
<th>Specifications</th>
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</thead>
<tbody>
<tr>
<td><strong>PAINTING</strong></td>
<td>All internal and external surfaces shall be painted with an approved type of paint. The application of paint shall be in accordance with the paint manufacturer's instructions and specifications. All walls unless otherwise specified, shall receive one coat primer, one coat filler and two coats of the approved paint.</td>
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<table>
<thead>
<tr>
<th>Item Code</th>
<th>F.03</th>
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<tr>
<td><strong>TILE WORK</strong></td>
<td>All kitchens and bathrooms, shall have ceramic tile finish. The height of the wall tiles shall extend 200mm above the false ceiling level. There shall be 4 single decorative design tiles for every bathroom and kitchen walls with a border tiles strip around the walls at a height of 900mm. The colour of the tile adhesive or mortar between the tiles must have a matching colour to the tile itself.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Item Code</th>
<th>F.04</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GYPSUM CEILING</strong></td>
<td>Supply and fix of gypsum board false ceiling using an approved method of fixing, all gypsum false ceiling shall receive one coat primer, filler, tape and two coats of emulsion paint, with a colour specified by the engineer.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item Code</th>
<th>F.05</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WOODEN DOORS</strong></td>
<td>Teak door of first quality, with decorative moulding as per the drawings and to the approval of the consultant. All wooden doors, frames, door shutters and architraves, shall be supplied, fixed and painted by the constructor.</td>
</tr>
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</table>

<table>
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<tr>
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<tbody>
<tr>
<td><strong>ALUMINIUM WINDOWS</strong></td>
<td>Aluminium framed windows shall be of Technal, powder coated section. The colour shall be selected by the consultant. All glass shall be 6mm thick &quot;Spectrafloat&quot;, bronze tinted, reflective glass. All aluminium windows shall comply with BS4873.</td>
</tr>
</tbody>
</table>
**BILL OF QUANTITIES**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SPEC HEADLINE</th>
<th>Area / Quantity</th>
<th>Material Rate</th>
<th>Labour Rate</th>
<th>Plant Rate</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.01 Excavation</td>
<td></td>
<td>41.00 m³</td>
<td>4.000 m³</td>
<td>5.000 nos</td>
<td>80.000 nos</td>
<td>274</td>
</tr>
</tbody>
</table>

Constructor should excavate according to the level shown on the drawings and must allow for excavating in rock or any other type of soil or whatsoever nature encountered. Then grading to make up level and filling with imported approved materials, fillings must be made in layers of 200mm with each layer being compacted at least 98% of maximum dry density prior to placing subsequent layer.

| C.02 Foundations |               | 8.30 m³        | 30.000 m³     | 5.000 nos   | 20.000 nos  | 314        |

All concrete uses in foundations works must be ready mix concrete with a compressive strength of 45 N/mm², and should be tested with cube test from an approved lab. Sulphate resisting cement should be used, nominal size of aggregate is 20mm, and maximum water cement ratio shall be 0.45 and maximum cement content to be 370 kg/m³. Foundations must have a minimum concrete cover of 75 mm. All concrete works shall be vibrated using mechanical vibrator.

| C.04 Block Works |               | 86.90 m²       | 6.000 m²      | 5.000 nos   | 12.000 nos  | 558        |

Concrete hollow blocks 200, 150 or 100 mm thick as per drawing shall be having compressive strength 7N/mm², for load bearing walls otherwise, 5N/mm² for framed structures with sulphate resistant cement. The blocks shall be only from approved supplies and shall be tested at an approved laboratory. Cement and sand mortar shall be mixed in the proportion 1:3 mix. Block walls shall be built in stretcher bond. All joints between blocks shall be solidly filled to a general thickness by 10 mm at no point more than 15 mm.

| C.05 Precast Slabs |               | 36.00 m²       | 8.500 m²      | 6.000 nos   | 50.000 nos  | 380        |

Precast slabs 150 mm for the typical floors and roof slabs, to be designed to carry the required floor and roof imposed loads as BS. 6399 part (1). The pre-cast slabs should be from an approved supplies. The design and calculations to be approved by the consultant prior to placing the pre-cast at site.

| C.06 Plastering |               | 160.50 m²      | 1.600 m²      | 5.000 nos   | 12.000 nos  | 303        |

All internal walls, columns and other areas except wash, kitchen and toilets to be finished in smooth to receive paint. Walls of wash, kitchen and toilets areas to be plastered but rough to receive tiles. Internal and external pastering shall be done with cement mortar 1:3 one coat 15 mm thick. The mortar shall be prepared only in concrete mixer machine with approved cement plasticiser. The maximum horizontal and vertical tolerances for plaster shall be (+/-) 3 mm.

| EM.02 Electrical Wiring |               | 9.00 m         | 1.800 m       | 6.000 nos   | 8.000 Day   | 42         |

All wires and cables are to comply with BS specifications and codes of practice. no cable with conductor smaller than 1.5 mm² shall be used in the installation. Cables shall be colour coded for identification. Black shall be used for neutral only. Green/Yellow shall be for the earth conductors and Red/Blue for phase conductors. Flexible cables used for lighting fittings shall be of 250 V grade with strands copper conductors, high temperature cables.

| EM.07 Plumbing |               | 4.00 Nos       | 1.900 Nos     | 5.000 Nos   | 25.000 Day   | 42         |

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### BILL OF QUANTITIES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SPEC HEADLINE</th>
<th>Area (m²)</th>
<th>Material Rate</th>
<th>Labour Rate</th>
<th>Plant Rate</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>All hot and cold water pipe work shall be in half hard condition PVC pipes. Fittings shall be capillary type according to BS 864 part 2 in general. All hot water pipework to be concealed and exposed and shall be insulated with sectional fiberglass insulation. Provide ground water tank, and two water tanks at roof level made of fiberglass. All water supply and plumbing installation work in connection with the contract shall be executed in strict accordance with British standards.</td>
<td>137.00</td>
<td>1,300</td>
<td>6,000 nos</td>
<td>20,000 nos</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>All internal and external surfaces shall be painted with an approved type of paint. The application of paint shall be in accordance with the paint manufacturer’s instructions and specifications. All walls unless otherwise specified, shall receive one coat primer, one coat filler and two coats of the approved paint.</td>
<td>30.20</td>
<td>6,000</td>
<td>6,000 Nos</td>
<td>30,000 day</td>
<td>229</td>
<td></td>
</tr>
<tr>
<td>All kitchens and bathrooms, shall have ceramic tile finish. The height of the wall tiles shall extend 200mm above the false ceiling level. There shall be 4 single decorative design tiles for every bathroom and kitchen walls with a border tiles strip around the walls at a height of 900mm. The colour of the tile adhesive or mortar between the tiles must have a matching colour to the tile itself.</td>
<td>32.10</td>
<td>6,500</td>
<td>6,000 nos</td>
<td>30,000 nos</td>
<td>262</td>
<td></td>
</tr>
<tr>
<td>Supply and fix of gypsum board false ceiling using an approved method of fixing, all gypsum false ceiling shall receive one coat primer, filler, tape and two coats of emulsion paint, with a colour specified by the engineer.</td>
<td>2.00</td>
<td>85,000</td>
<td>6,000 nos</td>
<td>30,000 nos</td>
<td>219</td>
<td></td>
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<tr>
<td>Teak door of first quality, with decorative moulding as per the drawings and to the approval of the consultant. All wooden doors, frames, door shutters and architraves, shall be supplied, fixed and painted by the constructor.</td>
<td>3.00</td>
<td>40,000</td>
<td>6,000 nos</td>
<td>30,000 nos</td>
<td>180</td>
<td></td>
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<tr>
<td>Aluminium framed windows shall be of Technal, powder coated section. The colour shall be selected by the consultant. All glass shall be 6mm thick “Spectrafloat”, bronze tinted, reflective glass. All aluminium windows shall comply with BS4873.</td>
<td>3,032.95</td>
<td></td>
<td></td>
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Sum of Total Cost
## PROJECT NO. 123-4-2000

## PROJECT: JOHN SMITH EXTENSION

**PROJECT PLANNING CHART**

<table>
<thead>
<tr>
<th>ACTIVITY / WORK DESCRIPTION</th>
<th>DURATION</th>
<th>YEAR 2000</th>
<th>YEAR 2001</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
<td>Days</td>
</tr>
<tr>
<td>EXCAVATION</td>
<td>10/10/00</td>
<td>31/10/00</td>
<td>15</td>
</tr>
<tr>
<td>FOUNDATIONS</td>
<td>01/11/00</td>
<td>12/12/00</td>
<td>29</td>
</tr>
<tr>
<td>BLOCK WORKS</td>
<td>13/12/00</td>
<td>17/01/01</td>
<td>25</td>
</tr>
<tr>
<td>PRE-CAST SLABS</td>
<td>18/01/01</td>
<td>25/01/01</td>
<td>5</td>
</tr>
<tr>
<td>PLUMBING</td>
<td>18/01/01</td>
<td>14/02/01</td>
<td>19</td>
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<tr>
<td>PLASTERING</td>
<td>26/01/01</td>
<td>09/03/01</td>
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</tr>
<tr>
<td>ELECTRICAL WIRING</td>
<td>04/02/01</td>
<td>09/03/01</td>
<td>25</td>
</tr>
<tr>
<td>PAINTING</td>
<td>10/03/01</td>
<td>20/04/01</td>
<td>30</td>
</tr>
<tr>
<td>TILE WORK</td>
<td>10/03/01</td>
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<tr>
<td>GYPSUM CEILING</td>
<td>10/03/01</td>
<td>22/03/01</td>
<td>9</td>
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<tr>
<td>WOODEN DOORS</td>
<td>21/04/01</td>
<td>09/05/01</td>
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<td>ALUMINIUM WINDOWS</td>
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## MATERIAL CHART

<table>
<thead>
<tr>
<th>ACTIVITY / WORK DESCRIPTION</th>
<th>Qty/ Area Unit</th>
<th>Budget Amount</th>
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<tbody>
<tr>
<td>EXCAVATION</td>
<td>41.00 m³</td>
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<tr>
<td>FOUNDATIONS</td>
<td>8.30 m³</td>
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<tr>
<td>BLOCK WORKS</td>
<td>86.90 m²</td>
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<tr>
<td>PRE-CAST SLABS</td>
<td>36.00 m²</td>
<td>306</td>
</tr>
<tr>
<td>PLUMBING</td>
<td>4.00 No</td>
<td>7</td>
</tr>
<tr>
<td>PLASTERING</td>
<td>160.50 m²</td>
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<tr>
<td>ELECTRICAL WIRING</td>
<td>9.00 m</td>
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<tr>
<td>PAINTING</td>
<td>137.00 m²</td>
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<tr>
<td>TILE WORK</td>
<td>30.20 m²</td>
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<tr>
<td>GYPSUM CEILING</td>
<td>32.10 m²</td>
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<td>WOODEN DOORS</td>
<td>2.00 no</td>
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</tr>
<tr>
<td>ALUMINIUM WINDOWS</td>
<td>3.00 m²</td>
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| | YEAR 2000 | | YEAR 2001 |
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |

**Total Material Budget**: 2,378
# PROJECT NO: 123-4-2000
## PROJECT: JOHN SMITH EXTENSION

### LABOUR BUDGET CHART

<table>
<thead>
<tr>
<th>ACTIVITY / WORK DESCRIPTION</th>
<th>Qty</th>
<th>Unit</th>
<th>Budget Amount</th>
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<tbody>
<tr>
<td>EXCAVATION</td>
<td>6</td>
<td>nos</td>
<td>30</td>
</tr>
<tr>
<td>FOUNDATIONS</td>
<td>9</td>
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<td>45</td>
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<tr>
<td>BLOCK WORKS</td>
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<td>nos</td>
<td>25</td>
</tr>
<tr>
<td>PRE-CAST SLABS</td>
<td>4</td>
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</tr>
<tr>
<td>PLUMBING</td>
<td>2</td>
<td>Nos</td>
<td>10</td>
</tr>
<tr>
<td>PLASTERING</td>
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<td>nos</td>
<td>35</td>
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<tr>
<td>ELECTRICAL WIRING</td>
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<td>18</td>
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<tr>
<td>PAINTING</td>
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<td>30</td>
</tr>
<tr>
<td>TILE WORK</td>
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<td>Nos</td>
<td>18</td>
</tr>
<tr>
<td>GYPSUM CEILING</td>
<td>4</td>
<td>nos</td>
<td>24</td>
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<tr>
<td>WOODEN DOORS</td>
<td>3</td>
<td>nos</td>
<td>18</td>
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<tr>
<td>ALUMINIUM WINDOWS</td>
<td>5</td>
<td>nos</td>
<td>30</td>
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**Total Labour Budget:** 307
## Project No. 123-4-2000

**Project:** JOHN SMITH EXTENSION

**Plant Chart**

<table>
<thead>
<tr>
<th>Activity / Work Description</th>
<th>Qty</th>
<th>Unit</th>
<th>Budget Amount</th>
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<tbody>
<tr>
<td>EXCAVATION</td>
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<tr>
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<td>20</td>
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**Total Material Budget:** 347

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## CUMMULATIVE BUDGET CHART

**PROJECT NO.** 123-4-2000  
**PROJECT : JOHN SMITH EXTENSION**

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**Project Total Budget** 3,033
CUMMULATIVE BUDGET S-CURVE

PROJECT NO.  123-4-2000
PROJECT :   JOHN SMITH EXTENSION
CLIENT :     JOHN SMITH

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LABOUR BUDGET GRAPH CHART

PROJECT NO.    123-4-2000
PROJECT        JOHN SMITH EXTENSION
CLIENT         JOHN SMITH

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PROJECT NO. 123-4-2000
PROJECT: JOHN SMITH EXTENSION
CLIENT: JOHN SMITH

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PLANT BUDGET GRAPH CHART

PROJECT NO.  123-4-2000
PROJECT :  JOHN SMITH EXTENSION
CLIENT :  JOHN SMITH

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