Intelligent computer system for enhancing value engineering implementation in the Egyptian construction industry

Hazem M. El-Senoussi

INTELLIGENT COMPUTER SYSTEM FOR ENHANCING VALUE ENGINEERING IMPLIMENTATION IN THE EGYPTIAN CONSTRUCTION INDUSTRY

HAZEM M. EL SENOUSSI

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The American University in Cairo
School of Science and Engineering

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by
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Hazem M. El-Senoussi

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ABSTRACT

The American University in Cairo

INTELLIGENT COMPUTER SYSTEM FOR ENHANCING VALUE ENGINEERING IMPLIMENTATION IN THE EGYPTIAN CONSTRUCTION INDUSTRY

BY: Hazem Mohamed El.Senoussi

Supervised by: Dr. Mahmoud Abdel Salam Taha

Value Engineering (VE) is a well organized technique that has been successfully adopted by many industries, including construction, to reduce cost and improve the value of their products. In an attempt to investigate the extent of awareness and application of VE in the construction industry in Egypt, this research presents a survey questionnaire conducted on 18 large-size public and private construction firms. Analysis of the survey was established where it was found that VE is limited within most publicly owned projects while it is starting to show wide spread within privately owned projects in Egypt. Often VE is executed informally and the true VE methodology is not properly implemented adding that qualified personnel are very hard to find, which make training programs and regular workshops extremely essential. To overcome these obstacles, the research presents a VE computer system (VECS) that uses the VE techniques and principles introduced within its job plan as an aiding tool for effective and reliable implementation. The proposed system forms a decision support mechanism that significantly reduces time through sparing the user all the long tedious tasks performed in a traditional VE session. The system also

represents the foundations for a potential training tool that could help tutor unprofessional personnel in conducting VE studies.

Keywords: Value engineering, Computer system, Decision support, Survey, Egypt, Questionnaire, Construction firms, Database development, Training.

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Chapter 1: Introduction

1.1 Introduction

The construction industry in Egypt represents a significant part of the country's economy. Thousands of millions of pounds are spent each year on different construction projects from simple housing projects to highly sophisticated power and industrial plants. These projects normally pass through several phases that begins with the planning phase and conceptual design phase and ends by the construction and commissioning phase. Often decisions made in the conceptual design phase are the ones that have great impact on the total cost and the life-cycle cost of a project Figure1.1. Therefore, if strong effort is spent on the initial stage of design, great savings could be made. These savings could be achieved through conducting value engineering (VE) study.

Value engineering is a creative, organized approach whose objective is to optimize cost and/or performance of a facility or system. (Dell'Isola, 1982). A workshop is usually carried out through the selection of multidiscipline teams representing different technical fields. The teams engage in a job plan that encompasses different phases like information, speculative, analytical, proposal, and final reporting. The result of this workshop is development of a number of different alternatives that posses lower cost solutions where the optimum alternative is chosen.

In this study, a value engineering computer system is developed to carry out these phases systematically in a fast efficient way. It will help achieve significant cost savings for owners or clients. Moreover, the system will be able to accept feedback and continuously update its internal database library, which will help enhance and improve VE studies.

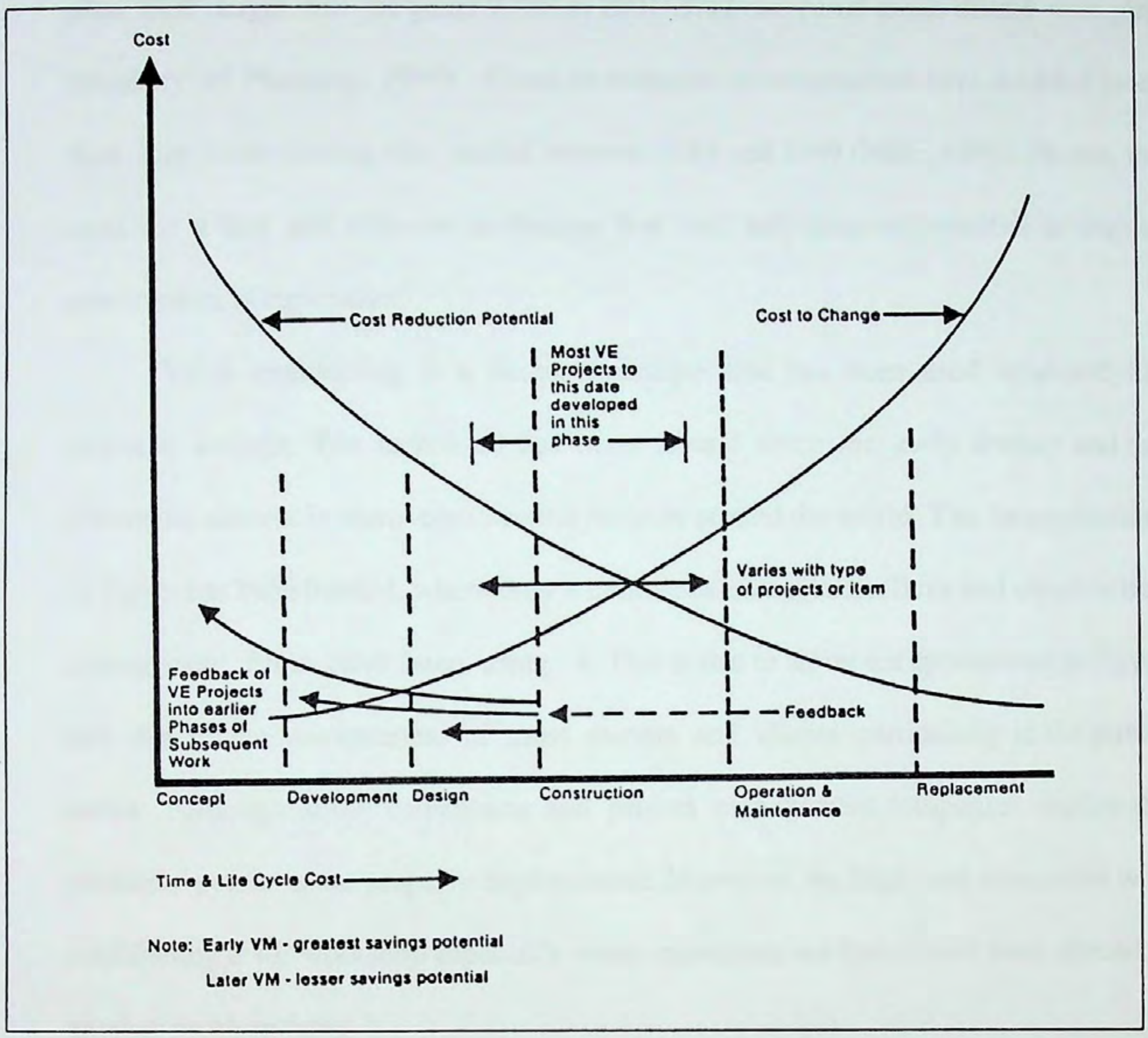


Figure 1.1 Cost reduction potential vs. cost to change (Dell'Isola, 1982)

1.2 Problem Statement

Construction in Egypt accounts for a considerable portion of the country's gross domestic production (GDP). During the past ten years, many changes have occurred in the construction industry in Egypt. Expenditure on Housing & Communication has increased more than four times from the year 1986 to 1995 to reach 3,012 Million Pounds (International Monetary Fund, 1998). The yearly percentage increase in construction work is estimated to be 9.1% for the fourth 5-year

plan GDP target for the years 97/98 to 2001/2002 compared to the third 5-year plan (Ministry of Planning, 1998). Fixed investments in construction have doubled more than four times during the period between 1989 and 1999 (NBE, 1998). Hence, the need for a fast and effective technique that will help pinpoint potential savings in construction is imperative.

Value engineering is a strong technique that has been used in identifying potential savings. The technique has been around since the early seventy and has proven its success in many construction projects around the world. Yet, its application in Egypt has been limited, where only a number of consultant offices and construction management firms have been using it. This is due to its recent appearance in Egypt and due to the unawareness of most owners and clients particularly in the public sector. Although some consultants and project management companies employ the principle yet it is not properly implemented. Moreover, the high cost associated with establishing a VE workshop especially when expatriates are introduced from abroad is another problem faced.

This research presents a Value Engineering Computer System (VECS) that will handle the VE process effectively. The system will be able to collect, store, sort, and retrieve previous VE studies for different projects. An internal database library will be used to help support decision making in similar projects. This will provide useful lessons for future reference in similar projects. Moreover, it will help guide engineers and practitioners implement VE studies effectively and save significant time by reducing the time consuming paperwork.

1.3 Objectives of the Study

The objectives of this study are:

1- Investigate and explore the application and practice of the VE concept in the construction industry in Egypt.

2- Develop a computer VE system (CVES) that will help improve and enhance the VE process in the construction industry.

3- Provide a database management system for all previous VE studies, which will aid in decision making of similar studies.

The first objective of this study is to investigate the application of the VE concept in the construction industry in Egypt and the roadblocks obstructing its application. The results of this investigation will aid in the design of the computer VE system which can assistance in reducing some of the roadblocks faced. The success of the system output will depend heavily on the reliability of the data entered, since the system is there to guide the user. The last objective is to augment a database management system that can store all available data from previous studies. These data will work in providing valuable feedback that will help in enhancing and improving the VE application and implementation.

1.4 Contents and Organization

The thesis is divided into six chapters. The first chapter serves to introduce the research topic with an outlook at the situation. The problem statement is then presented with an outline of the main objectives of the research.

The second chapter offers a critical look at the existing research in the construction literature that is significant to VE and the application of computer technology to this principle.

The third chapter is an in-depth theoretical review of the concept of VE, which forms the basis for the thesis topic. The chapter starts with a brief description of VE, its history, and the reasons behind its appearance. Subsequently, the VE job plan is discussed which is the key to success in a VE study. The different stages of the job plan are identified and the essential key elements in each stage are highlighted. Moreover, the procedures and techniques used in the job plan is clearly discussed and explained.

The fourth chapter presents a field investigation of the extent of awareness and application of VE within the construction industry in Egypt. This is performed through a survey questionnaire that was conducted on 18 public and private firms. The data gathered were analyzed to identify the level of VE utilization and explore the roadblocks and obstacles facing its application. Ways and methods to reduce or eliminate these obstacles are also suggested.

Subsequently, the fifth chapter which represents the core of the research introduces an extensive and complete study of the proposed VE computer system and its actual application on two VE cases. The chapter illustrates the methodology and development of VE computer system. The system design process is explained with illustration of its basic parts. Hereinafter, testing and validation of the system is introduced with implementation of two VE cases.

The sixth and final chapter is a summary and conclusion of the research including the characteristics of the Egyptian construction industry with respect to the application of the VE principle. An assessment of the suitability and efficiency of the

proposed VE computer system is also introduced. System deficiency and operational considerations are presented with highlights on possible future extensions to the study. Finally, a sample of the utilized questionnaire plus all related tables and figures are provided in the appendix section at the end of the research document

Chapter 2: Literature Review

2.1 Introduction

The early emergence of VE, which was during World War II, led many authors to investigate and write about it. The technique was adopted by many industries and agencies for its potential short-term and long-term benefits. As a result evolution of the technique was tremendous and showed significant results. Many authors prepared valuable work in the VE field and suggested different ways to improve it.

This chapter introduces a synopsis of previous work prepared in the construction literature. Commencing with a review of early work prepared in the VE arena, then presenting a number of VE applications are discussed. A survey of a variety of VE improvement methods is finally illustrated.

2.2 Literature Review

The construction industry is experiencing day by day increase in prices. The commitment to control costs is showing more attention, especially that owners nowadays are more aware of the significant impact of life-cycle costs of facilities. Moreover, the increasing pressure to meet budget requirements has led both owners and contractors to look for ways to reduce costs without compromising the quality. Value Engineering (VE) is a proven successful technique in identifying alternative approaches for satisfying project requirements while lowering costs and ensuring technical capability and performance (Acharya et al, 1995).

Lawrence D. Miles who was working for General Electric developed the concept of VE. The shortage of materials and labor during World War II, led to the search for other ways to fulfill functions of an item or component using other alternatives. This method of "function analysis" later proved to have reduced costs without reducing the quality. VE after the war was used as a system for removing unnecessary costs and improving design. Miles work, however, was unsystematic and had to be organized and rationalized, which was performed later by both Mudge (1971) and Heller (1971). At this stage, VE was developed into a three-branched technique, which later was referred to as the VE job plan (Palmer and others, 1996).

Many industries have adopted the VE technique since its early discovery. The construction industry is one of the industries that strongly employed the VE concept in project optimization. The first two major construction agencies which utilized and introduced VE, were the U.S Army Corps of Engineers and the U.S Navy Bureau of Yards and Docks. Later, the Public Building Service adopted VE in all its major work (Barrie and Mulch, 1977).

Since the appearance of the VE approach and its applications in the different areas of the construction industry, many obstacles have emerged which hindered its effective implementation. For example, the nature of the owner/ client, whether public or private, and depending on the method of handling the construction project-traditional general contractor, design-constructor firm, construction management firm. Consequently, several authors have worked on tracking these obstacles, analyzed them, and looked for solutions to help reduce or eliminate them. Some others found solutions and potential opportunities to enhance the VE process through integrating the process with other present tools.

Barrie and Mulch (1977) found successful implementation of the VE techniques within most designers and contractors who were involved in construction work with the public sector. Yet, its utilization in the private sector did not show any substantial development, although its awareness was considerably equal between both designers and contractors. This was due to the adoption of old and more traditional methods in project construction, like the traditional single contractor and the design construct system. Both methods showed poor results when trying to apply VE. Barrie and Munch, however, found that the appearance of the professional construction manager at the early ages of a project would dramatically help in VE implementation. This is due to the early involvement of all parties - owner, architect/ engineer, and construction manager personnel - which help provide a healthy climate of communication.

The successful application of VE has gained increasing demand worldwide. Dell'Isola (1984), Vice President and Director of the Value Management Division at Smith, Hinchman and Grylls Association, presented a paper that discussed the results of a VE study that was made to an airport facility in the United States. The study provided $ 7,000,000 initial cost savings and more than twice that amount in ownership cost savings. By comparing that airport to another airport in Dallas, 38% less annual energy costs were realized and 33% less than another airport in Chicago. Return on investment as a result of this study was over 50:1.

Basha and Gab-Allah (1991) displayed the broad and intelligent quality of VE application in the construction industry by utilizing some of its techniques. They have employed VE principles to evaluate the selection of construction systems for major bridge projects in Egypt. They have studied 18 bridge projects under eight construction systems. The weighted evaluation technique was used on each project

where the most significant criteria included in the study were construction cost, resource availability, ease of construction, durability, construction progress rate, service life, design efficiency, and maintenance. The study resulted in 6 out of 14 bridge project cases, representing about 43%, which were not constructed using the best construction system alternative. Similarly, Meetkees (1997) prepared a Ph.D. study involving the utilization of VE approach to the planning and design phases of long span bridges. He has discovered that VE application aid planners and designers achieve optimal planning, design and construction solutions. He studied of one of the vital and largest long span bridges in Egypt, El-Moneeb Bridge, included a full and comprehensive analysis particularly studying planning alternatives and its effect on the level of traffic services. Long term and short term losses due to poor planning were also estimated with consideration to time value of money.

Al-Hammad and Hassanain (1996) in Saudi Arabia were able to apply VE techniques in the assessment of exterior building wall systems. They used the weighted evaluation techniques on 14 exterior wall systems. The criteria used in this study were achieved after surveying 25 professional designers and consultants. The evaluation technique has proved to be reliable and suitable for the evaluation and selection of other similar construction systems.

Other authors have looked for different methods to improve the VE process for the sake of obtaining effective implementation. The utilization of microcomputers in the VE process was one of the methods that have been introduced. Benator (1990) was one of the early authors who explored the advantages of microcomputers in enhancing the VE performance. He suggested using microcomputer capabilities in doing some cost modeling and life cycle cost (LCC) analysis which usually consumes a lot of time and effort. The determination of the cost/worth ratio (Value Index) was

one of the things the author explored, where he suggested the use of a built-in cost database for different items to be used in calculating the cost/worth ratio. Furthermore, by using microcomputer spreadsheets he was capable of defining the cost/worth formula for items that can be computed automatically for each cost component. Another useful tool the author added was the computer generated graphical cost analysis, which can easily help identify items with potential savings. The big advantage of the computerized system suggested was the presentation of a computerized life cycle cost analysis that can significantly save time. This is usually because a manual LCC may take up to 20-35 minutes and where one VE study could have an average of 20 LCC analysis, this could reach up to 10-12 hours per study. Mainly the author here has concentrated on three major parts of the VE study, which consumes a large amount of time. Through the application of microcomputers, he was able to increase the value engineer's productivity significantly and consequently enhance the process.

Significant work in the area of VE improvement using computer technologies particularly artificial intelligence has been introduced by De La Garza and Alcantara (1993). A paper by the two authors illustrated the use of computer-aided design and artificial intelligence in the coupling of both design intent and VE. Design intent is the process of transforming the owners needs into a physical object. In this stage the owner's and designer's intents are the reasoning behind the design output. This reasoning is usually lost during project information exchange and as usual will rest in the minds of the owners and designers. The authors were able to develop a system that makes use of the design intent information available with both owners and designers to enhance the VE process. Through the utilization of a variety of computer techniques in the different VE phases, they were able to develop a computer-aided

Value Engineering System prototype (CAVE). The system is capable to communicate and initiate data links with three Windows applications – AutoCAD, Kappa, and Excel, which adds an important advantage to the system. Furthermore, the CAVE system employs database management systems by providing information on previous projects which users can use as a guide in their current projects. This suggested coupling improves the VE process and provides a foundation for a computer-integrated facility life cycle concept.

Expert System (ES), a branch of Artificial Intelligence (AI) has been continuously improving through out the years. Gibbs (1989), who has been a VE Program Manager at US Army Missile Command (MICOM), Alabama since 1986, presented the benefits of using expert systems in enhancing the VE process within organizations. Expert systems, which are a type of artificial intelligence (AI), can save time, maintain and enhance corporate knowledge, provide a learning tool for personnel, and identify items with good VE potential. The system will be able to generate alternatives as equivalent as a skilled person would do. Not only that, but the system will help close the gap created from the continuos change of work force by preserving corporate knowledge. Furthermore, as the system performs a number of VE studies, the knowledge base is continuously occupied which forms the bases for an excellent tutorial system that can help prepare new personnel in VE as well as highlighting new areas of VE potential. The author also presented P/VEX, which is a prototype developed by MICOM that does VE analysis on a small set of problems. The system showed the feasibility of employing expert systems to do VE studies efficiently and reliably (Gibbs, 1989).

Going along the same pace, Shen and Brandon (1991) stressed on the potential benefits of utilizing ES to improve the value management implementation in the

construction industry. Through the authors' study of the supply and demand of Value Management (VM) in the United Kingdom, they have displayed the qualifications of ES to improve VM implementation. In addition, the implementation problems they examined in the UK showed that ES would best help overcome them. They also introduced a prototype called ESVMDOB (Expert System for VM in the Design of Office Buildings) which included a VM domain Knowledge to support decision-making.

Another example was the integration of the VE process with other computer applications like CAD (Computer Aided Design) and KBSs (Knowledge-Based Systems). Gargari and Elzarka (1998) introduced an integrated knowledge-based computer-aided design system that captures structural design-knowledge and cost information to generate several design alternatives. The system can generate new parameters for design, which could be imported from the CAD to produce several drawings. Improved cost estimates were generated allowing more alternatives to be compared for achieving the optimum design. The limited time of design schedule and budget was no more of concern, since the system could deal with a large number of design alternatives in short time. The lack of time, which was one of the major causes of unnecessary costs generated into the design, now could be significantly reduced (Gargari and Elzarka, 1998). Although, the authors concentrated on the use of computer technology to explore the feasibility of different design alternatives only, yet they have established the foundation for future inclusion of other capabilities like material management and scheduling capabilities.

In conclusion, due to the ever-increasing costs of construction, owners and users are looking for ways to reduce these costs without compromising quality, reliability, or maintainability. VE is one of the techniques that have proven its

effectiveness through the past several years. Through the study, several phases are performed where each phase relatively requires great time and effort. Often, time can be a significant factor in the success or failure of a VE study, especially if the study is made in the pre-construction stage where less time is available. From this standpoint, the desire to look for better ways to improve the VE process has led to the introduction of computer technologies and its integration with VE. Computer integrated systems not only can save time but can improve the VE process and make use of previous similar projects that can aid in the decision making of current projects.

Chapter 3: Value Engineering Approach

3.1 Introduction

The construction industry in Egypt represents a significant part of the country's economy where billions of pounds are spent each year on various construction projects. Many factors influence the cost of construction, which differ from one project to the next depending on the environment the project was brought up in. Owners and users of facilities consequently are the ones affected by the ever-increasing costs of construction. This led owners look for several techniques that will help reduce construction costs without affecting the quality, reliability, or maintainability of the facility. Value Engineering (VE) is one technique, which is considered a very efficient one.

This chapter primarily focuses on the VE concept and the methodology used in applying it. It further elaborates on the recommended job plan for effective VE implementation. Essentially, this chapter gives an in depth presentation of the VE concept which is utilized in this research.

3.2 What is Value Engineering?

Value Engineering (VE) has been introduced by many specialist as a systematic and organized approach that help identify areas of unnecessary costs, and provide its intended function at the lowest optimum cost whether it is a product or service. Miles, who was responsible for developing the VE program while working

with General Electric (GE), defined VE as, "a creative approach which has for its purpose the effective identification of unnecessary cost, i.e., costs which provide neither quality nor use nor life nor appearance nor customer features" (Barrie & Paulson, 1992).

Dell'Isola in his book defines VE as, "a creative organized approach whose objective is to optimize cost and/or performance of a facility or system" (Dell'Isola, 1982).

Zimmerman and Hart also define VE as, "a proven management technique using a systematized approach to seek out the best functional balance between the cost, reliability, and performance of a product or project" (Zimmerman & Hart, 1982).

The Society of American Value Engineers (SAVE) defines VE as, "the systematic application of recognized techniques which identify the function of a product or service, establish a monetary value for that function, and provide the necessary function reliability at the lowest overall cost" (Mudge, 1990).

Many designers think that VE is a way to criticize his design without looking into engineering principles. Therefore, to identify and explain the VE principle, Zimmerman and Hart (1982) stated that:

Value Engineering Is:

1- Systems Oriented – a formal job plan to identify and remove unnecessary costs.
2- Multidisciplined Team Approach – teams of experienced designers and VE consultants.
3- Life Cycle Oriented – examines the total cost of owning and operating a facility.
4- A proven Management Technique.

5- Function Oriented – relates function required to the value received.

__Value Engineering is Not:__

1- Design Review – it is not intended to correct omissions made in design, nor to review calculations made by the designer.

2- A Cheapening Process – it does not cut cost by sacrificing needed reliability and performance.

3- A requirement Done on All Designs – it is not a part of every designer's schedule review, but a formal cost and function analysis.

4- Quality Control – it does more than review fail-safe reliability status of plant product design.

3.3 History of Value Engineering

Value engineering is not a new program, yet it has been around since the late 1960s. It evolved during World War II at General Electric Company (GE) by Mr. Lawrence D. Miles, an electric engineer, who was responsible for material procurement in GE. Because of the war, shortage of material and labor forced the company to look for other substitutions. Products had to be manufactured using different materials but at the end had to do the same function. This led to the exploration of new inexpensive materials that substituted the old ones without affecting the function.

When the war was over both Erlicher and Miles found out that there should be some way to develop a mechanism that will help stimulate continuous alteration. This

led Miles to develop a technique for value analysis, which helped make significant improvements in the American industry using a more systematic approach. GE reported big savings, which reached sometimes 60-80 percent of project costs. Miles' program found wide acceptance all over the country and now he is referred to as the "Father of Value Engineering" (Zimmerman & Hart, 1982).

It was later in 1954 that the Navy's Bureau of Ships applied the concept of VE to its procurement department. In 1963, Dell'Isola was able to introduce the VE concept to the Navy Facilities Engineering Command as an incentive provision in all construction contracts. In 1964, many federal states and local government agencies adopted the VE program as part of its management programs. In 1965, the Army Corps of Engineers adopted VE program as will as including an incentive provision. It was in 1968 that VE requirements were utilized during design A/E contracts by the Public Building Service Agency. Following the lead, the Facilities Division of the National Aeronautics and Space Agency used VE programs during design. The Public Building Services later required VE be written into the required scope of work for Construction Management services. The Environmental Protection Agency in 1975 also required a VE provision in all granted wastewater treatment plant projects over ten million Dollars. The Department of Transportation followed the lead for their projects in 1976.

As in the private sector, the American Telephone and Telegraph Company (AT&T) adopted the VE program in all of its communication facilities. The same was true for Canada Bell System, Dravo, Morrison Kundsen, B. F. Goodrich, Corporate Engineering of Owners Corning Fiberglass, Sealand Services, Johns Manville, Ciba-Geigy, Union Carbide, and AIRCO.

As for foreign companies outside the USA, the Japanese have introduced the VE concept in 1970 through the auspices of the Institute of Business and Management of Tokyo. Italians also used VE programs in CHEMINT of Milan, which was in 1978. Then the Australians followed in 1979 through Brian Farmer of Woolworth, Inc., and McLachlan group of Sydney for Australian Mutual Provident (AMP) (Dell'Isola, 1982).

3.4 Factors that impact the cost of a project

Figure 3.1 shows major decision makers and the relative cost impact of each group on the facility.

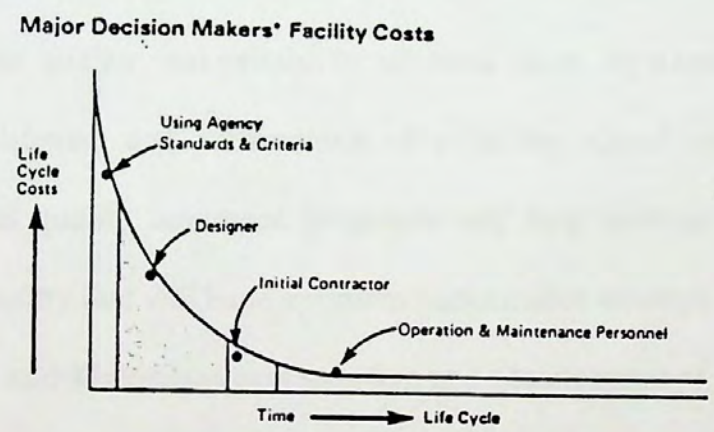


Figure 3.1 Major Decision-Makers of Facility Costs (Dell'Isola, 1982)

1- **Owner/User impact:** Both the owner and user of a facility have a great impact on the total life cycle cost. The owner or user determines the quality level, size, capacity, layout, etc. that has a direct effect on the project cost. Also, they can influence the operating and maintenance cost of a facility by assigning certain

staff and through specifying an estimated budget for performing this task which consequently affect the overall total project cost.

2- **Designers:** The designer has a significant impact on the total cost of a facility through the planning stage and the preparation of facility specifications. Under the direction of the owner or user, the architect or engineer work on preparing plans and list of specifications that will meet the owner's requirements. The selection of structural systems, architectural ideas, materials, energy allocation, etc. will strongly affect the life cycle cost of a facility. Therefore, it is important that effective coordination between the designer and the owner arise in order to reduce unnecessary costs.

3- **Contractors:** Also, contractors have a significant impact on the total cost of a facility. The quality and reliability of work done by a contractor will strongly affect the lifetime and performance of a facility. Good workmanship, quality control, and quality assurance programs will help produce a reliable and cost effective facility that will have optimum performance through its lifetime.

4- **Operation and Maintenance:** Operation and Maintenance of a facility represents the purchasing of materials and fuels required for running the necessary equipment and providing power. Also, hiring the right personnel that will maintain the facility, keep it running, and provide the necessary preventive maintenance. Therefore, it is important to provide the needed staff and prevent equipment failure in order to reduce the overall life cycle cost of the facility.

3.4.1 Total Cost of Ownership

Figure 3.2 illustrates the different blocks for a typical office building using a 40-year life cycle and an 18% interest rate. The total life cycle cost of a facility is the

sum of the design, construction, operation, maintenance, and replacement of the facility plus the debt service cost that fund the facility for a specified life cycle. It is important that owners and users look at the different areas of the life cycle cost of the facility when they are searching for potential savings. Yet, it is important not to affect other areas while reducing the cost of another.

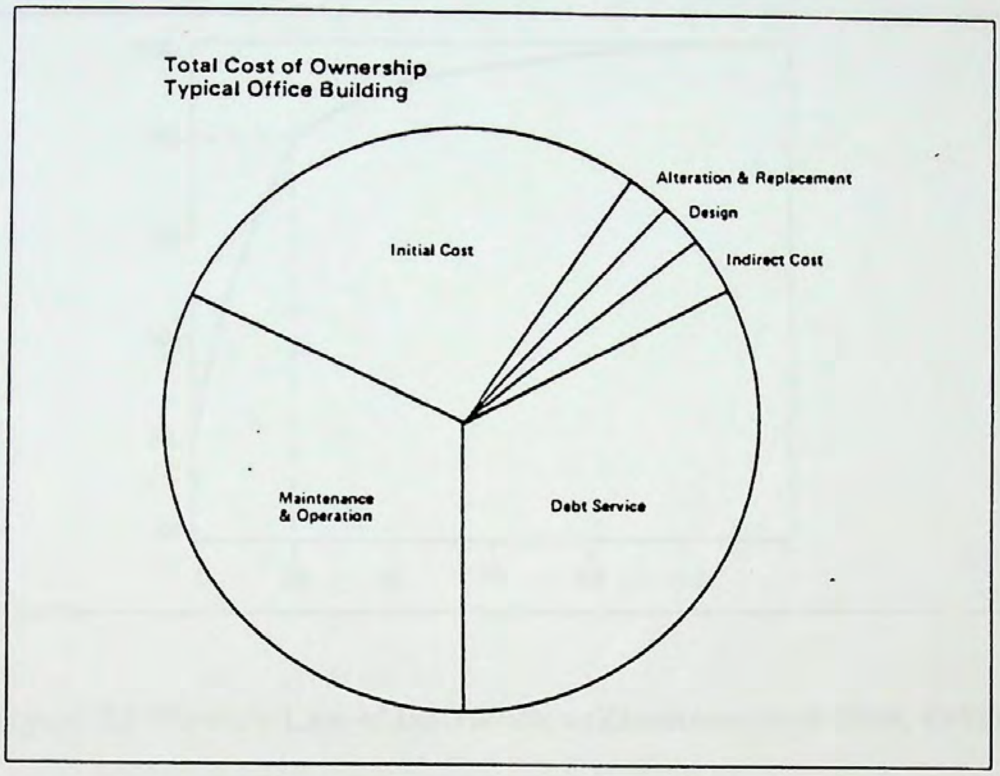


Figure 3.2 Life Cycle Costing – Typical Office Building (Dell'Isola, 1982)

3.4.2 The VE application phase

Facility cost reduction is a function of the time at which VE is applied. Figure 1.1 illustrates a graph showing the expected potential saving during each phase. The graph shows significant savings during early stages of planning and conceptual design. This is because recommended changes at the early stages usually have lower cost than late changes. Therefore, it is advisable to make early studies in order to provide maximum savings possible.

3.4.3 Pareto's Law of Distribution

Another important factor is the general rule which states that a small number of elements of a system or facility will contain the bulk of costs Figure 3.3. The rule states that, "approximately 20% of the elements of a system will contain 80% of the total cost." This will help value engineers concentrate their work and effort on these areas where potential savings are expected (Dell'Isola, 1982).

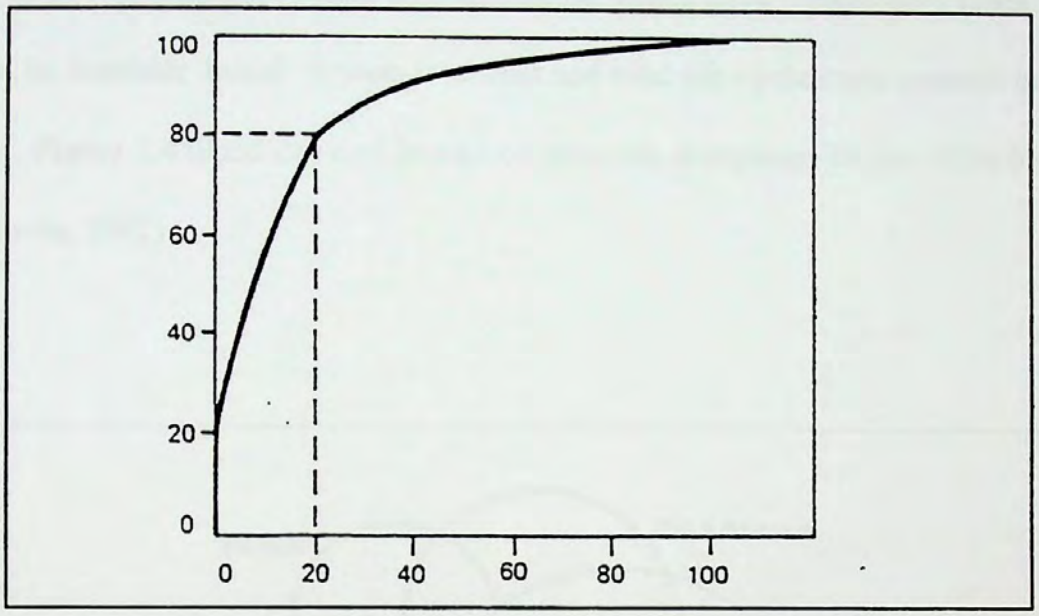


Figure 3.3 Pareto's Law of Distribution (Zimmerman & Hart, 1982)

3.4.4 Validity of Cost Estimates

In addition, another factor is how valid the project cost estimate is. Since, estimates significantly vary between owners and designers and since the whole VE study is based on the cost data, this can result in poor results. Moreover, the format of the cost estimates are not always standardized, which cause serious problems in the application of VE programs. The format should represent the estimated cost along each phase, like the budget phase, concept phase, design phase, working drawings phase and so on (Dell'Isola, 1982).

3.4.5 Cost Impact of Principal Disciplines

The impact of each principle discipline on the cost of the project is also important. This is because each discipline tend to work on his discipline part according to the owners requirements and later review the project focusing on his part without looking at the overall performance of the system. Moreover, there is a "reluctance" to challenge owner's requirements, which have unnecessary costs. Often failure to consider initial system total cost and total life cycle costs appears in many studies. Figure 3.4 illustrates cost impact of principle disciplines for an office building (Dell'Isola, 1982).

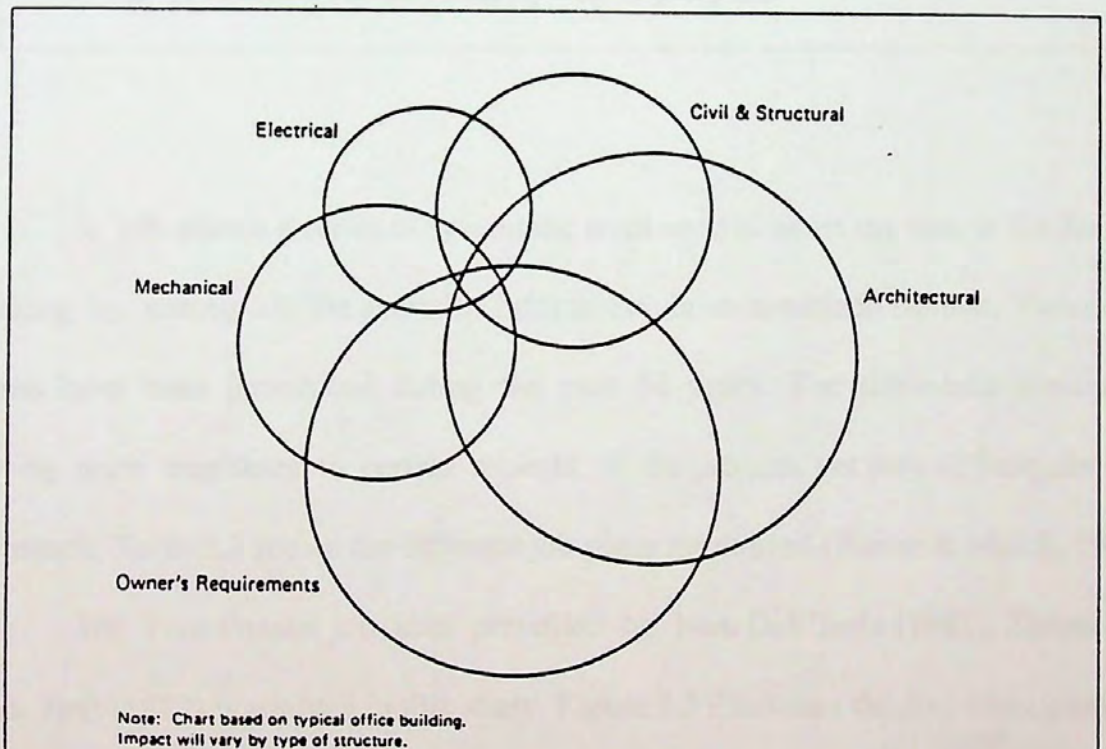


Figure 3.4 Cost impact of principle disciplines – Office Building (Dell'Isola, 1982)

3.5 Value Engineering Job Plan

VE makes use of several techniques that help implement the program successfully like function analysis, creative thinking, cost models, FAST diagrams, and evaluation matrix. These techniques fit into a job plan that follow an organized approach of thinking which help maximize the effectiveness of the VE study. The job plan helps identify high cost areas and help remove unnecessary costs without affecting the quality. This job plan provides the VE with (Zimmerman & Hart, 1982):

- **a. Organized approach**
- **b. Objective approach**
- **c. Universal approach**
- **d. Forces people to think deeper than their normal habit solution**
- **e. It zeroes in on high cost areas**
- **f. It forces a concise description of purpose**

A job plan is a series of systematic steps used to assist the user in his decision making by stating all the available information in an organized fashion. Various job plans have been introduced during the past 30 years. The difference is mainly in giving more emphases to certain aspects of the process, yet they all have the same approach. Table 3.1 shows the different job plans introduced (Barrie & Mulch, 1977).

The Five-Phases job plan presented by both Dell'Isola (1982), Zimmerman and Hart (1982) is adopted in this study. Figure 3.5 illustrates the five basic phases of the job plan presented by Dell'Isola. Figure 3.6 shows a flow chart for the VE procedures starting from the information phase and ending with the preparation of the final report.

Table 3.1 Job Plan Category Comparison (Barrie and Paulson, 1992)

JOB PLAN CATEGORY COMPARISON

Dell'Isola*	GSA-PBS P 8000.1 1972	L. D. Miles† 1961	L. D. Miles‡ 1972	E. D. Heller§ 1971†	A. E. Mudge¶ 1971	PBS VM Workbook 1974
Information	Orientation	Orientation	Information	Information	Project selection	Information
Speculation	Information	Information	Analysis	Creation	Information	Function
Analysis	Speculation	Speculation	Creation	Evaluation	Function	Creative
Proposal	Analysis	Analysis	Judgment	Investigation	Creation	Judicial
	Development	Program planning	Development	Reporting	Evaluation	Development
	Presentation	Program execution		Implementation	Investigation	Presentation
	Implementation	Summary and conclusion			Recommendation	Implementation
	Follow-up					Follow-up

*A. J. Dell'Isola, *Value Engineering in the Construction Industry*, Construction Publishing Corp., Inc., N.Y. 1974.
†L. D. Miles, *Techniques of Value Analysis and Engineering*, 1st ed., McGraw-Hill, New York, 1961.
‡L. D. Miles, *Techniques of Value Analysis and Engineering*, 2nd ed., McGraw-Hill, New York, 1972.
§E. D. Heller, *Value Management. Value Engineering and Cost Reduction:* Addison-Wesley, Reading, Mass., 1971.
¶Arthur E. Mudge, *Value Engineering*. McGraw-Hill, New York, 1971.

Phases of the Value Analysis/Engineering Job Plan

Information

Objectives
- Provide an information base
- Select areas for detailed study

Questions
- What is it?
- What must it do?
- What does it cost?
- What is it worth?

Techniques
- Information gathering
- Functional analysis
- Cost-Worth Concept
- Graphics
- Cost & Energy Modeling

Speculative

Objective
- Generate alternatives for meeting requirements

Question
- What else will perform the required function?

Technique
- Creative thinking processes (eg. brainstorming)
- Deferred judgement

Analytical

Objective
- Evaluation and selection of best cost saving alternatives

Questions
- What will the alternatives cost?
- Will the alternatives meet the required functions?
- What proposals have greatest cost savings?

Techniques
- Life cycle costing
- Weighted constraints evaluation'
- Idea ratings

Proposal

Objective
- Presentation of best alternatives to the decision maker

Question
- How best to present proposals?

Techniques
- Narrative reports
- Schematic overlays
- Graphics

Final Report

Objective
- Define and qualify results

Question
- What was implemented?

Techniques
- Bid analysis
- Life cycle costing
- Post occupany evaluation (optional)

Figure 3.5 Value Analysis/Engineering Job Plan (Dell'Isola, 1982)

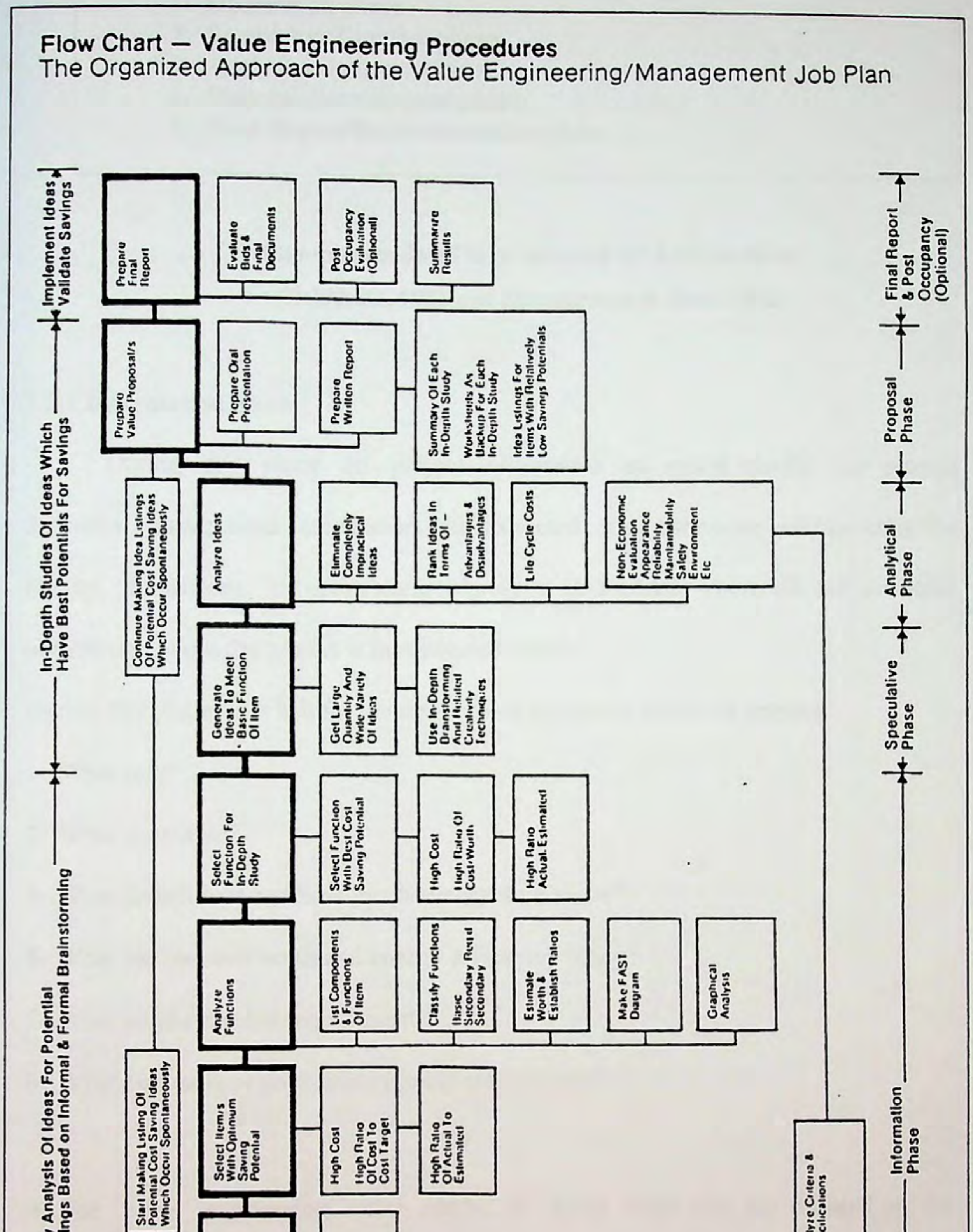


Figure 3.6 Flow Chart – Value Engineering Procedures (Dell'Isola, 1982)

1- Information phase
2- Speculative/Creative phase
3- Analytical/Judgment phase
4- Proposal/Development phase
5- Final Report/Recommendation phase

Five-phases Job Plane adopted by both authors

(Dell'Isola, 1982 and Zimmerman & Hart, 1982)

3.5.1 Information Phase

During this phase all project information are stated clearly like project definition, background information, the expected costs for owing and operating the facility, limitations or constraints. Mainly it is a phase where all the available information about the project is investigated clearly.

During this phase, it is helpful to answer these questions about the project.

1- What is it?

2- What does it do?

3- What does it cost and how much energy does it use?

4- What are the cost/worth and energy efficiency ratios?

5- What are the needed requirements?

6- What high-cost or poor-energy areas are indicated?

- The value engineering team needs to know what was the rational in the development of the design. What were the assumptions used to establish the design criteria in the selection of the material, equipment, method of construction, and so on.

- The team also needs to know how long was that design been used. This will help indicate whether they should use new material and method of construction or just stick to that design.
- Investigation of different alternatives, systems, materials or methods should be clearly stated. Since the system which could have been rejected several years ago because of construction difficulties, can be highly adequate today and might even result in optimum performance.
- Any special problems that might appear in the project should be clearly stated so that to avoid from the start.
- If the design has been repeated before several times, then potential savings should be weighted against the VE study cost. If the savings did not exceed the cost by several times then the study should be dropped.

Figure 3.7 illustrates a filled out information sheet for a VE study for a wastewater treatment plant (Dell'Isola, 1982).

3.5.1.1 Cost Analysis

During the information phase, it is important to adapt a unified cost model that will help present cost data in a more systematic and organized way. All the costs that are used by the VE team are life-cycle costs. These cost data are presented by the designer of a project, where they are studied by the VE team and compared for possible discrepancies or high deviations. Cost is the foundation for attaining value for all the work presented by the different disciplines in the project. Therefore, it is important to have as much accurate cost information as possible, since all VE programs will be based on it.

Team No. 1 - Layout	April 24 to April 28, 1978
Study No.	Study Date (from – to)

Wastewater Treatment Plant Expansion - Maryland
Study Title

Name	Title	Symbol	Telephone No.
Team Leader:			
A. Dell'Isola	Smith, Hinchman & Grylls		202-296-4090
Team Members:			
1. John Walter	Sanitary Engineer		301-823-8000
2. Bill Henning	Project Engineer		301-823-8000
3. Walter DeRieux	Sanitary Engineer		301-383-8000
4. Viet Hong	Civil Engineer		301-383-8000

Describe Problem To Be Studied (existing procedure, design, system)

The existing W.T.P. plant is a two-stage highrate trickling filter process incorporating the recirculation of both effluent and secondary sludge. The treatment and disposal of waste solids is accomplished by anaerobic digestion and the lagooning of digested sludge. The facility has nearly reached the design capacity of 4.0 MGD.

The present facility is to be up-graded to handle 5 MGD and is to be designed to function in conjunction with the proposed new 5 MGD to provide a total plant capacity of 10 MGD. The design, includes a headwork area consisting of a mechanical bar screen, raw sewage pumping station, comminutor, grit removal chamber, primary/ clarifiers, carbonaceous first stage reactor, first stage clarifiers, second stage nitrification reactor, second stage clarifiers, and chlorine contact tank. The effluent will be pumped and discharged approximately 2400 feet out into the river. The sludge treatment and handling equipment includes gravity thickeners, dissolved air flotation thickeners, associated pumps, anaerobic digesters and rotary vacuum filtration units. It is proposed to truck the treated sludge to a land fill some 15 miles away. Present plans include an on-site oxygen generator driven by electricity to supply the reactor needs.

Support facilities such as the laboratory building, chlorinator building, pump buildings and maintenance vehicle and service buildings are to be heated and air conditioned as appropriate by electrical energy. Use of waste gas from the digesters, after the process needs are served, is contemplated for heating and cooling the support facilities where practicable. The excess gas will be burnt-off. The effluent limitations and quality of effluent discharge must, as a minimum, meet the following criteria:

Figure 3.7 Format for gathering information – Example of Wastewater Treatment Plant (Dell'Isola, 1982)

There are two types of cost models commonly used by Value Engineers. One is the matrix cost model that separates the project into two classifications, one by construction trade and the other, by various elements, systems, and subsystems. Figure 3.8 illustrates a form for value engineering cost matrix. The other type divides the project into systems and subsystems only, see Figure 3.9. Depending on the type of project, cost is introduced in terms of cost/unit.

Both models follow the Construction Specification's Institute (CSI) format also called the "Uniformat". This format is widely used in automated cost control and estimating procedures oriented for the design control. It has greater application for the designers, as it breaks down the functional area to systems, subsystems, items, components, and so on. Figure 3.10 shows a functional cost model for a Health Care Facility based on the Uniformat system that is recommended in VE studies (Zimmerman & Hart, 1982).

3.5.1.2 Function Analysis

Function is defined as, "the specific purpose or intended use for an item or design, it is that characteristic which makes it work, sell, produce revenue, or meet mandatory owner/user requirements" (Dell'Isola, 1982). Zimmerman and Hart (1982) define function analysis as, "function analysis helps to identify what we really want to do and how much we really should have to pay for doing it." Miles define function as: "The basic purpose of each expenditure, whether it be for hardware, the work of a group of men [people], a procedure, or whatever is to accomplish a function."

Function analysis is the most important part of VE study. Since, it is the bases for defining the work done and the requirements for the project. It is a method of

COST MATRIX FOR WASTEWATER TREATMENT PLANT

Item No.	Description	Liquid System: Influent Facilities	Liquid System: Primary Clarifier & Pump Sta.	Liquid System: R.B.C.'s	Liquid System: Final Clarifier & Pump Sta.	Liquid System: Effluent Pump Sta. & Chem. Storage	Solids System: Sludge Processing Bldg	Solids System: Thickener	Support System: Tunnel	Support System: Control Bldg	Support System: Site Work	Percent	Totals
1	Major Equipment	150,000	194,400	1,142,000	176,500	617,900	841,400	198,000	-0-	37,500	-0-	30.7	3,367,700
2	Concrete	92,500	349,500	337,500	378,750	184,000	179,000	125,000	117,050	90,200	-0-	16.9	1,853,500
3	Site Work	2,000	259,500	119,500	311,500	65,000	43,000	39,500	-0-	4,000	826,000	15.2	1,670,000
4	Piling; 60 Ton	36,000	146,700	234,000	144,000	139,300	117,900	95,400	32,400	84,600	15,300	9.5	1,045,600
5	Architectural	12,000	-0-	-0-	-0-	278,500	185,000	-0-	-0-	328,800	-0-	7.3	804,300
6	Electrical	3,000	45,000	90,000	45,000	270,000	35,000	35,000	10,000	60,000	20,000	5.6	613,000
7	Inside Piping	35,000	75,600	-0-	50,300	180,000	30,200	41,300	41,200	-0-	-0-	4.1	453,600
8	Outside Piping	-0-	34,600	-0-	55,000	-0-	-0-	-0-	-0-	-0-	287,500	3.4	377,100
9	Instrumentation	10,000	15,000	10,000	15,000	60,000	40,000	10,000	-0-	140,000	-0-	2.7	300,000
10	Misc. Equipment	60,000	10,500	75,000	37,000	-0-	15,000	-0-	-0-	20,000	-0-	2.0	217,500
11	HVAC	5,000	2,600	2,600	2,600	15,000	60,000	2,600	2,600	112,000	-0-	1.9	205,000
12	Plumbing	1,000	2,000	2,000	2,000	2,000	12,000	2,000	1,000	36,000	-0-	0.7	60,000
	COST	406,500	1,135,400	2,012,600	1,217,650	1,841,700	1,558,500	548,800	204,500	913,100	1,148,800	100.0	10,987,300
	PERCENT	3.6	10.3	18.3	11.1	16.8	14.2	5.0	1.9	8.3	10.5		
		60.1					19.2		20.7				
										Contingencies 20%			2,197,700
										Total			13,185,000

Taken from a study conducted by Arthur Beard Engineers, Inc and Greeley and Hansen.

Figure 3.8 Completed Cost Matrix for a Wastewater Treatment Plant (Zimmerman and Hart, 1982)

Development Phase

Item	Quantity		Labor		Material		Total Cost
	No. Units	Unit Meas.	Per Unit	Total	Per Unit	Total	
FOUNDATION							47,242
SUBSTRUCTURE							54,510
SUPERSTRUCTURE							163,530
EXTERIOR CLOSURE							190,785
ROOFING							79,212
INTERIOR CONSTRUCTION							190,785
MECHANICAL							236,210
ELECTRICAL							127,190
GEN. COND., OVUD. & PROFIT							156,262
SITE WORK							152,628
TOTAL							1,398,354
CONTINGENCY 5%							69,917
TOTAL							1,468,271

Figure 3.9 Cost Summary Worksheet – Level 1 (Dell'Isola, 1982)

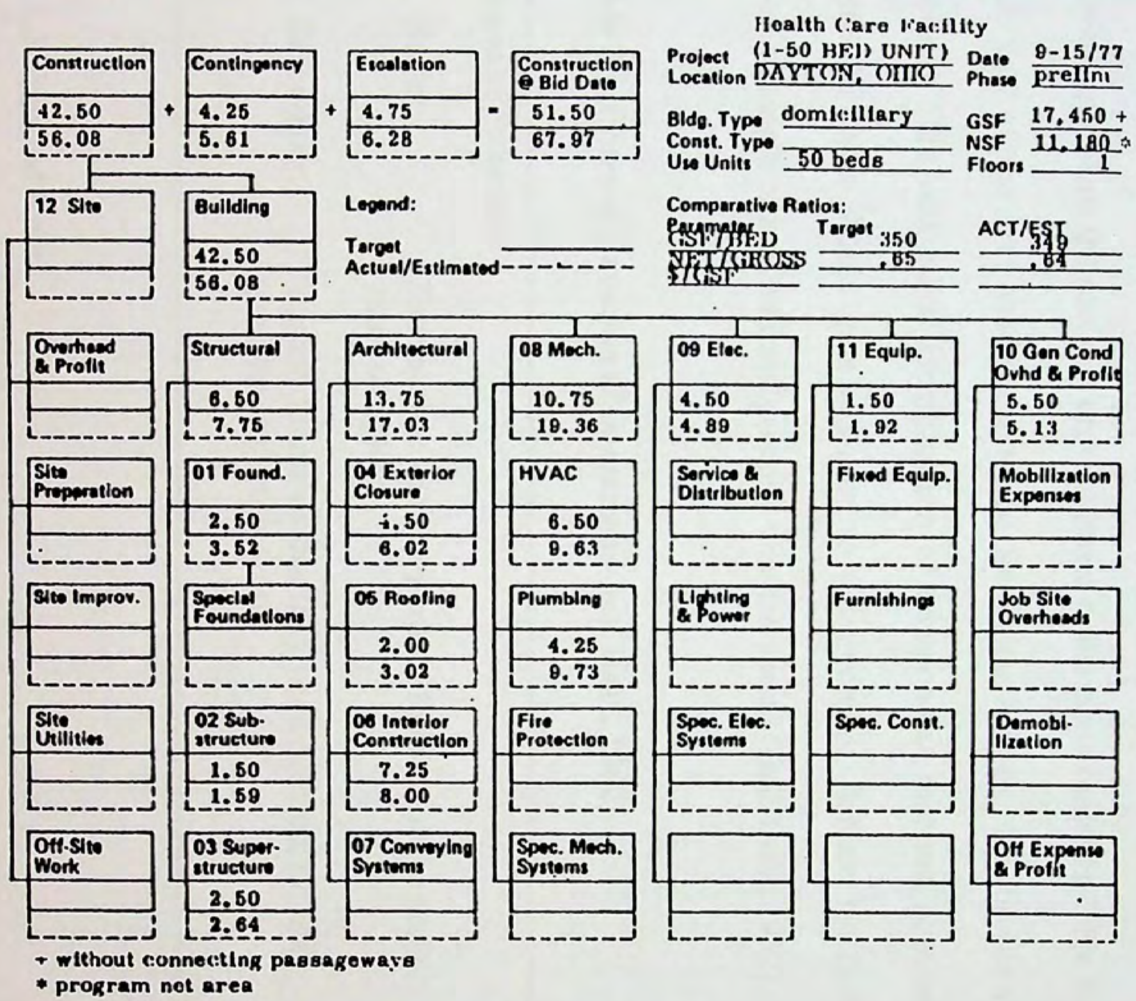


Figure 3.10 Cost Model of a Health Care Facility (Zimmerman and Hart, 1982)

clearly identifying the role of each item or component of a project by stating what does it do. This help separate those areas that provide secondary support more than performing the main requirement.

The first step in performing function analysis is to identify the basic and secondary functions of the project, systems, subsystems or the area analyzed. The basic function represents part that performs the primary task, while the secondary function represents the part that only augment to the basic function Table 3.2.
Each part of the area studied is tested for being a basic function or a secondary function. This will allow identification of components that are nonessential, and where VE team should give attention to (Zimmerman & Hart, 1982). Figure 3.11 shows a sample of function analysis of a wooden pencil (Dell'Isola, 1982).

Table 3.2 Types of Function (Zimmerman and Hart, 1982)

Types of Function:	
- **Basic:**	The specific work or purpose the product or project must complete.
- **Secondary:**	Support functions that may be needed but do not perform the actual work.

3.5.1.3 Types of Value

The dictionary defines "value" as the "worth of a product or thing." Value is that elusive commodity that we all attempt to achieve in our design. There are four kinds of value:

Use Value: the value received from the delivered function. It usually represents the properties and qualities which perform a function.

Project: *Function Analysis* | Item: *Pencil* | Basic Function: *Make marks* | Date: *April '80*

Quantity	Unit	Component	Function: Verb	Function: Noun	Kind	Explanation	Original Cost	Worth
		Pencil	Make	Marks	B		$.14	
		Eraser	Remove	Marks	S		.02	
		Ferrule	Hold	Eraser	S		.01	
		Wood	Hold	Lead	S		.05	
		Paint	Protect	Wood	S		.01	
			Provide	Beauty	S			
		Markings	Identify	Product	S		.01	
		Graphite	Makes	Marks	B		.04	0.04
		Carbon						
						Cost/Worth Ratio =		
						$^{14}/_{4}$ = 3.5		

Figure 3.11 Function Analysis of a Wooden Pencil (Dell'Isola, 1982)

Esteem Value: which encompasses our emotional regard for the item which we are purchasing.

Exchange Value: is the amount that we are willing to accept in trade for an item.

Cost Value: is the amount of money that we are willing to incur to produce an item.

There are other types of values that are used to assess the social qualities of our society. These values are difficult to quantify. Both quantifiable and non-quantifiable values are used in the VE study. One tool that is used to analyze non-quantifiable values is the weighted matrix analysis, which help analyze the different alternatives, based on abstract non-measurable means.

3.5.1.4 Criteria (Evaluating Value)

There are a number of criteria used to evaluate the value of a product or an item in a project. Many people in a VE study evaluate the criteria used to judge an item. The owner, purchaser, designer or engineer will be involved in the evaluation and each individual will have a different opinion that will usually serve his interest. The criteria upon which evaluation of value is executed are (Zimmerman and Hart, 1982):

- Initial cost
- Energy cost
- Return in profit
- Functional performance

- Reliability
- Operability
- Maintenance ability
- Quality
- Salability
- Regard for aesthetics and environment
- Owner requirements
- Safety

3.5.1.5 Cost/Worth Evaluation

Cost: What we are paying for the item. (Engineers Estimate)

Worth: Least cost for performing the function. (What ideas do we have that will perform the function at a lower cost)

The cost is used in function analysis and it is usually based on the engineer's estimate. All detailed project costs are usually available in the cost model explained earlier. Next, we assign worth to that component or item which represent the least cost for performing the required function. During this process generation of new alternatives take place, since all team members work hard to find other methods and alternatives that will substitute that part which help diversify thinking. After, doing the same thing to all the parts of the project or item being studied, a comparison of the total cost of the project divided by the total worth is performed for those basic functions only. The ratio generated is called the cost-to-worth ratio. If the ratio is greater than two, then potential saving usually is expected. Figure 3.12 illustrates an

FUNCTION ANALYSIS

ITEM #	DESCRIPTION	FUNCTION			COST	WORTH	COMMENTS
		VERB	NOUN	KIND			
	Excavation	Prepare	Site	S	491	0	
	Piles	Transfer	Load	S	1,029	0	
	Footings	Distribute	Load	S	422	0	
	Shafts	Elevates Sets Collect	Load Clearance Load	S	598	0	
	Spanning Members	Support	Deck	S	2,121	0	
	Bridge Deck	Supports	Traffic	B	968	968	
	Parapets	Protect	Traffic	S	157	0	
	Approach Embankments	Elevates Supports	Roadway Pavement	S	366	0	
	Roadway-Surfacing	Supports	Traffic	S	156	0	
	Drainage	Directs	Flow	S	28	0	
	Expansion Joints	Allows	Movement	S	32	0	

ACTION VERB
MEASURABLE NOUN

KIND: B = Basic; S = Secondary

(Basic Function Only)
Cost/Worth Ratio = ______

Cost in thousands

PROJECT ______
LOCATION ______
CLIENT ______
DATE ______
PAGE ______ OF ______

INFORMATION PHASE

FUNCTION ANALYSIS

ITEM : Bridge
FUNCTION : Support Traffic

WORKSHEET Nº 2

Figure 3.12 Example Function Analysis of a Bridge (Zimmerman and Hart, 1982)

FUNCTION ANALYSIS

PROJECT ______
LOCATION ______
CLIENT ______
DATE ______
PAGE ______ OF ______

INFORMATION PHASE

FUNCTION ANALYSIS

ITEM : Bridge
FUNCTION : Support Traffic

ITEM #	DESCRIPTION	FUNCTION: VERB	FUNCTION: NOUN	FUNCTION: KIND	COST	WORTH	COMMENTS
	Protective Coatings	Reduce Provide Protects	Maintenance Aesthetics Structure	S	100	0	
	Bridge Bearings	Support Anchor	Structure Structure	S	15	0	
	Misc. Road Items	–	–	S	55	0	
	Lighting	Provides	Safety	S	25	0	
	Mobilization	Prepares	Construction	S	90	0	
					6653	968	

ACTION VERB
MEASURABLE NOUN

KIND: B = Basic; S = Secondary

(Basic Function Only) Cost/Worth Ratio = $\frac{6653}{968} = 6.9$

WORKSHEET № 2

Figure 3.12 Example Function Analysis of a Bridge – Cont. (Zimmerman and Hart, 1982)

example of completed function analysis of a highway bridge (Zimmerman & Hart, 1982).

The results of the functional analysis table can be converted into a graphical representation to ease up communication. It is illustrated in bar chart format moving from the highest cost item to the lowest. Every item will be identified by its function for clear representation. Other parameters such as cost and worth can be illustrated to show areas of potential savings and cost-effective items. Figure 3.13 illustrates a graphic function analysis (Zimmerman & Hart, 1982).

3.5.1.6 Function Analysis System Technique (FAST)

FAST was first developed by Charles W. Bytheway, who was a Value Engineer and Cost Reduction Administrator for UNIVAC of Salt Lake City, Utah. He introduced this technique in a paper for the SAVE (Society of American Value Engineers) 1965 National Meeting in Boston.

The FAST technique is "a systematic roadmapping of functions." It is a well-established mechanism that helps analyze sophisticated projects and illustrates its functional components. FAST is used in the construction industry to simplify project components and clearly identify the relation between each component. In addition to its analysis capabilities, FAST is used as a problem solving mechanism by identifying the required function to be performed and all the secondary supporting functions. FAST has helped in eliminating, modifying or sometimes reducing unnecessary functions (Zimmerman & Hart, 1982).

FAST helps to pinpoint problems and sub-problems of situations. It also assists in finding the right problem without wasting time in other problems. By breaking down the problem into small parts that are easy to manage and fast to

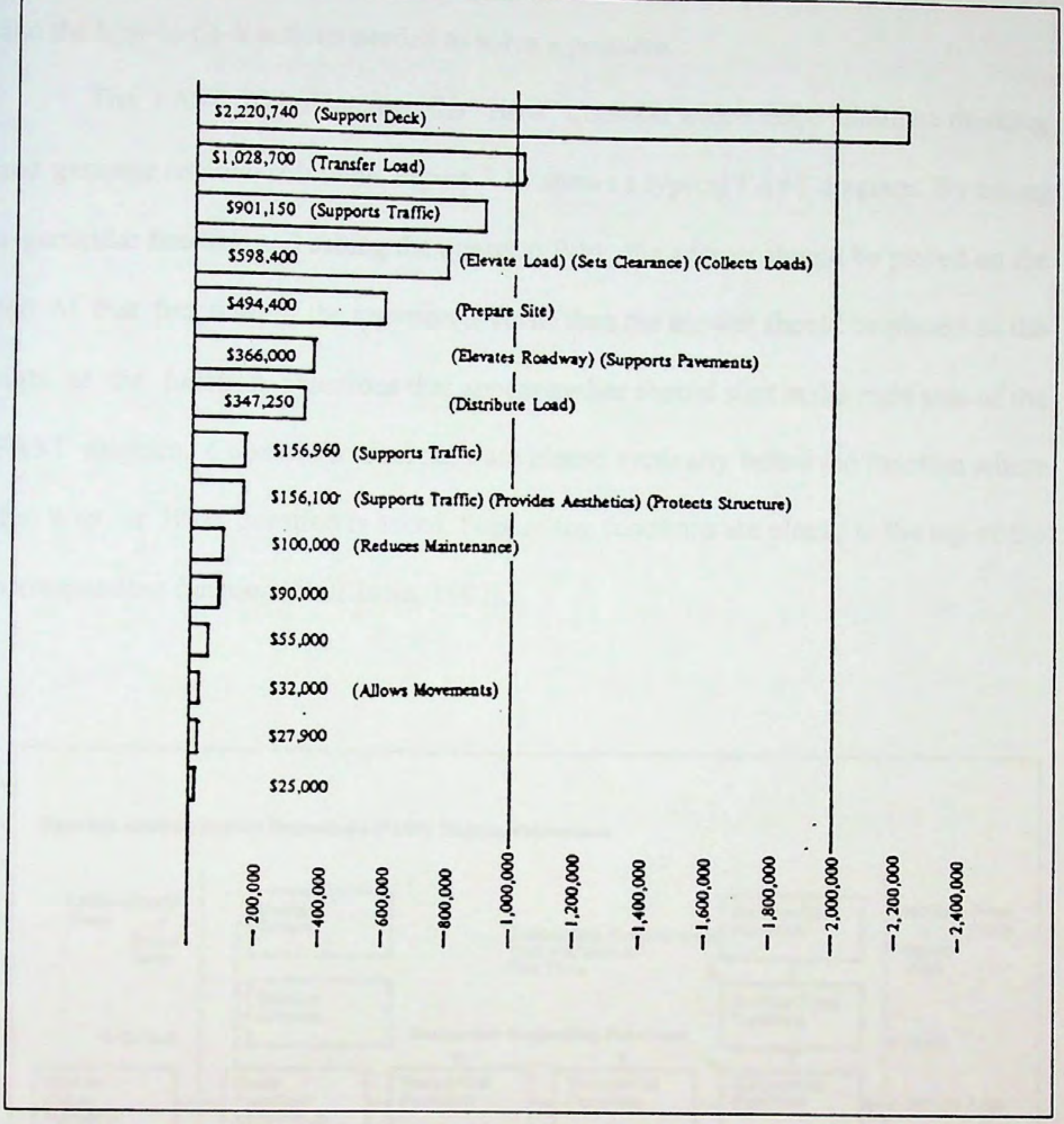


Figure 3.13 Graphical Cost Model-Function Analysis of a Bridge (Zimmerman and Hart, 1982)

handle. Moreover, it helps provide equal attention to high-level aspects of a problem and the how-to-do-it actions needed to solve a problem.

The FAST technique uses the "How" question which helps stimulate thinking and generate creative solutions. Figure 3.14 shows a typical FAST diagram. By taking a particular function and asking the question Why, the answer should be placed on the left of that function. If the question is How, then the answer should be placed on the right of the function. Functions that appear earlier should start at the right side of the FAST diagram. Concurrent functions are placed vertically below the function where the Why or How question is asked. Supporting functions are placed to the top of the corresponding function (Dell'Isola, 1982).

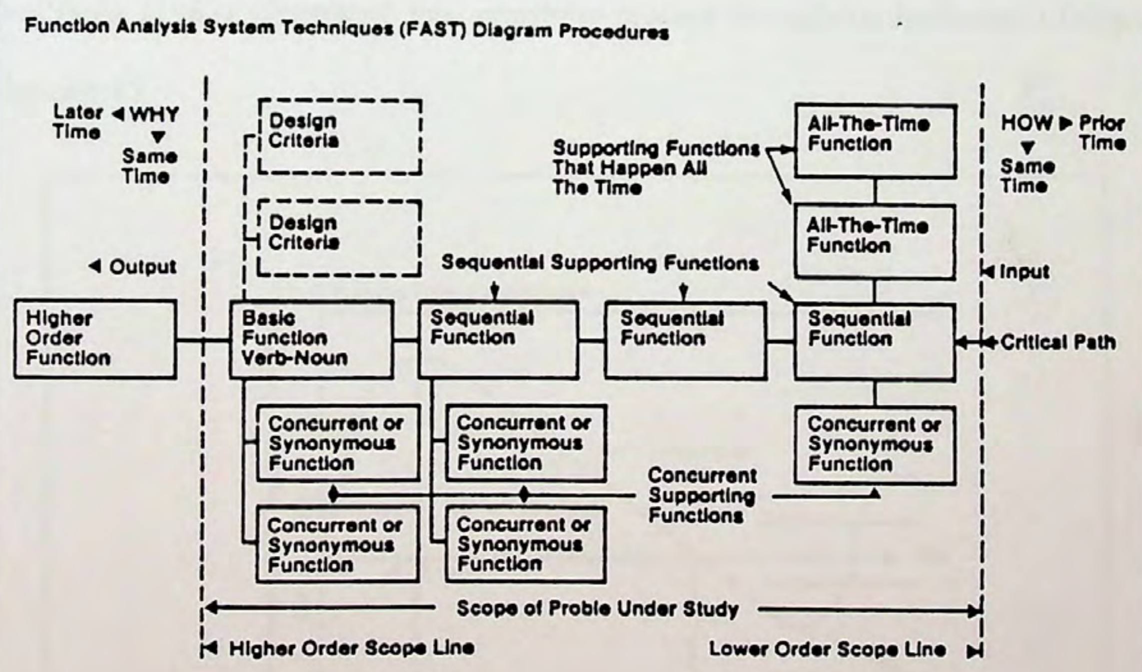


Figure 3.14 Typical Fast Diagram (Dell'Isola, 1982)

3.5.2 Speculative/ Creative phase:

After identifying areas of potential savings through the previous phase, generation of new alternatives that will perform the necessary function is anticipated. New ideas are generated using different creative and problem solving techniques. These ideas will serve as possible alternatives that not only will decrease cost but also may increase the overall performance of the project.

Creative thinking is," a product of imagination where a new combination of thoughts and things are brought together." Creative thinking is considered a way of overcoming problems by generation of new ideas that will solve these problems. Creative techniques are used to stimulate and help bring up new ideas. These ideas will help improve and optimize projects. The challenge is not in idea generation as much as in ways to evaluate and find the best one to use (Zimmerman & Hart, 1982). Dell'Isola (1982) illustrated the creativity process throughout the human lifetime in Figure 3.15.

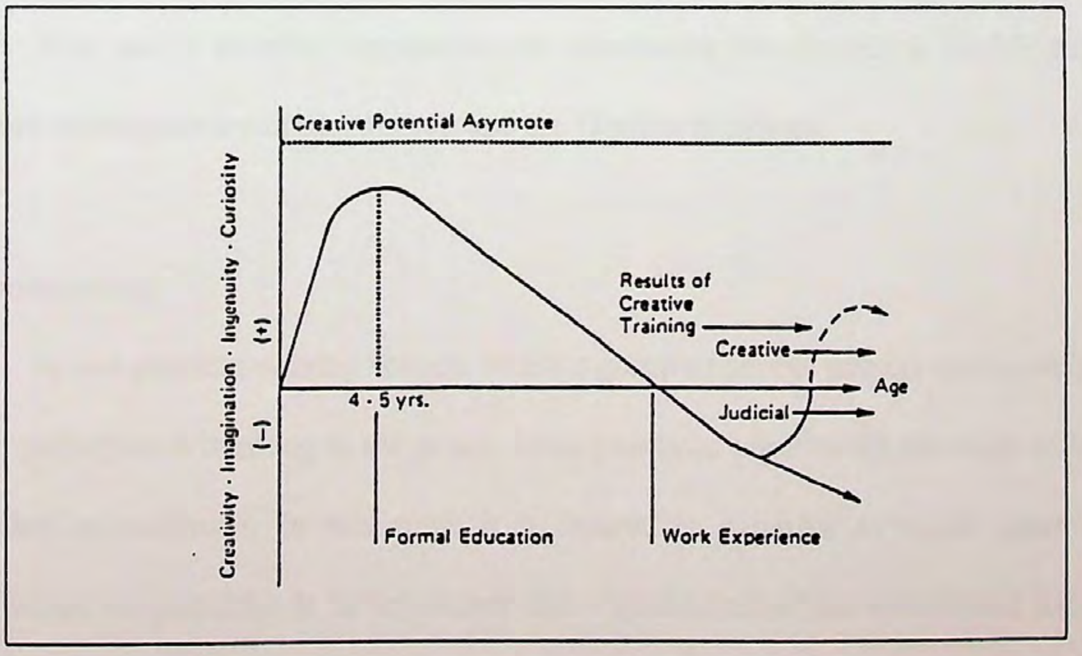


Figure 3.15 Creativity Process (Dell'Isola, 1982)

3.5.2.1 VE and Creativity

Creativity is applied in the VE program to come up with different ways to accomplish the objective and purpose of each phase in the job plan. In the information phase, creativity is used to clearly define the value problem and to evaluate the feasibility of making a value study; also, to better identify the function of each item being studied. In the creative phase, creativity is utilized to bring up different alternatives that will provide the same basic function with less cost. In the analytical phase, creativity is utilized to objectively judge and assess the different alternatives and find the anticipated obstacles to the intended alternative if implemented. In the proposal phase, creativity is used to help "sell" the reached solution in the VE study and know ahead of time problems that might be faced when the proposal is presented (Dell'Isola, 1982).

3.5.2.2 Creativity Approaches

Two major creative approaches are introduced that can help in the VE study. The two techniques are brainstorming and the Gordon technique.

Brainstorming:

It is a problem-solving session where a group of people gathers and stimulates each participant's thinking in the group. Ideas produced are directly recorded without criticism or judgment. In this stage it is desired to generate as much ideas and alternatives as possible. It is important that "ground rules" are established prior to starting the session, these rules are:

1- No criticism of ideas
2- "Free wheeling" is encouraged
3- A large quantity of ideas is desired
4- Combination and improvement of ideas is sought
5- All ideas should be recorded

Procedures of Brainstorming

1- **Checklisting:** checklists are used to help stimulate thinking and as a question reminder, yet it is important not to allow it to restrict thinking.
2- **Combining:** try to take two ideas or more and combine them together to reach a "relatively new" different idea.
3- **Idealizing:** try to think of one or more "ideal" or "nearly ideal" answers for the subject assessed.
4- **Imitating:** try to come up with similar things that could be the bases for a new idea.
5- **Modifying:** by modifying an idea from the checklist that have been already prepared to generate a "relatively new" idea.
6- **Morphological Analyzing:** By using a three-dimensional grid that help list three things that when combined will result in a new idea.
7- **Piggybacking:** using one of the ideas already in the checklist as the bases for generating a new idea.
8- **Role Projecting:** By imagining yourself that item you are studying, you ask your self, what would you do or be doing? and, how could it be improved?

9- **Unusualizing:** By trying to think of unusual ideas even if they seem "impractical", they may be helpful to you or other individuals in the group to generate new ideas.

10- **Group Formation**: Attention and care should be given when choosing group members and recording secretary.

If the number in the group exceeds eight persons, then they should be divided into two or more groups for better performance. A group of two to eight is usually advisable (Dell'Isola, 1982).

Gordon Technique:

The Gordon technique is totally opposite to the brainstorming. In this technique, the group leader is the only person who knows the exact nature of the problem. The leader of the session works on guiding the team through constructive discussion until they reach the best solution. The leader makes sure that all possible solutions are explored before identifying the exact solution (Zimmerman & Hart, 1982).

3.5.3 Judgement/Analytical Phase

During this phase screening of alternatives and ideas previously generated in the creative phase is performed. The ideas are developed into lower-cost ideas or energy-saving ideas and listed in descending order. All ideas are carefully studied and those that are impractical are eliminated. Different methods of combining and consolidating of ideas are used whenever feasible. Ideas that don't abide by the owner requirement are dropped. If the idea is far from being implemented because of

technological difficulty for example, then it is put aside for later discussion of manufacturing possibilities.

All the advantages and disadvantages of each idea are listed in a worksheet and those ideas showing higher potential advantage over disadvantage are chosen for further evaluation. The group work on overcoming the disadvantages of those ideas to make them acceptable. It is advisable during this phase to consult different disciplines that can help solve different problems faced.

3.5.3.1 Idea and Cost Comparison

Figure 3.16 illustrates an example of a worksheet used in judging and evaluating effective ideas. Idea rating is utilized in this phase to evaluate ideas. It starts from 1, the best idea, to 10, the poorest idea. Figure 3.17 shows an idea comparison worksheet for an HVAC system.

It is also required that the VE team perform cost comparison on the different ideas selected in order to make sure that the ideas presented are truly less costly. Yet, the idea chosen should perform the same basic function without reducing the quality, reliability, or maintainability. The cost comparison is mainly done based on the idea total cost, which is the initial cost added to it the operation and maintenance cost. This is because in some cases, the initial cost could be lower but the total cost is much higher due to the high operational and maintenance cost. Figure 3.18 shows a worksheet that illustrates total life-cycle costs for an HVAC system (Dell'Isola, 1982).

Judicial Phase

Study No.

Select the most feasible ideas or combination of ideas. List them below. List both the advantages and disadvantages of each idea to determine where additional work must be done.

Idea	Advantage	Disadvantage	Rank
List potentially workable ideas related to basic function and action required to develop ideas.	*Such as: Low cost, simplicity, light weight, standard part, mass produced, easy to repair, low maintenance, reusable.*	*Such as: Not fully developed, limited availability. In some cases, opposites of advantage list.*	*Use a rating system of 1 to the limit of ideas, 1 being the best idea.*

Keep An Open Mind

Indicate what ideas are to be given further consideration. Check latest information from trade associations, technical societies, research reports, commercial or government specialists, user or agency requirements, etc., as means to confirm the potential of the ideas.

Figure 3.16 Idea comparison format for the analytical phase (Dell'Isola, 1982)

HVAC SYSTEM (AIR HANDLING)

Judicial Phase

Study No.

Select the most feasible ideas or combination of ideas. List them below. List both the advantages and disadvantages of each idea to determine where additional work must be done.

Idea	Advantage	Disadvantage	Rank
1. rooftop (VAV)	less cost & space	maintenance	1
units	less architectural		
	more flexible		
2. adjustable speed fan	better turn	higher cost	7
	DW control		
3. direct drive vane axial fans	less cost than other	noiser, have	6
	type fans, less	to acoustical	
	maintenance lighter	treat	
	weight		
4. Air intakes and exhaust louvers	save space & cost	aesthetics	8
5. in the space fan coil units	save cost	increase maint.	5
with separate vent. syst.	greatly decreased	add'l piping	
	size of AHU system	noiser	
	possible energy sav.		
6. VAV reheat for perimeter heating	elim. perimeter	central system	4
	run and floor space	must run for	
		heating possible	
		add'l cost	
7. VAV induction for peri. heating	energy savings	higher PD	3
	better repair circ.	cost savings.	
8. Individual fan rooms ea. floor	reduce shaft req'mts	increase maint.	2
	individual fl. control	more space	
	flexibility	longer piping	
		more controls	
		more BHP	

Keep An Open Mind

Figure 3.17 Idea comparison – HVAC System (Dell'Isola, 1982)

3.5.3.2 Weighted evaluation

Weighting evaluation is the last step used in the analytical phase. Here ideas are weighted against other elements that are not assigned dollar value such as aesthetics, durability, salability, etc. It is recommended that all team members from different disciplines participate, since this step involves diverse parameters.

Figure 3.19 illustrates a format for criteria weighting process. The lower part of the format is designed to isolate important criteria and generate what is called paired comparison, in order to evaluate the different relative importance and consequently their weights are calculated. Figure 3.20 shows an analysis matrix where each alternative is listed and ranked against each criterion. The rank is multiplied by the different weights previously calculated and a total number is calculated for each alternative. Finally, each alternative is given a score based on the total number calculated. Figure 3.21 is a criteria weighting sheet for HVAC system for an administration facility. While Figure 3.22 shows an analysis matrix for the criteria weighting previously illustrated (Dell'Isola, 1982).

3.5.4 Development/Proposal Phase

The development phase presented by Zimmerman and Hart (1982) include life-cycle cost analysis and matrix evaluation which are already presented by Dell'Isola (1982) in the analytical phase. Therefore, stress will be given to Dell'Isola's proposal phase.

The proposal phase is also referred to as the planning and reporting phase. It is important to provide the following:

1- All presented alternatives are reviewed thoroughly by the VE team in order to make sure that the optimum value is reached.

Life Cycle Cost Analysis
Using Present Worth Costs

Item: HVAC AHU
Life Cycle Period: 40 Years Date: 12/14/78

		Built-Up Fan Sys. Original		Roof VAV Alternate No. 1		Alternate No. 2		Alternate No 3.	
		Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth
Collateral/Initial Costs	Base Cost		92,000		70,000				
	Interface Costs								
	a. piping (insul.)				4,000				
	b. elec				4,500				
	c. structural supports				4,000				
	Other Initial Costs								
	a. space		153,000						
	b.								
	Total Initial Cost Impact (IC)		245,000		82,500				
Salvage & Replacement Costs	Single Expenditures @ 10% Interest								
	1. Year 20 PW Factor .1486	79,000	11,739						
	2. Year 15 PW Factor .2394			70,000	16,758				
	3. Year 30 PW Factor .0573			70,000	4,011				
	4. Year ___ PW Factor ___								
	5. Year ___ PW Factor ___								
	Salvage Yr. ___ PW Factor ___								
	Total Present Worth		11,739		20,769				
Annual Costs	Annual Costs @ 10% Interest								
	a. Maintenance Escal. Rate 0% PWA Factor 9.777	350	3,422	750	7,332				
	b. Operations Escal. Rate ___ PWA Factor ___								
	c. Others Escal. Rate ___ PWA Factor ___								
	d. Others Escal. Rate ___ PWA Factor ___								
	e. Others Escal. Rate ___ PWA Factor ___								
	Total Annual Costs		3,422		7,332				
	Total Present Worth Costs		260,161		110,601				
	Life Cycle (PW) Savings				149,560				

PW – Present Worth PWA – Present Worth Of Annuity

Figure 3.18 Life Cycle Costing Example – HVAC System (Dell'Isola, 1982)

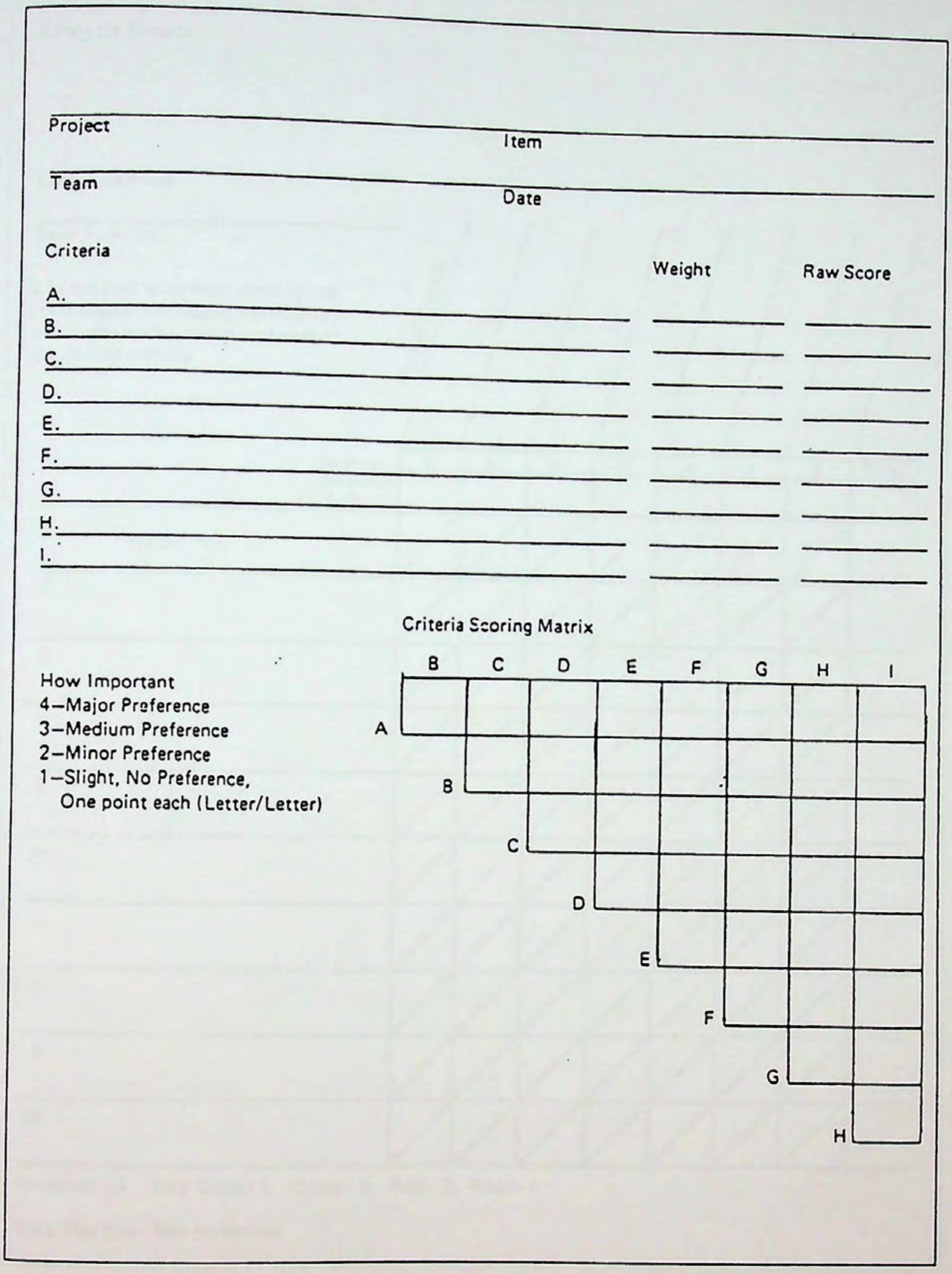
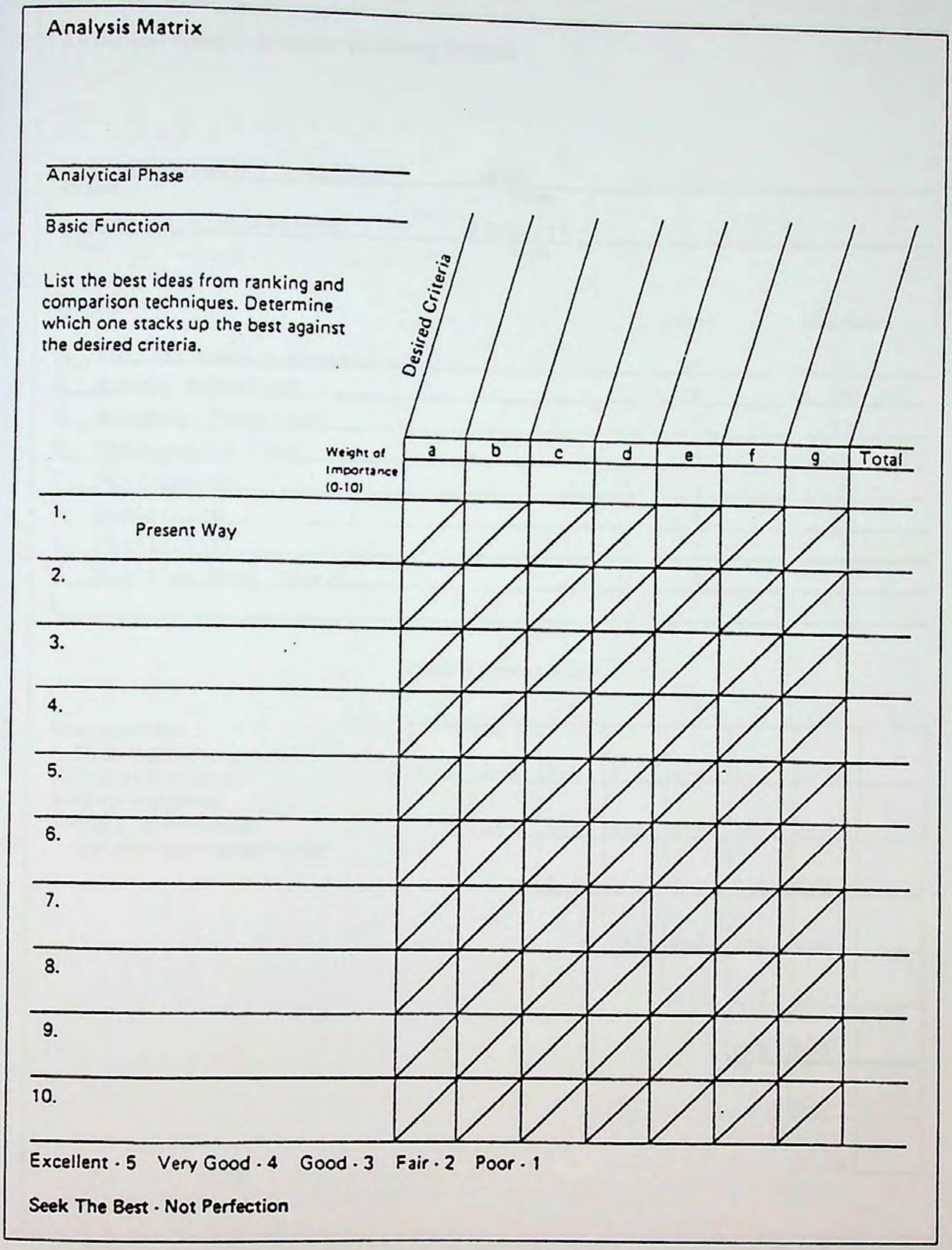

Project
Item
Team
Date
Criteria
Weight
Raw Score
A.
B.
C.
D.
E.
F.
G.
H.
I.
Criteria Scoring Matrix
How Important
4—Major Preference
3—Medium Preference
2—Minor Preference
1—Slight, No Preference,
One point each (Letter/Letter)
B C D E F G H I
A
B
C
D
E
F
G
H

Figure 3.19 Format for Criteria Weighting Process (Dell'Isola, 1982)



Analysis Matrix

Analytical Phase ______

Basic Function ______

List the best ideas from ranking and comparison techniques. Determine which one stacks up the best against the desired criteria.

	Weight of Importance (0-10)	a	b	c	d	e	f	g	Total
1. Present Way									
2.									
3.									
4.									
5.									
6.									
7.									
8.									
9.									
10.									

Desired Criteria

Excellent - 5 Very Good - 4 Good - 3 Fair - 2 Poor - 1

Seek The Best - Not Perfection

Figure 3.20 Analysis Matrix Format (Dell'Isola, 1982)

Analytical Phase – Criteria Weighting Process

Project: Administration Building Item: HVAC

Team: Team #2 - Mechanical Date: 12/20/77

Criteria	Weight	Raw Score
A. Initial Cost - Mechanical	10	21
B. Energy Reduction	10	20
C. Redesign Time/Cost	7	13
D. Maintenance Cost	5	10
E. Performance	3	5
F. Aesthetics	1	1
G. Flexibility	2	3
H. Building Cost Impact	5	9
I.		

How Important
4–Major Preference
3–Medium Preference
2–Minor Preference
1–Slight, No Preference,
One point each (Letter/Letter)

Criteria Scoring Matrix

	B	C	D	E	F	G	H	I
A	A-3	A-3	A-3	A-3	A-4	A-2	A-3	
B		B-4	B-2	B-3	B-4	B-4	B-3	
C			C-3	C-2	C-3	C-3	C-2	
D				D-3	D-3	D-3	D-H	
E					E-3	E-2	H-2	
F						G-3	H-3	
G							H-3	
H								

Figure 3.21 Criteria Weighting Process – HVAC System Example (Dell'Isola, 1982)

Analysis Matrix

Administration Building
Analytical Phase

Control Environment
Basic Function

List the best ideas from ranking and comparison techniques. Determine which one stacks up the best against the desired criteria.

Desired Criteria	a Initial Cost	b Energy Reduction	c Redesign Time/Cost	d Maintenance Cost	e Performance	f Aesthetics	g Flexibility	h Building Cost Impact	Total
Weight of Importance (0-10)	10	10	7	5	3	1	2	5	
1. Electric Cool/Water Present Way Steam Heat V.A.V.	20 / 2	10 / 1	35 / 5	15 / 3	12 / 4	2 / 2	6 / 3	10 / 2	110 (5)
2. Fuel Source All Electric Omit Steam	50 / 5	10 / 1	28 / 4	20 / 4	6 / 2	5 / 5	8 / 4	25 / 5	152 (2)
3. Abandon Basement Mechanical Room Use DX	50 / 5	30 / 3	14 / 1	25 / 5	6 / 2	4 / 4	8 / 4	25 / 5	162 (1)
4. Change to 4' - 0" module	20 / 2	10 / 1	14 / 2	15 / 3	15 / 5	4 / 4	8 / 4	15 / 3	101 (7)
5. Redesign Perimeter Heating System	20 / 2	40 / 4	28 / 4	10 / 2	15 / 5	4 / 4	8 / 4	15 / 3	140 (3)
6. Revisions of Ductwork Layout Use Rect. Duct	40 / 4	20 / 2	14 / 2	5 / 1	3 / 1	3 / 1	2 / 1	20 / 4	107 (6)
7. Consider two hour rated corridor walls	40 / 4	10 / 1	28 / 4	5 / 1	3 / 1	4 / 4	8 / 4	15 / 3	113 (5)
8. Use recipro. chiller and air cooled unit	50 / 5	10 / 1	21 / 3	15 / 3	3 / 1	3 / 3	4 / 1	10 / 2	116 (4)
9.									
10.									

Excellent - 5 Very Good - 4 Good - 3 Fair - 2 Poor - 1

Seek The Best - Not Perfection

Figure 3.22 Analysis Matrix – HVAC System Example (Dell'Isola, 1982)

2- The proposal must be prepared in a "sound" way and should be targeted to management so that to have the strongest effects.

3- A plan for implementing these alternatives should be prepared, in order to successfully convince management with the work done.

3.5.4.1 Salesmanship Concepts

VE always should work on foreseeing obstacles that might occur while doing the study and try to avoid them. Roadblocks are one of these obstacles that appear especially when presenting a solution to a problem. Anything that opposes an approach to a solution is considered a roadblock. It is recommended to consider all types of roadblocks, which may be encountered.

The best method to "cope" with roadblocks is by preventing them from happening and minimizing their seriousness. Also, through using killer phrases and investigating all related facts. The application of functional thinking, good communication to sell the idea, and most effectively the use of verbal presentation of results, at the end of the VE study.

3.5.4.2 Report Preparation

At this stage, the report will be ready to be presented to management where it should include the following:

1- A short description of the project studied and the corresponding problem and recommendations.

2- The outcome of the functional analysis, showing both existing and proposed.

3- Sketches of before and after design, illustrating the proposed changes.

4- Any technical data to support the selection.

5- Cost analysis of the existing and proposed solution showing all detailed data.

6- Acknowledgement of different contributors to the study.

7- A brief summary list of all reasons for accepting the proposal and the corresponding required action.

Figure 3.23 illustrates a recommended proposal format (Dell'Isola, 1982).

3.5.5 Recommendation/Final Report Phase

This phase is considered optional. During this phase, implementation of the recommendations presented in the previous phase is executed. Bid prices are prepared and the total cost for each VE idea is implemented. Attention is made to life cycle cost savings for accepted proposals. Moreover, a "post-occupancy" evaluation is made for implemented ideas that show significant life cycle savings. Realistic operation and maintenance cost evaluation should be presented in the final report in order to know the "true" impact of the VE study.

It is important during this phase to avoid possible roadblocks in implementing the VE study. Major roadblocks are:

1- The role of the VE group is to recommend, not decision making. Therefore, this should be guaranteed to the design personnel. Certain Ethics should be followed when conducting the VE program in order to avoid possible confrontation with other disciplines.

2- Active support from management should be present in order to assure that all VE recommendations are heard in its real image without the misinterpretation, or dishonesty of middle management.

Project ______________________ Date ______________

Item ______________________ Project No. ______________

Summary of Change (description)

Estimated Cost Summary (see attached cost estimates)	No. of Units	Unit Cost	Total
A. Original (Total Initial)..			
B. Proposed (Total Initial)....................................			
C. Initial Savings..			
D. Annual Savings			
E. Present Worth Annual Savings			
F. Present Worth Annual Difference (Escalated)			

Percent Savings Instant	
Percent Savings Life Cycle	
Percent Savings Life Cycle (Escal.)	

Figure 3.23 Recommended Proposal Format (Dell'Isola, 1982)

3- Periodical review of the program should be made by management in order to make sure that the effort is not used for publicity, or for tasks outside assigned VE activities. Furthermore, management should make sure that no work "nit-picking" which may affect the overall cost effectiveness (Dell'Isola, 1982).

Chapter 4: Value Engineering in the Egyptian Construction Industry

4.1 Introduction

The benefits of value engineering are well recognized which makes its application necessary in almost all construction projects. The concept of VE is relatively new. Value engineering was first used in 1954 by the Department of Defense in the USA. Later its application was made mandatory for all public projects (Dell'Isola, 1982). In Egypt, awareness of the concept was nearly introduced in the late 1980s, early 1990s. Its potential benefits were first recognized through its successful application on bridges in Egypt. Value engineering was applied on a number of bridges to identify the most applicable construction system chosen for each bridge case (Basha and Gab-Allah, 1989).

This chapter investigates the extent of the awareness and application of value engineering (VE) in Egypt. The main objectives of this chapter are:

a) Identify the level of VE utilization in the construction industry in Egypt
b) Explore the road blocks and obstacles facing its application
c) Find ways and methods to reduce or eliminate these obstacles and suggest ways to expand the use of VE in Egypt

The chapter starts with a general information about the questionnaire and its structure. A description of the participating firms is then presented and the reason of selection is then explained. Commencing with an analysis of the corresponding responses, emphasis is laid on the obstacles and roadblocks in applying value engineering. Basically, this chapter serves as a detailed identification of the difficulties facing the implementation of the VE concept and introduces some ideas to improve the process,

which will help in the formulation of the proposed computer system explained later in the research.

4.2 Survey-Questionnaire

4.2.1 Data Collection

The necessary data was generated by conducting a survey addressed to 18 public and private firms involved in relatively large volume of work which are illustrated in Table 4.1. These firms constitute a number of local and foreign organizations representing a combination of architectural engineering (A/E), construction management (CM), and a number of construction firms. The survey focuses on the category of large-size firms, primarily involved in major projects like infrastructure, industrial, power plants, and large hotels and commercial buildings. Hence, these firms would benefit the most from the utilization of the VE technique.

It was essential to select a number of firms involved in construction activities in Egypt in order to be able to investigate the utilization of VE. The Egyptian market houses a large number of firms involved in construction activities. Therefore, it was important to conduct the survey on a certain segment if profound results are anticipated. Since VE is generally applied during planning, design, and construction phases, it was thought best to address A/E design firms, construction firms, and construction management firms. It was also found beneficial to concentrate on "large size" firms involved in relatively "large size" projects where VE usage is conceivable and more feasible.

A sizable number of these firms include foreign firms or joint venture of local and foreign firms involved in construction activities in Egypt. This type of inclusion is

considered healthy to the research on hand since these firms is more likely to attain and utilize sophisticated techniques such as VE. Especially that it is newly introduced in Egypt. This will definitely help provide a better interpretation of the current status involving the VE approach and consequently aid in improving its implementation.

It is important to mention that the conducted survey questionnaire focuses on two important issues. One is to identify those firms that apply and utilize VE in their construction work and the second is to investigate whether this application conforms to the "proper implementation" of such a technique.

Table 4.1: Companies surveyed and the type of service offered

Company Name	CM Services		A/E Services		Contractor	
	Local	Foreign*	Local	Foreign*	Local	Foreign*
Participating firms by category	4	7	4	3	3	3
Firms applying VE by category	2 (50%)	5 (71%)	2 (50%)	3 (100%)	2 (66.67%)	3 (100%)
Total participating firms	11		7		6	
Total firms applying VE	7 (64%)		5 (71.4%)		5 (83.3%)	

* International Firms (Foreign, Joint Ventures, Consortium)

4.2.2 Questionnaire Composition

The survey conducted in this research was established through a questionnaire. Assif, et al (1996), used a questionnaire of similar type in a survey that was made in Saudi Arabia to explore the application of the concept of value engineering in public construction projects. This questionnaire provided some additional guidelines in constructing the questionnaire used in this research.

The questionnaire developed is divided into two sections see Appendix A:

1- The first section is general information about the firm studied. The organization or firm name, address, nationality, respondent name, position or title, type of

service/s offered, etc. This will help in the classification of the different organizations surveyed and also in the justification of the different answers received.

2- The second section represents the core of the survey, which deals with the application of the VE technique in the different organizations surveyed. In this part of the survey, exploration of the VE environment, process, duration, effectiveness, etc. is gathered. Examples of case studies prepared by these firms are also gathered and recorded. In the case of a negative answer, the reasons behind its limitation are investigated and analyzed.

4.2.3 Results and Analysis

The following sections discuss the different responses received from the survey made on 18 relatively large firms engaged in several construction projects in Egypt. The questionnaire analysis is presented based on the type of service provided by each firm. These services are construction management (CM), engineering construction, and A/E design services.

It is anticipated from this questionnaire to investigate those firms that utilize VE and depict the actual nature of implementation. Therefore, the methods and techniques used during the VE study should be identified clearly. Moreover, the type of personnel involved and the party asking to conduct the study would reflect the nature and general understanding of VE to the different parties involved in the project. True interpretation of the general understanding of the VE process could be greatly defined through cases provided by each firm. Here each firm presents an actual VE study including the different steps taken.

A- Expected Savings

The survey indicated that almost 80% of respondents expected savings between 2-5% of the total project cost as shown in Table 4.2. The rest of participants showed higher expectations for the amount of VE savings which was particularly concentrated on the 11-20% range. A similar survey was made by Assef et al. (1996) in Saudi Arabia which was addressed to 13 government agencies heavily involved in the construction of public projects. The analysis of the survey indicated that the majority of public owners, which represented almost 60%, indicated that they expected savings of up to 6% of the total project cost. Another study was made by Palmer et al. (1996) in the United States of America on performing a holistic appraisal of value engineering to investigate the true theory and practice adopted. The study included a questionnaire survey that was sent to VE consultants involved in the construction industry in the United States. Response rate was 67% of the 36 questionnaire sent. Proposed savings were generated from the analysis of the studies gathered from the corresponding VE consultants surveyed. The average proposed savings indicated by Palmer et al. was 32.7% while the average implemented savings were 10.7%. Table 4.3 illustrates the different savings presented by each country.

Table 4.2: Expected savings from VE study indicated by each firm

Expected savings	All Categories	CM Firms		A/E Firms		Contractors	
	%	No.	%	No.	%	No.	%
Less than 1% of total project cost	*0*	0	*0*	0	*0*	0	*0*
2 - 5% of total project cost	*77*	6	*85*	4	*80*	3	*60*
6 - 10% of total project cost	*8*	1	*15*	0	*0*	1	*20*
11 - 20% of total project cost	*15*	0	*0*	1	*20*	1	*20*
Over 20% of total project cost	*0*	0	*0*	0	*0*	0	*0*

* Number of respondents

Table 4.3: Corresponding VE Savings by Each Country

Type of VE Savings	Egypt %	Saudi Arabia* %	USA ** %
Proposed VE Savings	N/A	N/A	32.7
Implemented VE Savings	2-5	2-10	10.7

*Assef, Al Musallami and Al Sughaiyer (1996)
** Palmer, Kelly and Male (1996)

B- Best Time for applying VE study

The results showed that almost 85% of the respondents indicated that the best time to conduct a VE study is after the design is completed but before starting bid procedures as shown in Table 4.4. Clearly this is the case with CM firms and with contractors, however A/E firms recommend the VE study be implemented during early and final phases of design. This is generally true since the impact of VE changes is significantly low during early design time when compared to the cost of changes made during construction time.

Table 4.4: Best time for VE application

Best time for VE study	All Categories	CM Firms		A/E Firms		Contractors	
	%	No.	%	No.	%	No.	%
During early and final design phase	69.2	4	57.1	4	80	4	80
After the design is completed but before initiation to bid	84.6	5	71.4	3	60	5	100
After the award of the contract	61.5	3	42.8	3	60	4	80

* Number of respondents

C- Frequency of Personnel Involved in VE Studies

Often VE studies involve the participation of several personnel. These personnel could be owner or stakeholder representatives who make sure that the terms

of ownership are met or could be anyone from the different construction disciplines involved or their representatives. This participation is highly recommended as indicated by Dell'Isola (1982) and by Zimmerman and Hart (1982), since their input and judgement based on their long background experience is vital to the success of the VE study.

The survey made showed that owners are the personnel most highly involved in VE studies since they are the ones significantly affecting the VE direction through their constraints and requirements. The analysis showed that 85% of respondents think that owners have demonstrated frequent participation as illustrated in Table 4.5. Project managers also showed high frequent participation since he is the one often coordinating the study. Usually he is responsible to submit VE proposals to the owner for approval and asking the contractor for development of alternatives and specification preparation. The consultant is also involved in the technical evaluation and recommendations for the different alternatives presented. Overall most answers showed equal participation of the different parties with evident owner participation in these VE studies.

Table 4.5: Frequency of personnel involved in VE studies

Personnel	Always %	Often %	Sometimes %	Never %
Owner	85	23	0	0
Consultant	69.2	38.5	0	0
Project Management	76.9	30.8	0	0
Contractor	46.2	15.4	0	0

4.2.3.1 Construction Management Firms

Out of the 18 organizations surveyed, 11 firms are engaged in construction management services. Out of these 11 construction management firms, only 7 applied VE study on construction projects in Egypt.

Most CM firms surveyed indicated that they perform VE study during early and final design phase as well as just before the bid and after the contract award. Most answers indicated that VE is usually initiated by owners or owner representatives. Most studies usually take between 2 to 3 weeks to accomplish. Often the owner and contractors are involved in the study. Most savings are in the range of 2-5% while one answer was from 11-20% of the total project price. One CM firm had a variable saving range where the project was relatively large and it was divided into several phases.

In general most CM firms in Egypt coordinate the VE process between involved parties from designers, contractors, etc. The construction manager asks the parties to submit VE proposals for a group of items they think has poor value or by specifying a certain sum of VE proposed saving. In both cases proposals are reviewed by the construction management firm and then presented to the owner or stakeholders for final approval.

Since VE is relatively new in Egypt, owners are becoming aware of this technique and frequently asking their representatives to exercise it on their projects. The CM firms often representing the owner ask contractors and designers to come up with VE proposals as part of the service offered. Frequently, no incentives and no additional fees are paid to any party offering these proposals. Each contractor

submitting his bid proposal is usually required to submit with it a certain sum of VE savings. After the contract award, he is responsible to put these proposals into more detailed and concrete alternatives with all the necessary required data.

Only one CM firm within the survey made had employed the 40 hour workshop by employing a certified US VE consultant to perform the study. This of course required relatively high fee that can only be found feasible in the case of large size projects where cost savings would definitely be effective. None of the CM firms in Egypt incorporate a working group of certified value engineers. Nevertheless, one or two engineers working in different departments within these firms could be a certified VE. Often engineers working in the cost department are the one responsible to highlight high cost elements and raise it in front of the owner or owner representative during periodic meetings.

Very few CM firms where only 3 out of the 7 CM firms employ standard VE worksheets as a standard procedure for their study and also no recording is established to the different procedures implemented during the study. Only VE certified firms invited from abroad employ such procedure. The results from the questionnaire showed that the use of function analysis is not as clear as explained by the theory. Nevertheless, function analysis exercise might be applied indirectly by the reviews made by involved personnel from different disciplines. This tends to exclude others from sharing the function analysis procedure and aim behind it, which can lead to deviation from the main purpose of the VE study. This deviation could turn the study into a cost cutting process rather than a VE process.

The inclusion of other VE techniques were also absent in most of the VE studies made. Techniques like Cost-Worth, Life Cycle Costing Analysis, weighted constraints evaluation, FAST, idea rating, post occupancy evaluation, etc. It can be

inferred from the survey made that these techniques do not really have a significant effect on the alternatives proposed. Moreover, the real brainstorming or idea generation is mostly laid on the contractor and designer to come up with other ways to substitute for the original proposal. The CM firm does not give great attention to the VE procedure or job plan established, rather they want to receive as much cost reduction alternatives as possible. The investigation of function and life cycle characteristics is not formally adopted which raises the question whether quality or value could be degraded.

4.2.3.2 A/E Firms

Out of the 18 firms surveyed, 7 firms were involved in A/E design services. Out of these 7 firms, only 5 practiced VE on construction project designs in Egypt. In general, most A/E firms do not offer VE study unless owners or owner representatives ask them, while few others introduce VE as additional offered service. Not all firms apply VE formally; rather it is used as a cost reduction technique when owners ask them to review their designs.

Most A/E firms surveyed indicated that they perform VE study before and after conceptual design. Only one firm indicated that VE study is more effective at 90% design phase. Most studies usually take between 2 to 3 weeks to accomplish. Often the owner and project manager are involved in the study where their input is significantly important. Most savings are in the range of 2-5% while one answer were above that where it was from 10-15% of the total project price.

Again most A/E firms do not formally employ a standard procedure in their VE study. Very few use worksheets to record the different steps taken during the

study. Moreover, few A/E firms have certified VE specialists. Although VE study is exercised by these firms yet most of these studies lack the basic element that distinguish VE from other cost cutting methods which is function analysis. The selection and generation of alternatives is done differently. No one organization adopts the same method or selects the same path in analysis. This lack of standardization causes many valuable studies to be lost without benefiting from its experience.

One A/E firm involved in most of the design and consultant work of the major public bridges and highways in Egypt indicated that they do not apply any VE study on any part of their work. The main reason behind that could be associated with the lack of encouragement and incentives provided by government officials. Equally, they are unaware of both short and long term technical and financial benefits of VE and its applications on most infrastructure projects in Egypt. The other A/E firm is involved in major private and public projects in Egypt do not use VE. The reason behind that is the unawareness of the concept and its vast benefits in addition to the limited availability of value specialists engaged in previous similar projects, who are familiar with the techniques and tools used in VE workshops.

4.2.3.3 Construction Firms

Out of the 18 organizations surveyed, 6 were working in construction services. Out of these 6 firms, 5 used VE technique in relatively large projects in Egypt. Similar to A/E firms, construction firms are asked by owners or owner representatives to present VE proposals when submitting their bid proposal.

Most contractors surveyed indicated that they perform VE study before and after the contract award. Moreover, the study usually takes between 2 to 3 weeks to accomplish. All three owners, consultants, and project managers are involved in the study and the study is usually required based on owner requirements. Most savings are in the range of 2-5% while only one answer were above that where it was from 6-10% of the total project price.

None of the construction firms surveyed adopted a standardized system in recording and executing VE studies. None employed function analysis or life cycle analysis to the study submitted. Most firms submitted a list of alternatives and options for the different items required with a reference to the specifications of each alternative or option suggested (See Appendix C).

One of the 6 construction companies surveyed was involved in a 300 Million Egyptian Pounds project. It presented 30 Million Egyptian Pounds in VE savings where the owner approved only 15 Million. The bid package included a term that required the participating contractors to submit VE proposals as part of the bid package. After the award, review of each proposal was established through the involvement of most disciplines in the evaluation where alternatives found feasible were selected for final approval. Another contractor involved in a large shopping store in 6th of October City provided a proposal that saved around 0.5 Million Egyptian Pounds plus cancellation of a 2 months delay in work.

One of the large construction companies surveyed did not apply VE study on any of its projects. This company had been heavily involved in relatively large public and private projects. The concept may be known to some personnel working in the firm yet its application is not formally used and not supported by top management. Its application in such a firm would definitely be of great importance since the company

is continuously involved in large infrastructure and commercial projects. The Deputy General Manager in that company was well aware of the potential benefits that could be accomplished if the VE technique was applied. He indicated how a large company like this should be very keen to employ such a technique that can significantly aid in reducing cost overruns which the company suffer from.

4.3 Roadblocks and obstacles facing VE application:

From the survey conducted it was found that the main reason behind the limited application of VE in Egypt is the unawareness of many of the parties involved in construction projects like the owner, construction management firms, A/E firms, contractors, etc. The main responsibility is laid on the owner or owner representative since he is the one who will benefit the most from such a technique. For example, the government agencies in the United States of America were the ones that took the lead in encouraging VE application to most of its major public projects. It was then that VE incentive provisions were included in most of its construction contracts. Moreover, there are a number of problems that hinder the proper implementation of VE within firms employing the technique in the Egyptian construction industry, like the unavailability of finding qualified personnel capable of performing the formal 40-hours job plan. In addition, the high cost associated with consulting VE professionals from abroad is another major obstacle facing the wide spread of the technique in Egypt. Many firms in Egypt perform VE studies to construction projects without conforming to the proper methodology rather some firms see it as a cost reduction technique where they don't perform function analysis technique which forms the essence of VE.

4.4 Suggestions for reducing VE implementation obstacles and ways to expand VE application:

From the analysis of the survey questionnaire and after the major obstacles and roadblocks have been pinpointed it was vital to look for ways and methods to reduce or even if possibly eliminate such barriers. It was eventually found that developing a VE system capable of simulating the relevant VE job plan would provide a systematic process provided that it is a comprehensive one covering the whole process from the information phase to the final report phase. In addition, the system should have the feature of being flexible in order to account for all available information provided. In other words the key element is standardization and systematic simulation with proper unification which can lead the way for tremendous development and integration with other techniques that can provide significant support to the proposed VE system. This will definitely help assist practitioners by identifying the proper implementation and highlighting the major parts off a successful comprehensive VE study.

Automation of such a system would definitely save a considerable amount of time especially with the tedious tasks like cost modeling, life cycle cost analysis, cost-worth ratio estimation, etc. which form an important part of the VE job plan. Moreover, if the system is integrated with a decision support mechanism it can definitely help direct unprofessional personnel during the VE session. Not only that but this could form the basis for a tutoring and training tool that can help staff learn the proper methodology of VE. The automated system can help save time and money in both, the VE study session and in the training session. Further description of such a

system is introduced in the proceeding chapter where a proposed VE computer system is clearly explained.

Chapter 5: System Development

5.1 Introduction

Value engineering (VE) study involves long tedious workshops that require high level of organization and coordination. The amount of paperwork generated from one study is often considerable. Furthermore, VE studies are usually performed once or twice and sometimes when large projects are involved, an additional session is performed. The number of hours required for one workshop is therefore significant especially during the information phase, which involves cost modeling, function analysis, and cost/worth ratio comparison. Consequently, the need for an effective tool that will aid in improvement and enhancement of the VE implementation process is evident.

This chapter illustrates the methodology and development of a computer VE system that will aid in implementation improvement. The chapter starts with an objective analysis of the VE process. Subsequently, development of the VE system is inaugurated where the system design process is explained with illustration of the basic parts. Hereinafter, testing and validation of the system is introduced with implementation of two VE cases.

5.2 Analysis of VE process

As described earlier in chapter three, the VE process is accomplished through the use of a formal job plan that has been developed by many authors. This job plan is described by Dell'Isola (1982) in a number of phases as follow:

1) Information phase

2) Speculative phase

3) Analytical phase

4) Development phase

5) Final report phase

Each phase incorporates a number of procedures and techniques that should be followed and applied carefully since data provided in former stages will definitely influence the corresponding resulting data used in later stages. Often these procedures become a bit complicated, especially when dealing with relatively large projects. The manual worksheets used in performing detailed study can become hectic and less effective. It would require high level of coordination and organization since each worksheet is related and linked to other parts of the study process. In order to know the requirements and provisions for successful implementation, the VE process should be carefully analyzed and investigated.

In the first stage of the VE job plan, the information phase, various activities are explored. During this phase, a number of techniques and steps are required such as information gathering, function analysis, cost-worth exercise, cost-worth graphical representation, etc. The information that is gathered by the VE team concerning the project environment and constraints is crucial to the study. This is because failing to state project constraints can cause omitting VE proposals that took months to prepare. Such neglect during implementation can lead to loss of time and money. Thus, effective recording and management methods are strongly needed. Another technique like function analysis is also vital in such study since its main goal is to sustain the

basic intention and function of elements analyzed without compromising quality. This technique requires high level of awareness of its main objectives without unconsciously deviating from it. Moreover, when considering cost analysis and graphical representation. It is clear that dealing with a large project involving a large number of elements especially if performing the study during the project late stages that unintentional mistakes could be performed.

Other VE phases encompass similar problems that can occur if adequate experience and awareness is unavailable. To avoid such problems, qualified VE consultants who can provide VE services are usually employed. However, the fee for providing VE services is usually high especially if such service is scarce or not available. In addition, some consultants or specialized offices don't use VE analysis properly resulting in poor results (Brandon, 1991).

5.3 Development of VE System

5.3.1 Objectives and System Characteristics

The interdisciplinary coordination of the VE team involved in a workshop and the management of the large amount of paper work involved represent a major problem. The objective of this part of the study is to explore the potential of using a computerized system to overcome this problem and to effectively enhance the process. The approach is not to automate the current coordination and job plan process, yet rather to reengineer it using the unique capabilities of computers over those of humans. The reengineering approach directly targets the problems previously identified, mainly managing worksheet flow including data integrity, and taking care

of the large amount of calculations made in the different stages. Furthermore, a convenient step by step tutorial on VE is provided to make sure that the objective of each part of the VE process is defined clearly to the user.

The VE computer system proposed should have the following characteristics:

1- Capable of managing the flow of VE study process (worksheets in manual settings) efficiently.

2- Provide appropriate support and feedback form previous similar related projects during VE implementation.

3- Produce valuable reports and powerful analysis on past executed projects for the sake of continuous assessment and development.

5.3.2 System Definition

The system helps enhance the VE process through executing a number of exercises that assist in optimizing and providing cost effective products. In more details, the system helps in determining the most economical combination of functions to achieve the required task. It also helps in defining high cost areas in a project and work on removing unnecessary costs. During the later exercises, new ideas are generated that help in building up an internal library of new ideas serving later upcoming projects. Function analysis, the heart of VE, is effectively utilized in this system in order to identify the real requirement of the project and its components.

To meet the previous stated objectives, a number of functions and operations have to be prepared. The major proposed functional requirements are:

1- Identify project data, team members, project problem, documents available to team, etc.

2- Identify all types of constraints beforehand.

3- Provide project cost summary.

4- List areas of VE study, system, subsystem, component, etc.

5- Prepare function cost worth for items and components under study.

6- Generate a list of ideas where each idea is judged and ranked.

7- Study life cycle cost of items chosen.

8- Develop appropriate criteria for each case.

9- Evaluate and analyze alternatives against the different criteria developed.

10-Present proposal summaries and final reports and analysis.

Each of these functions will be materialized in a number of modules. Each module will receive input and generate output during the VE study process. The system is designed to be interactive with the user, so that the output of one stage represents the input for the next stage. As the system acquires more project information (input), the suggestions (intermediate output) available for the user will present greater selections.

5.3.3 Design Process

5.3.3.1 Database Approach

Before going forward with the design process, it is worthwhile to give a brief overview of the **Database** Systems and the **Database Management System (DBMS)**. Since, the VE system implemented depends heavily on the database

approach and employs the strong capabilities of the DBMS. First by presenting the definition of the two terminology:

Database	A shared collection of logically related data (and a description of this data), designed to meet the information needs of an organization.

DBMS	A software system that enables users to define, create and maintain the database and which provides controlled access to this database.

The database is a "single, large repository of data", which is logically related and once it is identified, all entities and users can simultaneously use it. The most significant part about database systems is that it integrates a huge amount of data with minimum amount of duplications. This makes the system more efficient and effective in its application. Furthermore, the database system can handle trémendous amount of data transactions with highest performance. Almost all organizations found in our lives like Banks, travel agents, libraries, credit card companies, insurance firms, universities, etc. utilize database systems.

The Database Management System (DBMS) is the software that enables the user to interact with the database application program. It allow the user to define the database, determine the data types, structure, and constraints on the stored data which is done through what is called Data Definition Language (DDL). The Data Manipulation Language (DML) is responsible for allowing the user insert, update, delete and retrieve data from the database. The DML also help provide an inquiry facility to the data through what is called a query language. Furthermore, the DBMS provides:

1- controlled access to the database through a security system that blocks unauthorized personnel from using or accessing the database;

2- a recovery control system, which help recover the database when a software or hardware failure occur;

3- an integrity system, which keeps the stored data in a consistent way;

4- a concurrency control system , which allows shared access of the database;

5- a user-accessible catalog, which include a description of the data in the database.

Entity-Relation Model

The Entity-Relation Model (ER Model) represents the conceptual model of a database and its associated transactions whether retrieval or update. Its main objective is to support the user's understanding of data and how it is related to each other. It is considered a high-level language where it is independent of the DBMS and the hardware principles used to execute the designed database (Connolly et. al, 1996).

In the VE proposed system, an ER model has been developed to form the basis for entity interactions. The model includes 16 entities forming the system's database structure as illustrated in Figure 5.1. All of the relations between entities are one-to-many since all many-to-many relations were transformed to a one-to-many relationship for practical implementation. Each entity represents a table that includes related attributes which are implemented using table design present in MS Access 97.

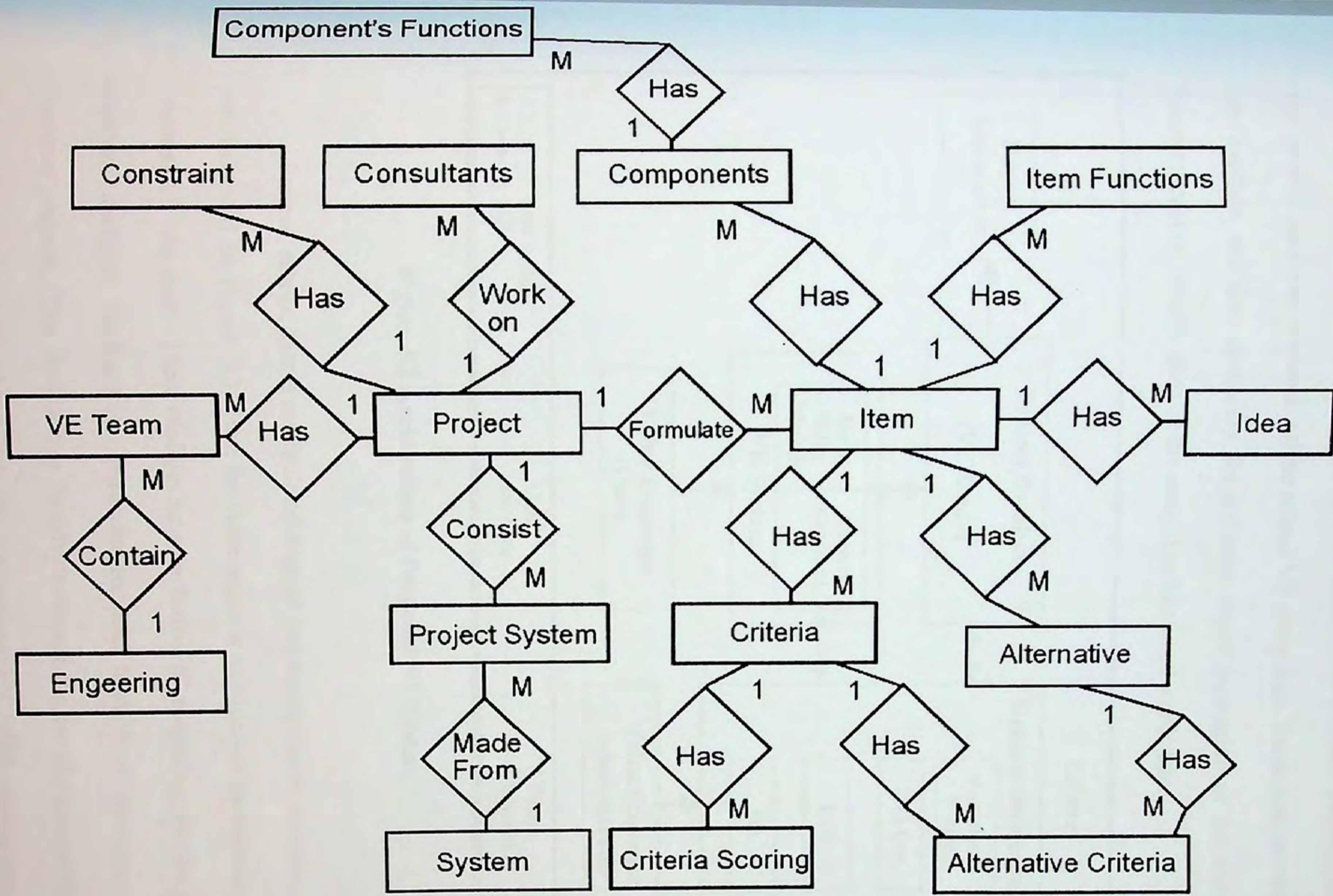


Figure 5.1 VE System Entity Relation Schema

5.3.3.2 Basic System Components

The core of the system, as shown in Figure 5.2, is a central project database. The project database contains all the related VE study data. These data are stored in the database and data dictionary for different report generation or for retrieving historical data on specific parts of the study, i.e. functional worth data.

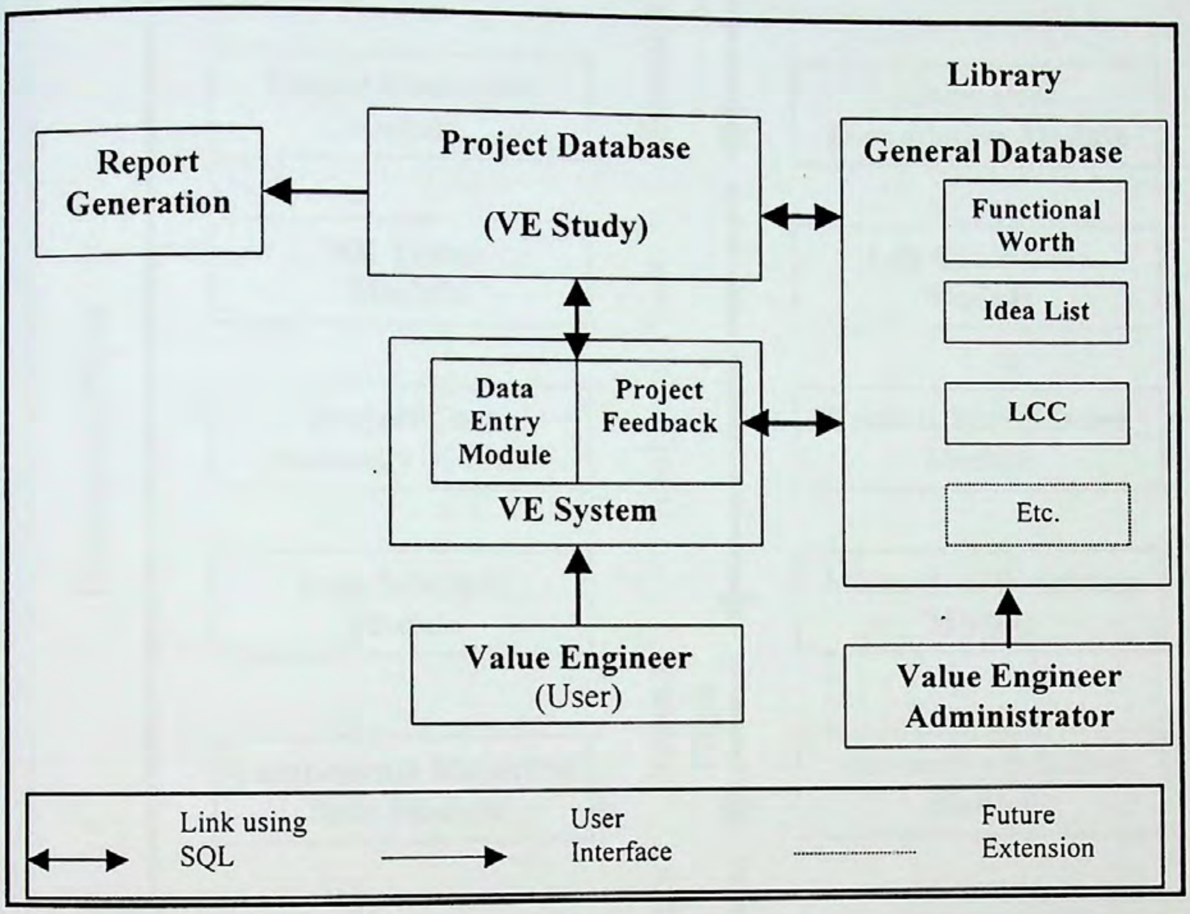


Figure 5.2 Architecture of Proposed VE System

Project related data is manipulated through data manipulation modules, which are illustrated in Figure 5.3. Here the value engineer provides all the necessary data required for the study. These modules have the feature of interacting with the user. It provides available feedback to particular required fields from previous similar executed projects. This feedback is facilitated through the use of a general database that holds a number of related data that can continuously fill in missing entry data.

Data like functional worth, ideas, alternatives, and other similar data can be presented in the general database.

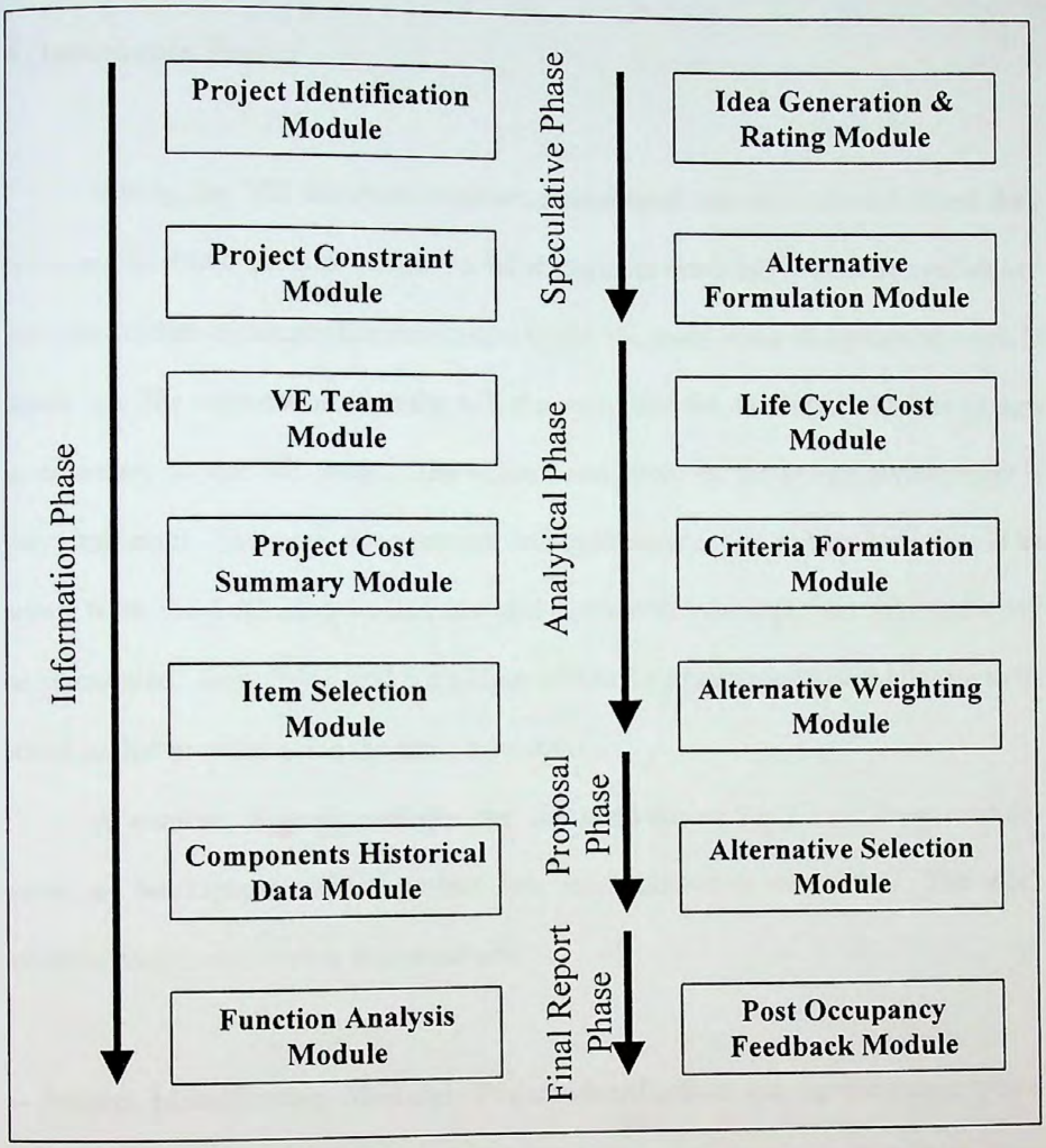


Figure 5.3 VE System Data Manipulation Modules

The general database can be continuously updated through direct or indirect process. The direct process is performed through updating modules that are provided for every type of data. So for the functional cost-worth data, a specific module is prepared, and the same thing for the other types of data. On the other hand, the

indirect process is done by the direct update of project data not found in the corresponding table, and this is done automatically while entering new project data.

A- Information Phase:

During the VE information phase, a number of data are collected. These data serve as the basic ground where the value engineer starts his work. The availability and the amount of information are crucial to the VE study since all upcoming work is based on. The information from the A/E that went into the development of the design is necessary to the VE study. The rational and intent for the design development is very important. The project constraint set by the owner and stakeholders should be stated from the beginning so that any idea that violates these project constraints will be eliminated. Any faults and complaints of similar projects are also advisable to be stated so that to avoid doing the same mistakes.

A number of work modules are designed during this phase. These modules serve as workspaces where project data manipulation is established. The work modules constructed during this phase are:

1- **Project Identification Module:** Project identification data represent descriptive information that characterize each project and explain its nature. Data like project ID, name, location, date, Economic life, and estimated budget are all essential for best identification. Other data like project type, owner or stakeholders, main contractor, participating consultants, and study phase are vital to the effectiveness of the VE system. Together these data with the strong capabilities of the database management system one can reproduce several analysis reports using the available

structured query language (SQL). For example, a query could be used to select all available projects since the year 1995 which are classified under special buildings and which showed a VE saving of more than 5%. Such output would definitely be enhanced and improved as many project identification data are accurately available.

The value engineer or user interacts with project identification data in order to view, modify, or add values. This interaction is materialized through project identification module. As illustrated in Figure 5.4 where the user can create a new project and add all the necessary related information. This stage represents the starting point where a project file is created.

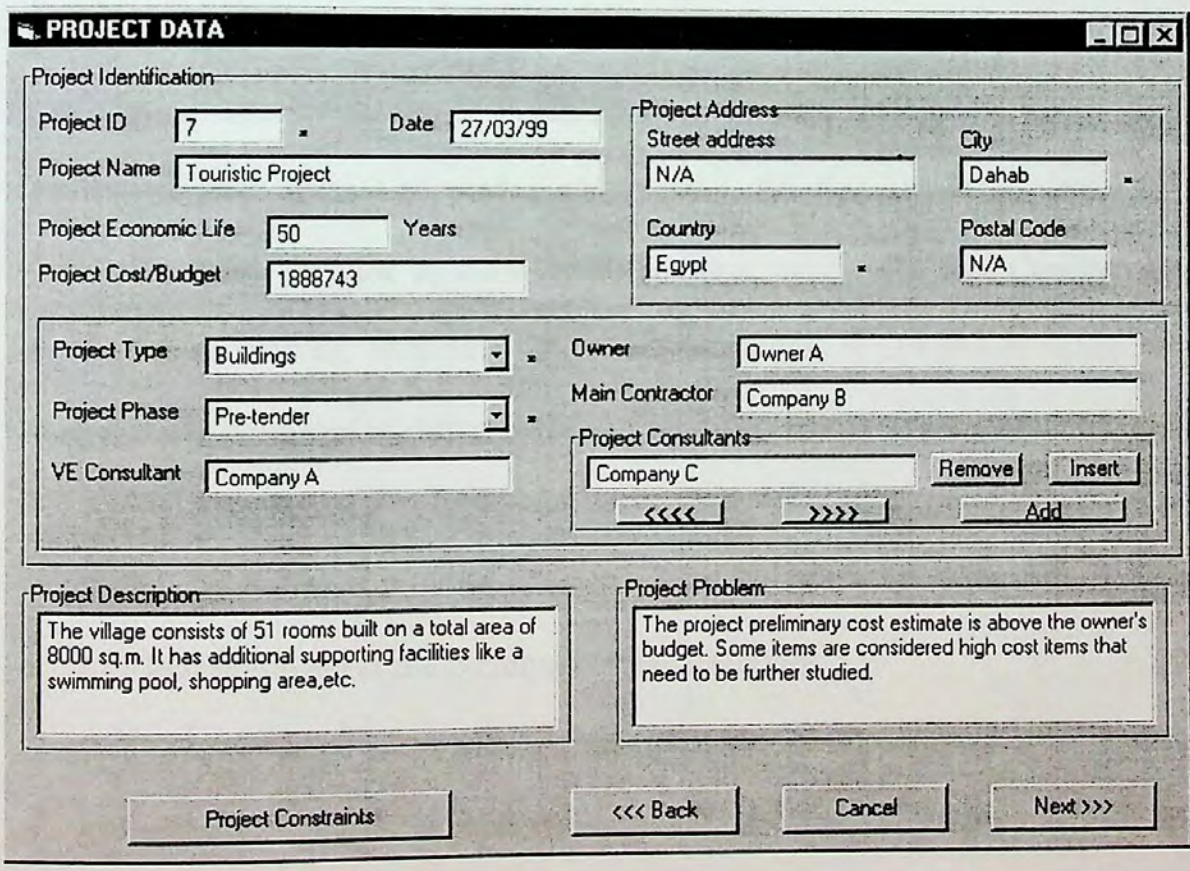


Figure 5.4 Project Identification Module

The project is given a unique number where it can be later traced when needed and it also serve as an index in organizing and manipulating the different data within available projects. Project type is chosen as a categorizing tool for the different projects present in the database. This grouping aid in the continuous data retrieval taking place during every VE study and help provide guidance along the different steps in the following modules. For instance, when the user is doing function analysis exercise using the function analysis module Figure 5.9 which will be discussed later, he/she can view similar cost and worth data available from previous studies. This is executed using a query that selects all previous cost and worth data based on the same project type since it would produce the most suitable data results (Code displayed in Appendix B-14).

For standardization reasons, classification of all types of contracts in the construction industry had to be identified. According to the Egyptian Contractors Federation, they have adopted a classification list that was taken from the technical studies prepared by the Egyptian Building and Construction Contractors Federation concerning sales tax. The list is composed of five sectors as follow (List detail is illustrated in Appendix D):

A- Buildings Sector

B- Special Buildings Sector

C- Electromechanical and building preparation sector

D- Utility and mine sector & irrigation and land cultivation sector

E- Land work and petroleum sector

Another important data that need to be added is the project phase attribute. Since the VE study could be applied at any time within the project period, it is recommended to identify the study phase especially that it is related to the VE

percentage savings. As illustrated in Figure 1.1 in chapter 1, the greatest payoff is found during early planning and design phase. The inclusion of this attribute aids in VE analysis where similar projects can be compared considering the different timing of the study made.

The project phases can be classified into four main phases as indicated by Hughes and Barber (1992) which are as follow:

Phase 1 – Pre-tender – Starts from initial concept up to invitation of tenders

Phase 2 – Contract formulation – preparation and submission of tenders, tender assessment, pre-contract negotiation and contract formulation.

Phase 3 – Construction – during construction up to substantial completion

Phase 4 – Post-completion– settlement of outstanding matters after substantial completion.

Project description and problems are also important elements in the study. The user can easily write down a full description of the project studied. Moreover, any problems formerly found or any similar faults and complaints of similar projects can be added which help provide an early notice to the VE committee.

2- **Project Constraint Module:** Another very important parameter is the project constraints. These constraints could be project constraints, owner constraints, stakeholders constraints, users constraints, or any other type of constraint. Constraints are limitations or restrictions that serve the interests of involved personnel which should be highly regarded in any VE study. This is because

knowing these constraints in advance can significantly save time and effort. For example, any idea that violates these constraints should be eliminated during early preliminary evaluation. This way, efforts made in studying ideas and alternatives violating these constraints will be salvaged.

The constraint module as illustrated in Figure 5.5 is designed to easily help users add and delete constraints by a click of a mouse. All constraints added to the project are displayed in a table format for clearer interaction. Those constraints the user wants to remove can simply be pointed out and removed. The constraint type whether owner, stakeholders, project, users, etc. can be chosen from the data bound combo box available in the project constraint frame. If the type of constraint is not found in the list, the user can easily add it and will automatically appear the next time he access the program. This capability is achieved through a query command that selects all unique constraint types from the project table present in the database (Appendix B-10 illustrates the code). As more VE cases are added to the system, the knowledge sources are continuously enriched.

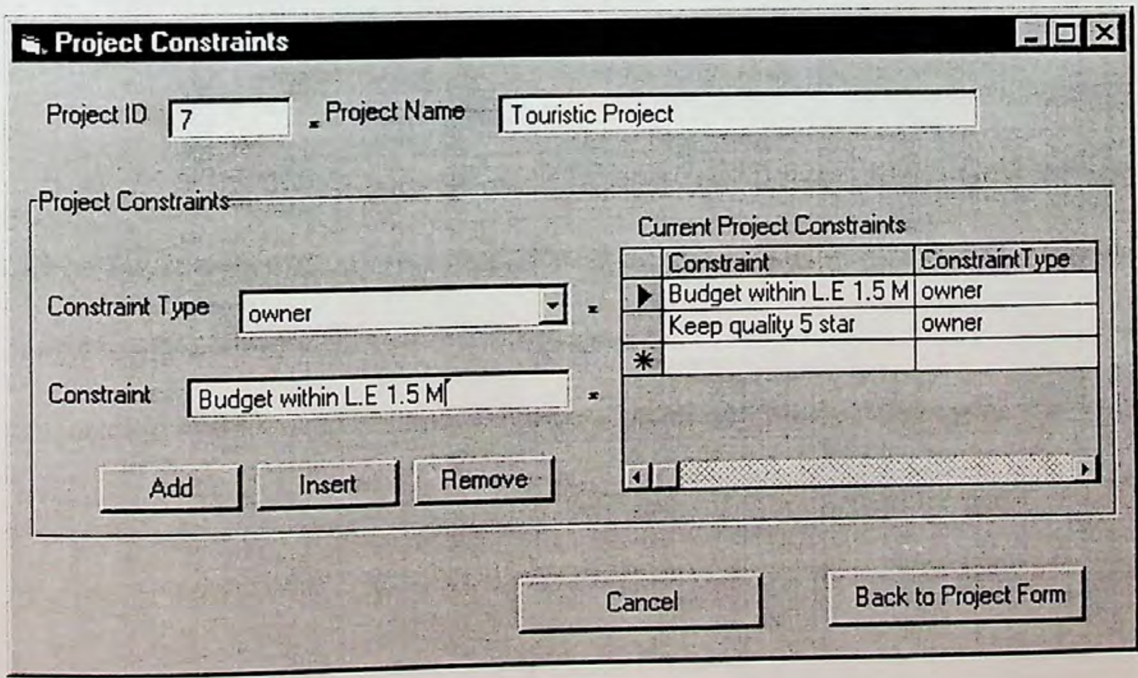


Figure 5.5 Project Constraint Module

3- **VE Team Module:** The VE team members are the group of multidisciplinary personnel involved in the study who will present their expertise and sense of imagination to generate ideas and communicate opinions that will contribute heavily to the study. As mentioned earlier by Dell'Isola (1982) that one of the ways for successful VE study is the participation of a multidisciplinary team. This is because each discipline tends to concentrate on his part of specialization without giving much attention to other fields of discipline.

In this module the participation of each discipline will still be valid since it is partially crucial to the study. However, this participation can be greatly enhanced and quickly materialized if it was aided by new ways of electronic communication. This way each person involved in the study can be easily connected to a pool of workshop and contribute to the decisions made.

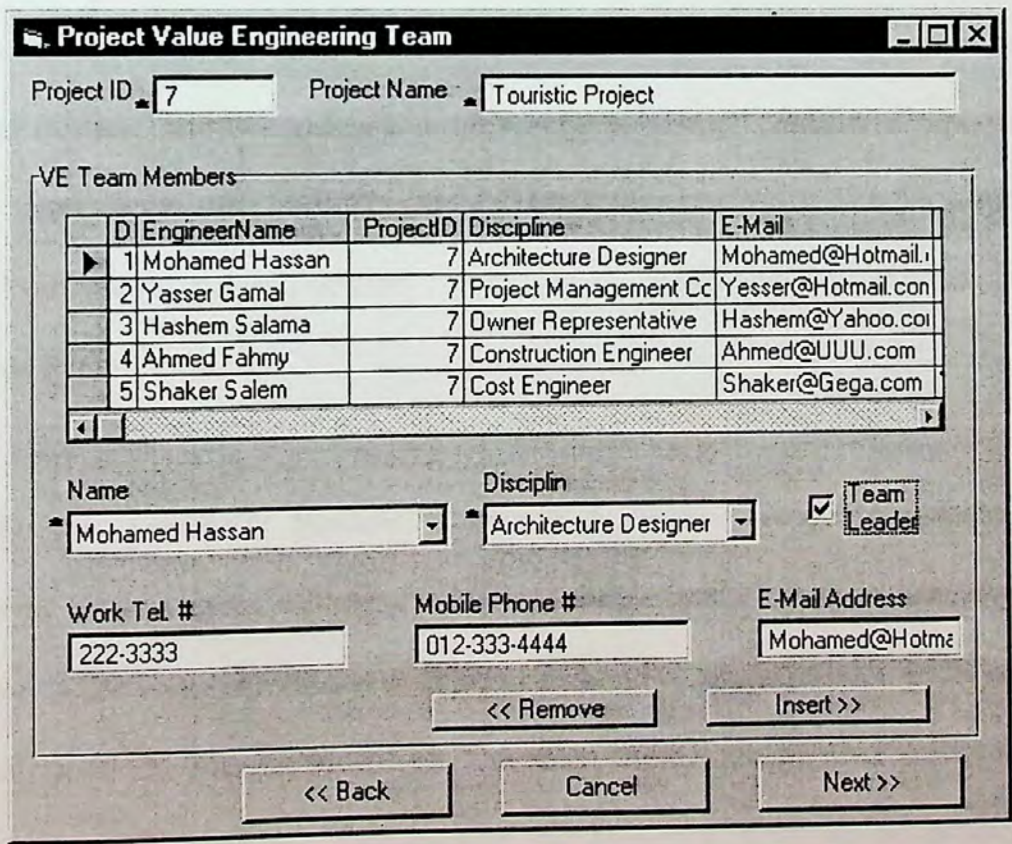


Figure 5.6 VE Team Module

As illustrated in Figure 5.6 the VE user is responsible to add the list of multidisciplinary team members to the project database. The member name is added to the project by choosing it from the data bound combo box list found below the table or by newly adding it if it is not found (Appendix B-10 shows the code that displays the list of past participants and their discipline). If the member name is added for the first time, it will be automatically added to the list of participants' table in the database for future retrieval or referencing. Other related information like discipline and ways to contact the person whether through regular telephone, mobile phone, or E-Mail. The VE user can then work as a coordinator between all disciplines to successfully circulate information and data that require fast action and final decision making.

For instance, the VE user can easily E-Mail one of the team members for cost and worth inquiries or for the validity of a certain idea or alternative presented during the creativity phase. Other members could be easily contacted particularly for contribution to the weighting and rating process of ideas and alternatives. As a result, tremendous time saving could be easily achieved with the improvement of multidisciplinary communication and thus improvement of the VE implementation.

4- **Project Cost Summary Module:** Project cost summary is prepared through structured project cost data, which are gathered and entered in the project database. Cost data represents the primary mean to compare value. It is the main foundation of a VE study, where the areas of the project that need to be investigated are identified. Theoretically, all high cost elements or items are

selected for in-depth analysis. The rule on which selection is performed varies from one consultant to another.

A standard presentation method for the different costs is favored for easier analysis and comparison. Two cost models have been adopted, the system oriented format (Uniformat), and the trade oriented format (Masterformat). Dell'Isola (1982) indicated how the Uniformat system has greater application for the designer since cost is broken down by functional area like superstructure, interior construction, etc. rather than amount of material in a facility. The Uniformat system is also preferred for VE studies during early designs as compared to the trade oriented format that follows the Construction Specification Institute Uniformat Construction Index (UCI) which is now called the Masterformat system. Such standardization in project cost summaries provides effective analysis and cost comparison between similar projects aid in generating cost and worth data reports which can easily be referenced.

The VE system developed in this research adopts the both Uniformat and Master format systems plus the capability to add any custom format system that might be suitable for special kind of projects. This provides higher flexibility in deciding which cost format suits the project under study. This flexibility also provides greater benefits during late stages of a project where more cost details are available. In addition, special formats can be easily developed to satisfy the needs for special types of projects where conventional cost formats are not feasible any more.

The cost summary module illustrated in Figure 5.7 is designed in a way that provides to the user the best interaction environment. It is anticipated during this module to experience a relatively large amount of cost data that need to be added.

Therefore, a detailed list of the type of format intended for use is available through a data bound combo box that displays all the required data. So, if the project adopted the Uniformat system in its cost estimate then by choosing the required level, all the corresponding data defining the cost elements will be directly available to the user. Consequently, great amount of time is saved and ambiguity is minimized due to the tremendous organization capabilities available to the system. As the user finish up adding all the necessary cost data, a list of all what have been added is presented clearly in a table format that can be easily checked for any errors.

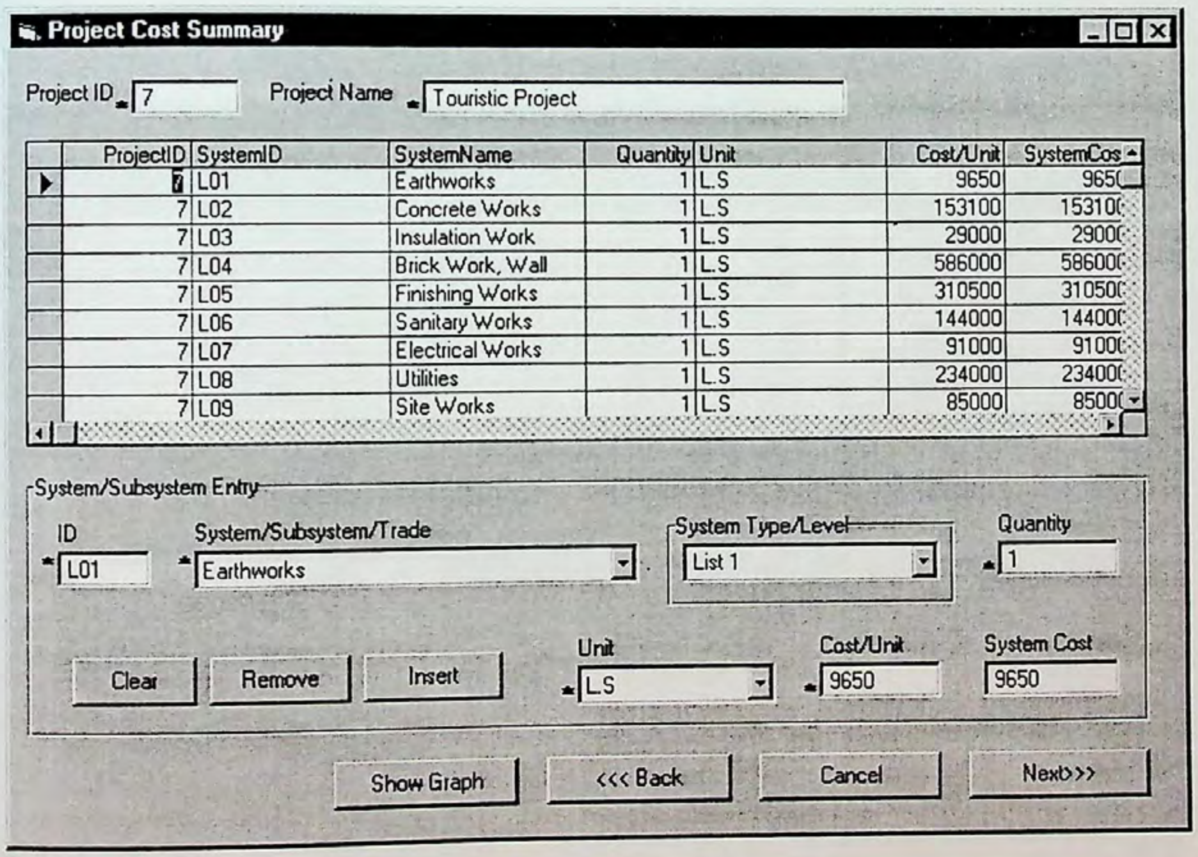


Figure 5.7 Project Cost Summary Module

Graphical representation is another available feature in this module. The user can simply click on the show graph button and a full graphical representation of

the cost summary list is displayed. Different means of representation can be exhibited like bar chart, pie chart, line chart, or area chart. This kind of presentation significantly helps users pinpoint high cost areas efficiently without having to read every cost element. Appendix B-11 illustrates the code responsible for this task.

5- **Item Selection Module:** After the project cost summary has been added to the database, it is necessary to identify those elements or parts in the project that has relatively high cost where potential savings could be achieved. The term "Item" here is frequently used to identify the elements selected for VE study. This "Item" could be a system or subsystem if using the Uniformat or any element included in the Masterformat or other formats adopted.

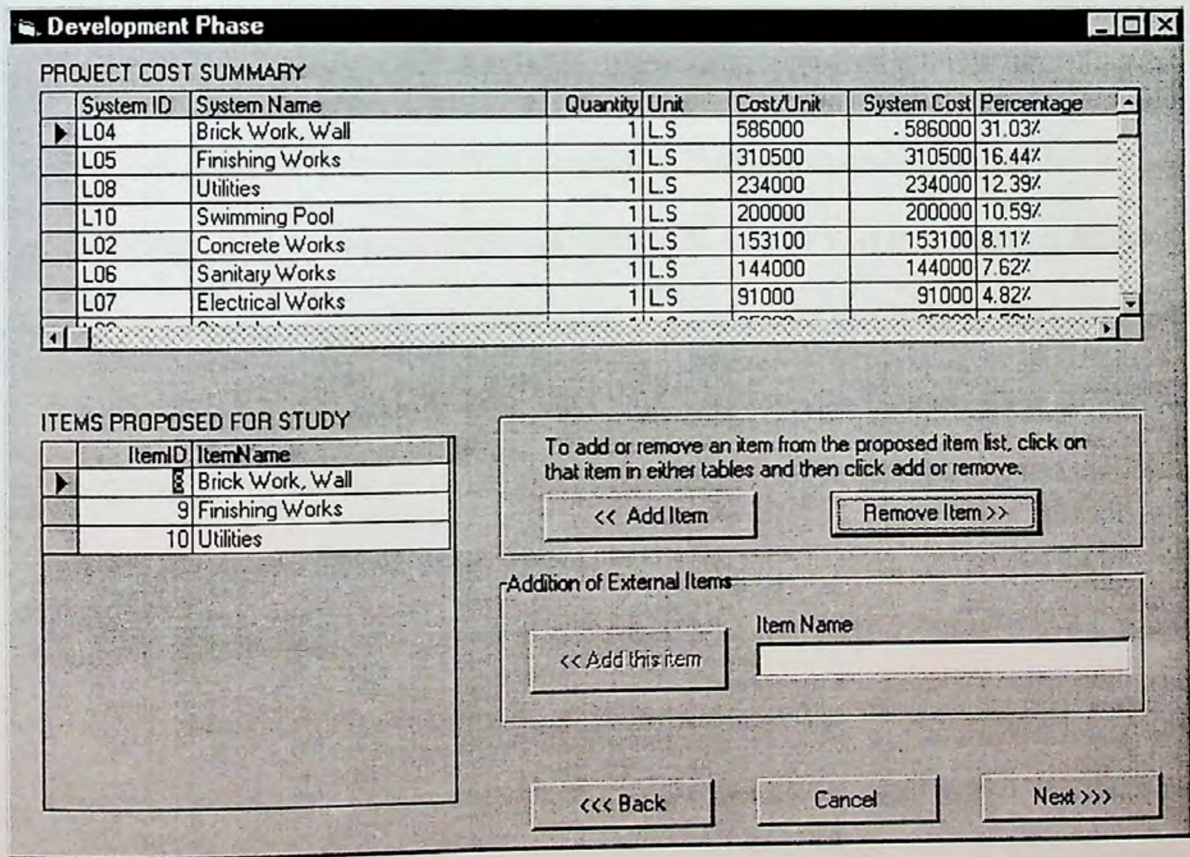


Figure 5.8 Item Selection Module

This procedure is established in the item selection module as shown in Figure5.8, where a list of all project systems and subsystems and their relative cost percentages is displayed in a table format. The cost percentage of each element in the project serves as a guide to highlight those areas that show high cost. The selection of these areas is determined based on Pareto's Law of distribution that states that, "approximately 20% of the elements of a system will contain 80% of the total cost" (Dell'Isola,1982). Therefore, all those items that represent 80% of the project total cost are selected for further analysis. This is performed by utilizing the programming capabilities of Visual Basic (Appendix B-12 encompasses the code responsible for this activity).

6- **Function Cost/Worth Module:** Now that the items or systems possessing high probable saving potentials are pinpointed, function analysis technique is exercised. This module is relatively crucial to the rest of modules presented in this VE system. The reason, as mentioned earlier in chapter 3, is that function analysis is what actually separates VE from other cost reduction methods. It represents the essence of VE principle. The aim is to further investigate these items or components by stating what does it do and to further separate those areas that provide secondary support and do not perform the main requirement.

The Value Engineer interacts with the function analysis process for each selected item, which is the item possessing poor value, through Function Cost/Worth Module as illustrated in Figure 5.9. The user through this module can choose the item or area of study he wants to analyze by clicking on it in the Data Tree Control located on the left side of the module. The basic functions of this item or area are chosen or newly entered in the Data Bound Combo Box located in

the upper part of the module. For the sack of presenting suggestions on what ought to be written for the item's basic function, a query is developed that lists all previous similar basic functions corresponding to the same item and under the same project conditions (the query is presented in Appendix B-14). All basic functions corresponding to the current item under study are displayed in the table next to the combo box for clarity and avoiding any possible ambiguity.

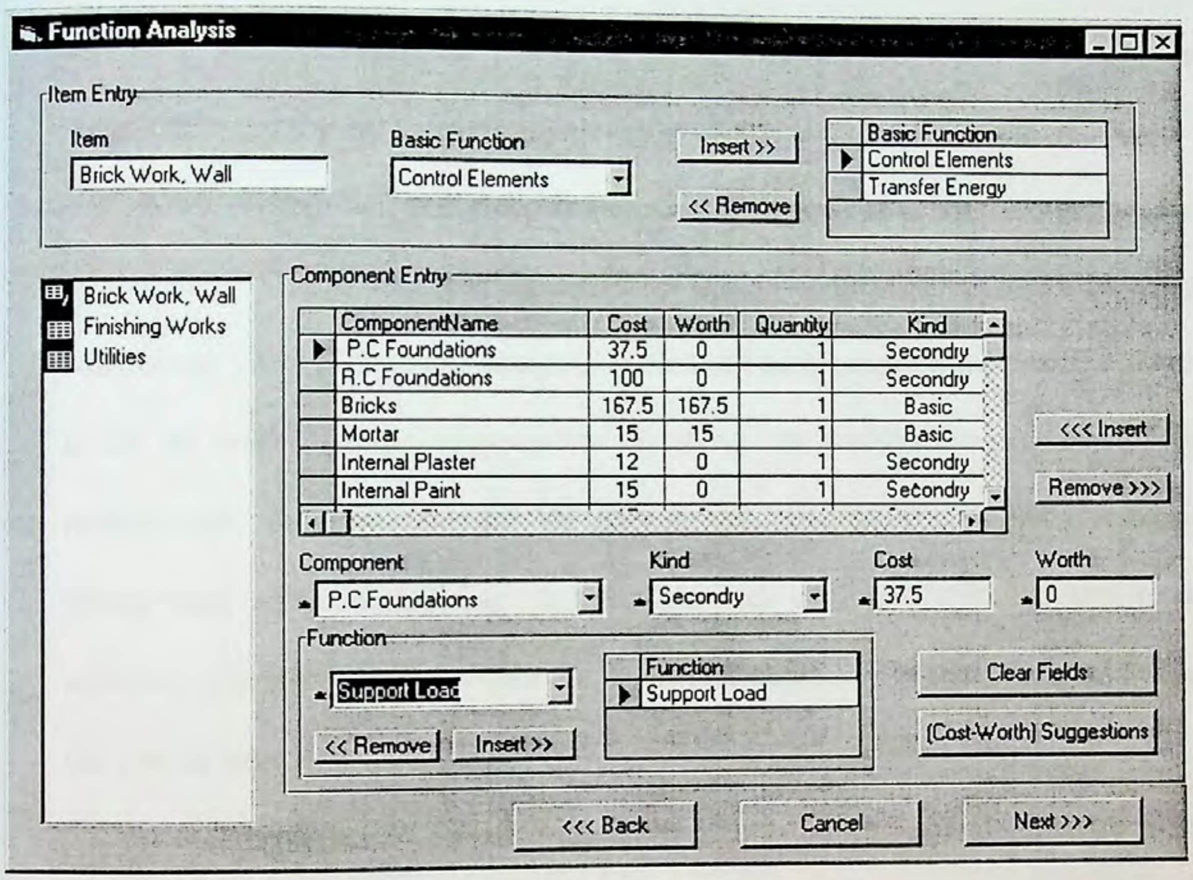


Figure 5.9 Function Cost/Worth Module

These added basic functions guide the user and help him through his analysis of each component under the corresponding item. For example, if the item is the superstructure of a building and its basic function is to "support load", then any of the item's components having a function that match the basic function which is "support load" will be considered a basic function and not secondary function. If

we take slab on grade component as one of the components found under the item superstructure we will find that its basic function is to support load which when compared to the item's basic function it shows good match. Therefor, the component function, support load will be considered basic and not secondary function. If we take Bearing Walls as another component, we will find that it has two functions, support floors and control elements. The former function when compared to the item's basic function can be identified as a basic function while the later function can be identified as a secondary function that adds or complements to the basic requirement.

After adding the items' basic function, it is required to list the components of the item. This is done by choosing or newly adding each component in the component combo box. The component combo box is programmed using a query to list all corresponding components matching the analyzed item under similar project type. This will aid the VE user in adding data efficiently, particularly saving time and standardizing data for the sack of future effective statistical analysis. These components will be examined carefully for their contribution to the overall item.

The cost and worth for each component are added to the component table through two text boxes. In case the user lacks cost or worth information for a particular component, the user can view previous cost and worth data of similar components. This is established through a query that selects cost and worth data for previous similar components under recent projects within close similar conditions (Appendix B-15 illustrates this query).

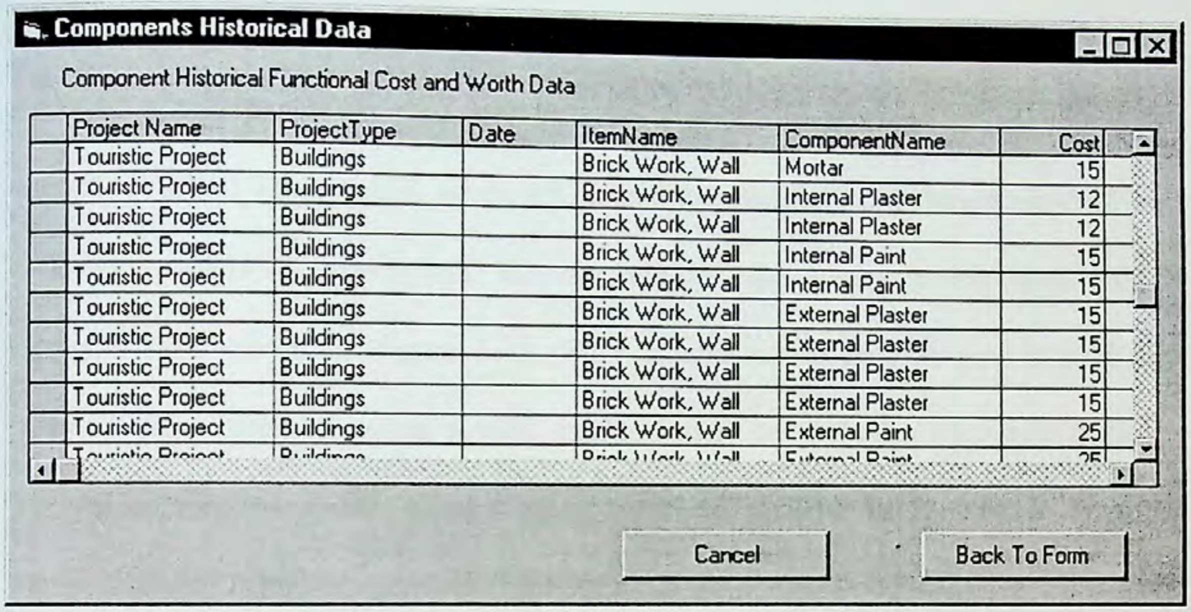
The cost and worth data are mainly used in calculating the cost/worth ratio for each item or area studied as mentioned earlier in chapter 3. Those items that have

cost/worth ratio of over 2 are candidates for significant savings (Dell'Isola, 1982). In addition, the functions of each component are either chosen or newly added through a data bound combo box that is programmed to list all functions corresponding to previous similar components. Those components that satisfy the item basic function are labeled basic functions, while other components are either labeled required secondary or secondary depending on their intended function.

The advantage of using the computer vast capabilities in arranging function analysis data is extremely notable. This is definitely true when dealing with a large number of items where considerable amount of components' data is processed. In addition to that is the high probability of making error when calculating cost/worth ratios, which need to be revised several times. Indicated by Benator (1991) who explained how this function analysis procedure may take 3-6 hours or more for a building in the range of 25,000 – 100,000 SF range. Benator also stressed on the benefits of microcomputer tools that aid in the calculation of cost/worth for each component.

7- **Components Historical Data Module:** The term "components" are used in this research to identify the basic parts that form an item in a project whether this item is a system subsystem or an element of a structure. While performing the function analysis exercise, each item studied has to be broken down to its comprising components for cost-worth analysis. Often VE practitioners look for historical cost and worth data for similar items they are examining. Through this module, users can display all the necessary cost and worth data for previous projects with similar conditions. The VE study data is also displayed so the user can have an idea of how old the presented data are.

The module is carried out when the user inquires for historical cost-worth data by clicking on the cost-worth suggestion button available on the function analysis module. Upon execution, the component historical data module is launched and the user can simply scroll through the table for suitable information. This is illustrated in Figure 5.10 and the code responsible for this task is displayed in Appendix B-14.



Project Name	ProjectType	Date	ItemName	ComponentName	Cost
Touristic Project	Buildings		Brick Work, Wall	Mortar	15
Touristic Project	Buildings		Brick Work, Wall	Internal Plaster	12
Touristic Project	Buildings		Brick Work, Wall	Internal Plaster	12
Touristic Project	Buildings		Brick Work, Wall	Internal Paint	15
Touristic Project	Buildings		Brick Work, Wall	Internal Paint	15
Touristic Project	Buildings		Brick Work, Wall	External Plaster	15
Touristic Project	Buildings		Brick Work, Wall	External Plaster	15
Touristic Project	Buildings		Brick Work, Wall	External Plaster	15
Touristic Project	Buildings		Brick Work, Wall	External Plaster	15
Touristic Project	Buildings		Brick Work, Wall	External Paint	25

Figure 5.10 Components Historical Data

B- Speculative Phase:

After identifying areas of potential savings using the former modules, generation of new ideas and alternatives that will perform the necessary function is anticipated. Two stages are established during this phase. The first stage encompasses the generation of new ideas that will help formulate new alternatives which represents the second stage. These alternatives will substitute original inefficient designs, which not only will help decrease cost but may also increase the overall performance of the project.

During this phase, two modules are designed to help materialize the planned goals. These work modules are:

1- **Idea Generation Module:** Now that the chosen items and areas of potential savings have been functionally analyzed and those high cost items have been stood out, it is time to generate new ideas that will satisfy the same item basic function. This is done in the creativity phase where creativity is utilized to the fullest to come up with as much ideas as possible.

In this module ideas generated for each filtered item are entered in a data base relation called Idea Table where all ideas corresponding to different projects are stored in. This is materialized through adding each idea in the idea data bound combo box shown in Figure 5.11. This combo box is programmed to fetch all stored ideas from previous similar projects that can help the VE user stimulate his/here thinking in developing even newer ideas. This can be done by combining ideas, modifying ideas, piggybacking, or even imitating ideas. Later on these new ideas are added to the data bound combo box list for future similar projects.

The different suggested ideas are further evaluated and judged. Ideas that don't meet owner/stakeholders constraints or requirements are dropped. Ideas that look impractical and unfeasible are also eliminated. Those ideas that have some probability of success are further analyzed and evaluated using a rating system that has been provided by Hill Consultants (Al-Salmi, 1989). The idea evaluation system provided takes into consideration five criteria which are:

a) State of the Art (Off the Shelf =5, Undeveloped Technology =1)

b) Cost to Develop (No Additional Cost = 5, High Added Cost = 1)

c) Time to Execute (No Delays = 5, Substantial delays = 1)

d) Potential Benefits (Major Benefits = 5, Minimal Benefits =1)

e) Problem of Acceptance (Excellent = 5, Little Chance = 1)

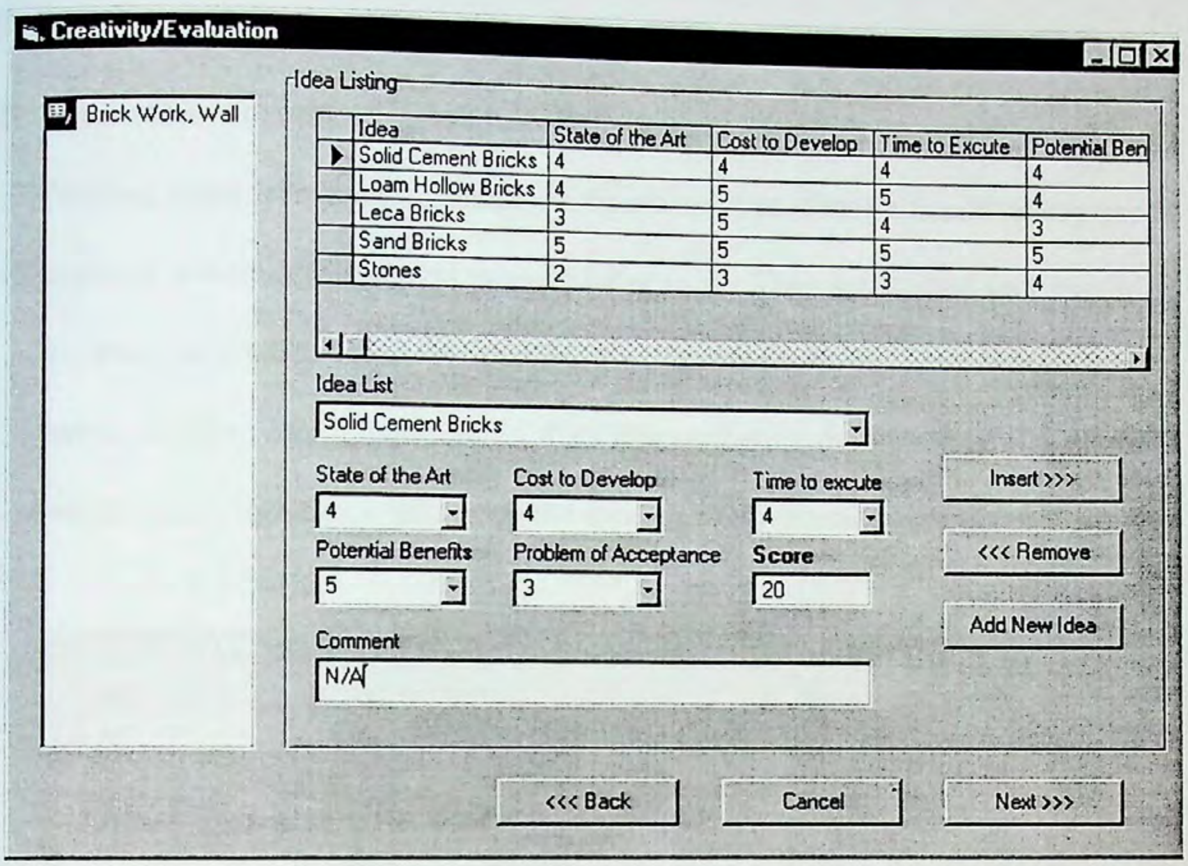


Figure 5.11 Idea Generation Module

The idea scores are then calculated and listed in a descending order. It is then up to the system user and eventually the multidisciplinary team to determine which ideas will be further considered. Any comments made on any of these ideas are also added since they will help the user identify any special cases or special recommendations. This process can even aid in future evaluation and development of newer ideas and suggestions for innovative thinking.

The advantage of this computerized system is its ability to store large numbers of information like ideas and suggestions in an organized manner. This ability helps the user generate a variety of reports that clearly identifies the

creativity and innovation of different team members with respect to different project conditions. A further step forward is the ability to apply statistical analysis tools on the VE database to come up with as much analysis as possible (Appendix B-18 contains the code that materializes this module).

2- **Alternative Formulation Module:** Alternative Formulation is the process of forming ideas previously generated into alternatives. These alternatives represent optional solutions that should posses higher value. They are studied very carefully in terms of total owning cost taking the life cycle cost into consideration and in terms of other non-quantifiable values like aesthetics, durability, flexibility, etc., which have a significant impact on the total alternative evaluation.

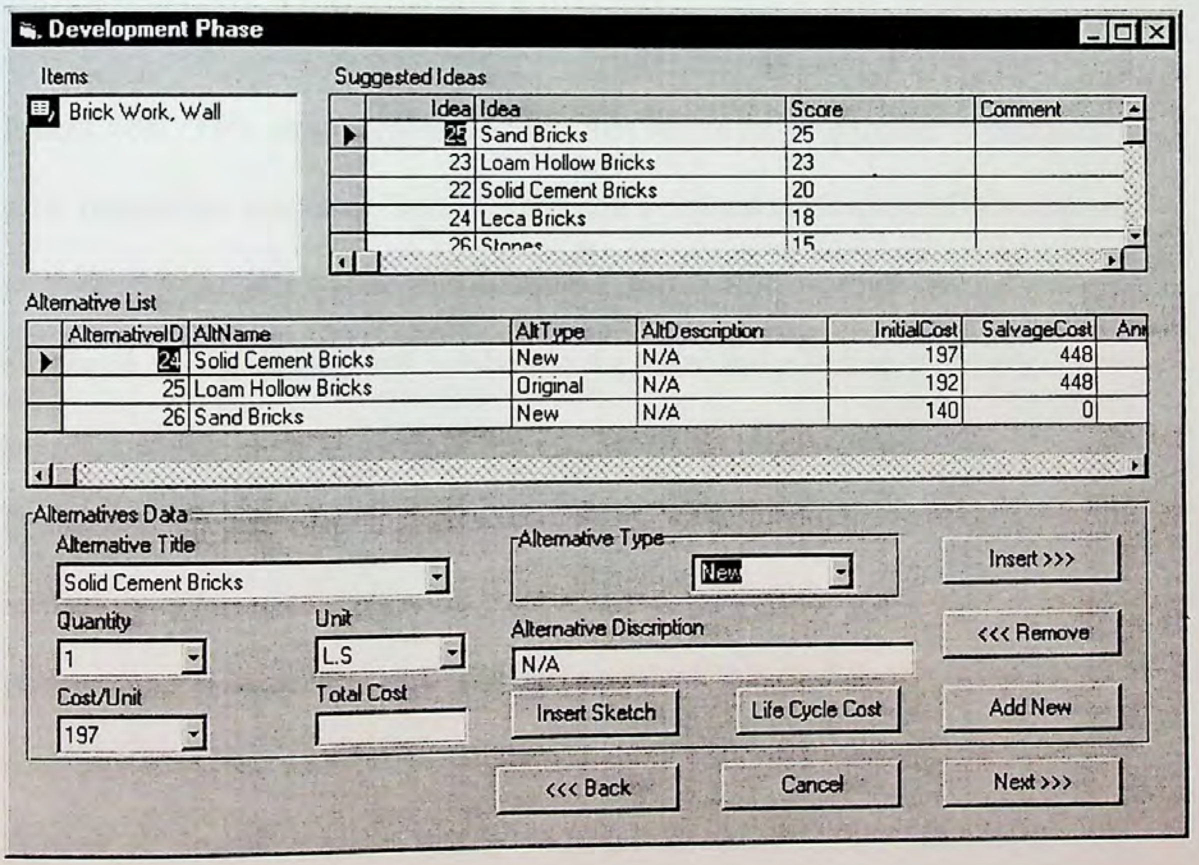


Figure 5.12 Alternative Formulation Module

As Fig. 5.12 illustrates, a user can formulate alternatives for the specified items displayed in the data tree located on the upper left side of the module. The alternatives' name either can be chosen as the same idea name or can be given a different name. The data bound combo box labeled Alternative Title is programmed to select all the ideas corresponding to the chosen item and display it to the user (Appendix B-23 illustrates the code). This ability enhances the VE process and saves lots of time, not to mention how this forms consistency. Corresponding Quantity, Unit, Cost/Unit, etc. are all added to the project database. These data help in calculating the cost of each alternative suggested which further aid in comparing alternatives and selecting those showing law costs.

Alternative cost comparison is done with respect to the original alternative and with respect to other newly suggested alternatives in order to boil down to the lowest cost. This stage represents the first before moving further to calculating total ownership cost and before exercising weighted evaluation. All alternatives formed are listed in a table with all related data. Suggested unit data and quantity are listed in the data bound combo box for faster and effective data entry. These suggestions are based on previous project data under similar conditions.

Users can go one step further in providing comprehensive cost data for the respective alternative by adding life cycle cost data. The LCC button is programmed to display a full life cycle cost analysis module where the user can add related cost data to calculate the total cost of ownership as shown in Figure5.13. In this module salvage and replacement costs are added and also the operation and maintenance costs where the time value of money is taken into consideration.

C- Analytical Phase:

As mentioned earlier in chapter 3, the analytical phase helps users objectively screen the various alternatives and ideas previously generated in the creative phase. This job is materialized using several techniques. Alternative weighting technique or the analysis matrix and life cycle cost analysis are two techniques adopted in this proposed system. The later is performed for each alternative formulated after the idea generation process, while the former technique is used after preparing the corresponding criteria for each item under study. The two techniques help analyze the proposed alternatives as accurately as possible and present a rational method for best selection.

During this phase, a number of modules are prepared to help implement its goals and objectives effectively and reliably. These module are as follow:

1- **Life Cycle Cost Module:** As mentioned earlier in chapter 3, the total life cycle cost of a facility is the sum of the design, construction, operation, maintenance, and replacement of the facility plus the debt service cost that fund the facility for a specified life cycle (Dell'Isola, 1982). This total cost consideration approach is extremely important to VE alternatives since they tend to look at the alternative different cost sides. Sometimes looking at one side of the picture is not enough to decide what is the best choice or alternative. This is because one solution might offer lower initial cost but might result in higher operational or maintenance cost. This process of calculating the total life cycle cost of alternatives is materialized through this module as illustrated in Figure 5.13. The user can add salvage or replacement related data and can also add maintenance and operational related cost data. The anticipated interest rate of return is identified which help in

calculating the present worth cost accordingly. For example, if a machine is expected to be replaced once during the lifetime of the project, the cost of replacement has to be brought up from the future time of replacement to the current time. This is established using discount tables in conventional manual settings. The proposed system, on the other hand, incorporates built in formulas that directly calculates present worth for any given value. The user can easily enter the expected interest rate and the year(s) of replacement with the cost of replacement and the system will be ready to calculate the present worth factor and finally calculate the total present worth amount of replacement (Appendix B-19 shows the formulas responsible for calculating the present value).

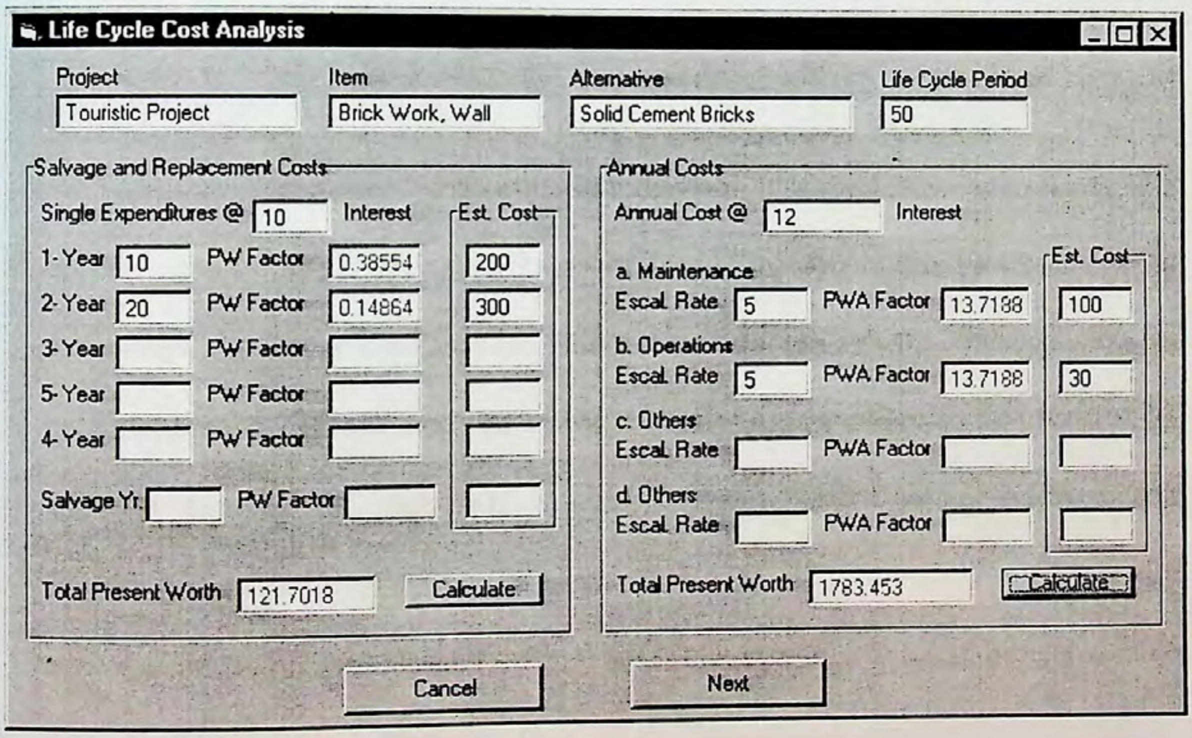


Figure 5.13 Life Cycle Cost (LCC) Module

The same thing is done for annual cost calculations where interest rate is entered together with the expected escalation rate if anticipated. Then by adding

the annual cost whether maintenance cost, operation cost, etc., the total present worth will be automatically calculated and stored for the corresponding alternative. Finally by adding the salvage and annual costs to the initial cost, the total life cycle cost will be successfully achieved.

Comparing this VE system to other manual systems one can find how significantly this system can save tremendous time not to mention its high accuracy especially when dealing with large number of alternatives. This aspect is made true by programming the text box controls located in the module to instantly calculate the present worth factors whether using escalation or not and storing it against the corresponding fields for further calculations. When the user finally finish adding all the necessary data in the various empty text boxes, the program will be ready to calculate the total cost within less than a fraction of a second and with high degree of accuracy.

The proposed system not only performs the intended task effectively and quickly but it also opens up huge opportunities for future development or integration with other tools that can generate additional analysis. This can open up potential opportunities to study previous projects and come up with trend and deep concrete analysis of past VE studies that can present strong feedback for upcoming studies.

2- **Criteria Formulation Module:** One of the first steps in weighted evaluation is criteria formulation. These criteria like Dell'Isola (1982) describe, represent elements that can not be assigned dollar value, but are essential for a full and complete VE study. These criteria aid in measuring other values that otherwise can not be measured whether these values are esteem, exchange, cost, use, or any

other quantifiable or non-quantifiable. Each discipline can participate in developing these criteria, which help serve his field of work. In the same token, as Zimmerman and Hart (1982) indicated, all participating disciplines are recommended to participate and give input during the evaluation process. The result and relative importance of each criterion will mainly depend on the owner and his terms of ownership.

This criteria formulation module mainly represents a working area where the user can view, modify, or add criteria to a specific item or element in a project. As illustrated in Figure 5.14 the user can easily select the item intended for manipulation by clicking on that item in the tree view control located on the left side of the form. This action will automatically clear all data entry controls located in the criteria adding frame so to be prepared for criteria formulation. The Add Criteria Frame is designated for criteria insertion and deletion. Here the user can insert as much criteria as required and in the case a user wants to delete any criteria from the added list, he or she can easily choose that criteria and click on the remove button.

After all required criteria are added to the corresponding item, criteria paired comparison is expected. Here the relative degree of importance for each criterion previously added is specified. The reason behind this exercise is to identify the relative importance of each criterion developed in order to correctly reflect the owner needs. This is done by selecting every criterion and giving it a degree of importance against each set of criteria starting with "1" for slight preference and "4" for major preference which was suggested by Dell'Isola (1982).

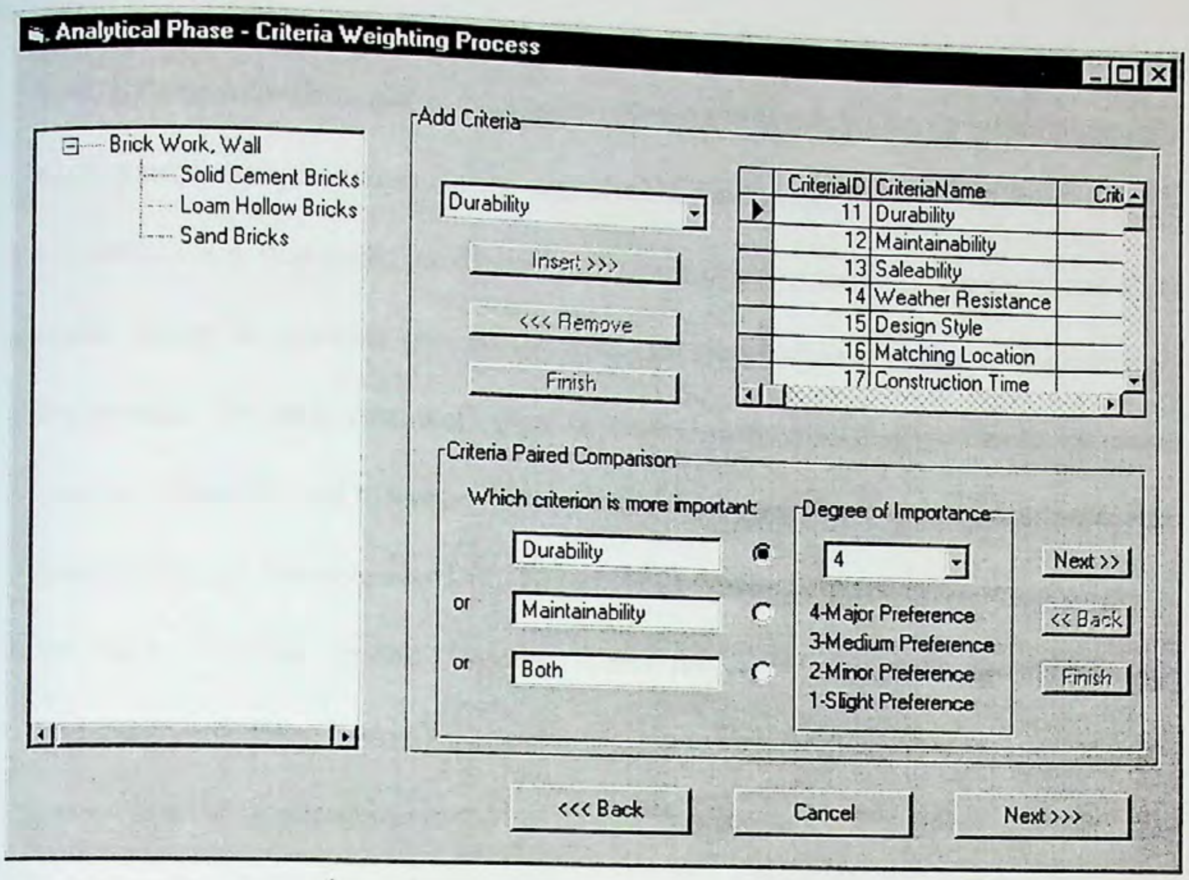


Figure 5.14 Criteria Formulation Module

After all required criteria are added to the corresponding item, criteria paired comparison is expected. Here the relative degree of importance for each criterion previously added is specified. The reason behind this exercise is to identify the relative importance of each criterion developed in order to correctly reflect the owner needs. This is done by selecting every criterion and giving it a degree of importance against each set of criteria starting with "1" for slight preference and "4" for major preference which was suggested by Dell'Isola (1982).

The method of paired comparison used in this module can be easily implemented when compared to manual methods (Appendix B-20 shows the code responsible for the paired comparison procedure). Upon user addition of all criteria and by clicking the finish button, the program is designed to store these

criteria in a table where each criteria is chosen and placed against another one for user judgement. The user is only required to choose the degree of importance for each paired comparison instance and click the next button after every job. When all criteria are compared with each other for all the corresponding items and the finish button is clicked, the program will be responsible to calculate the relative importance for each criterion. This is done by summing all the score for each criteria separately and then converting it to a scale from 0-10 which is called score normalizing as indicated by Dell'Isola (1982). These normalized scores are saved for each criterion in the database tables for the next step in the weighting evaluation process.

3- **Alternative Weighting Module:** The second part of weighting evaluation is the analysis or alternative weighting process. During this process, previously suggested alternatives are listed and ranked against each criterion. As indicated by Dell'Isola (1982), multiplication of the rank and weight for each criterion is implemented and the total is finally calculated for each alternative. The alternatives are then ranked and given a score for recommended execution.

Again when comparing this computerized system with manual methods, it can be easily recognized how simple this process can be. Manual methods would require high concentration effort in tracking the row and column of each criterion and its corresponding alternative. In addition to the long and tedious calculations required in multiplication and summation of the total. The problem would even exponentially increase when dealing with a considerable number of alternatives and criteria and certainly when repeating the same exercise for more than one item. Definitely, the amount of paperwork that would be involved in such an

exercise would significantly be tremendous and the energy to revise any document or even retrieve any piece of information would be equally hectic.

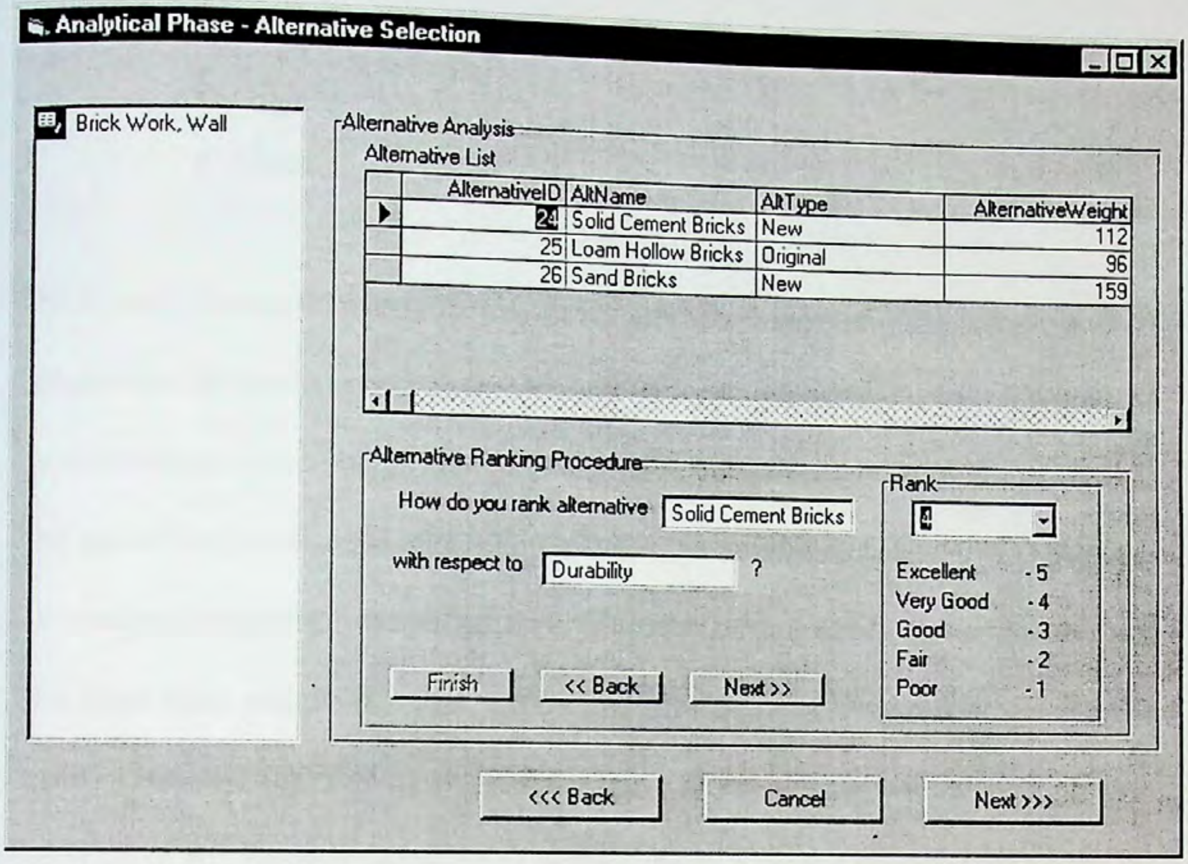


Figure 5.15 Alternative Weighting Module

This alternative weighting module shown in Figure 5.15 however is made as simple as possible where the user is saved from all the unnecessary hectic and repetitive alternative and criteria recording. The program is designed to recognize the previously added alternatives that correspond to the item currently on hand and display it in an organized table format. Next, the first alternative is selected and entered in a simple question dialogue asking the user to rank it with respect to the different criteria previously entered. The user is simply required to choose from a list of five ranks which were suggested by Dell'Isola (1982) and they are:

- Excellent ≡ 5
- Very Good ≡ 4
- Good ≡ 3
- Fair ≡ 2
- Poor ≡ 1

Each rank chosen is saved in a temporary table for later execution. After the first alternative has been ranked against the corresponding criteria, the next alternative is selected and placed within the question dialogue for similar implementation. At the end of the process and after all alternatives have been introduced, the program is designed to perform the necessary multiplication and addition to come up with the final total weight for each alternative (Appendix B-23 shows the developed code). The missing step now is the relative ranking of each alternative and the addition of any recommendations or actions made. This can be better explained in the following section.

D- Proposal Phase:

The proposal phase constitute the culmination of the VE study where the optimum alternative is identified and presented in a report format for final action to be taken by the assigned personnel. Here alternatives are reviewed thoroughly and a proposal is prepared in a sound manner with provision of a complete implementation plan in order to help convince management.

A module is prepared during this phase to help materialize its objectives by providing all necessary data that will aid in formulating the final proposal. This module is:

1- Alternative Selection Module: After the total is calculated for all alternatives within all selected items, the ranking procedure is established. The alternative having the highest total is ranked # 1 and the second highest total is ranked # 2 and so on for the rest of alternatives. The architecture of this module is illustrated in Figure 5.16.

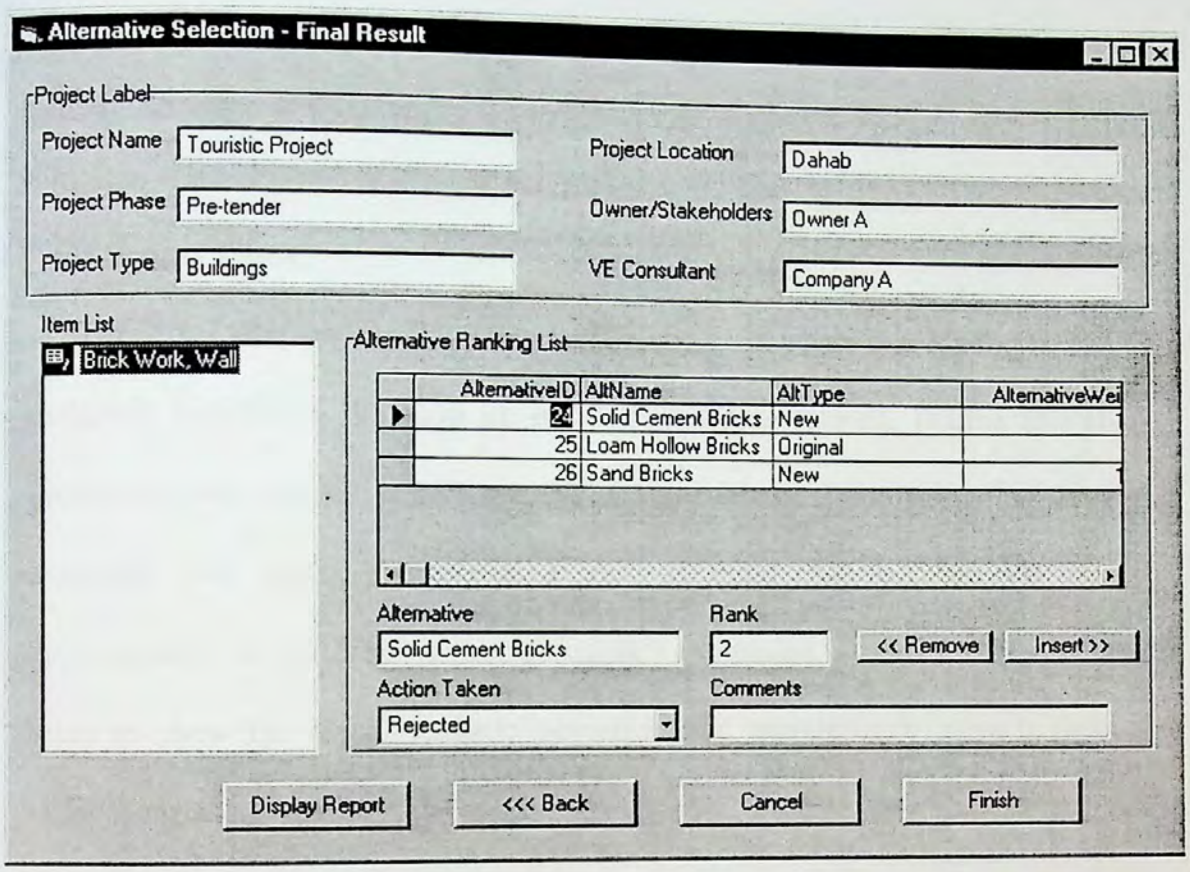


Figure 5.16 Alternative Selection Module

This module is mainly intended to rank alternatives and place them in a descending order based on the total weight. Moreover, any comments or actions made on any of these alternatives can be conveniently recorded which aid in VE proposal generation. Those alternatives that are rejected are omitted and only the one accepted are easily identified for VE proposals and final reporting.

Not all alternatives ranked number one will be accepted. Some alternatives ranked second or third could be accepted for implementation provided that some

modifications are made to them. These modifications can be easily added to the system through a modification attribute allocated for it. If one of the alternatives is conditionally accepted where modification of any sort is applied, then it is stated in the action attribute. This procedure helps rap up the study and clearly identify final decisions taken whether accepted, conditionally accepted or rejected. It also assists in future retrievals of VE information particularly the reason and rational behind these decisions taken.

E- Final Report Phase:

The Final Report Phase is considered an optional phase that if completed will definitely help close the loop of any VE study performed. During this phase implementation of the recommendations presented in the previous phase is executed. Bid prices are prepared and the total cost for each VE idea is implemented. In addition, a post-occupancy evaluation is máde for implemented ideas to show the actual realistic operation and maintenance costs in order to know the true impact of the VE study.

In other words, this phase represents a feedback task where actual related VE data are recorded for future system enhancement. This feedback is made possible through the following module:

1- **Post Occupancy Feedback Module:** After performing the VE study and all the necessary reports have been prepared. VE proposals are either fully or partially implemented. Moreover, bid prices are analyzed and the dollar value for alternatives implemented are estimated. Life cycle cost savings are also checked for the proposed alternatives. If the actual cost for performing the proposed

alternative was different than what has been formerly estimated, then it is worthwhile to record what have been truly implemented since this will definitely help close the loop from recommendation to actual implementation.

The data recorded could be the actual price for the different alternatives and ideas proposed. Any deviation from the VE proposed price would be easily detected and analyzed for adjustments in future study. In addition, actual life cycle savings are recorded as means of reliable follow-up. A post occupancy evaluation is greatly recommended in cases where life cycle savings are relatively large. This feedback can aid in future projects, where better estimates are achieved.

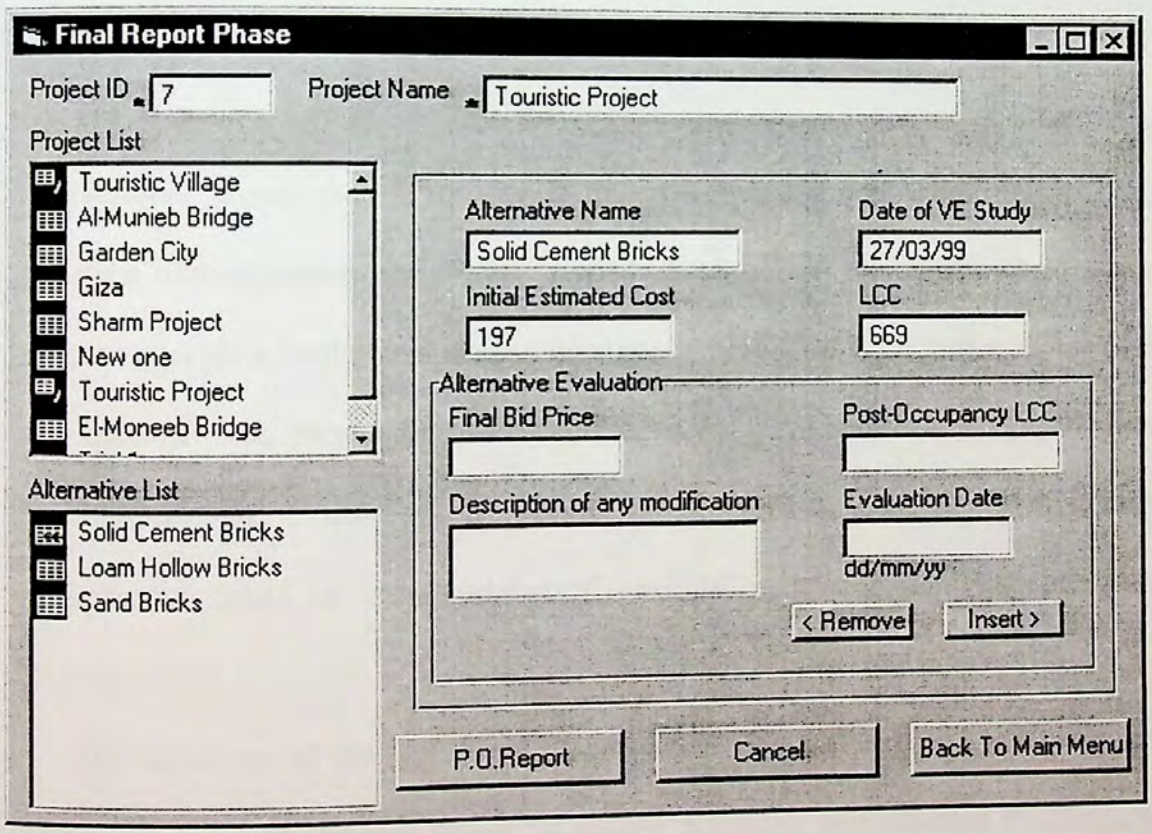


Figure 5.17 Post Occupancy Feedback Module

The post occupancy feedback module can be easily initiated from the interface module. The project intended for post occupancy study is easily selected from a list of projects already studied. Upon project selection, all the corresponding alternatives proposed and approved are selected from the alternative table and displayed in the tree view on the lower left side of the module as shown in Figure5.17. The user can only choose the alternative that need to be updated and add the available final bid price and life cycle cost. Any additional description of any kind of modifications made is included for comprehensive feedback. Finally, the user can either exit or prepare a post occupancy report with all the related detailed information (Appendix B-26 illustrates the code for this module).

5.3.3.3 Interface Design

The interface design include the layout of workspaces, controls, displays, instructions, forms, etc. After identifying the system structure and modules, the interface characteristics should be studied carefully. It is important during this stage to provide a workable and easy workspace where human frequent interaction is expected. This means that the interface should be compatible with human capabilities and limitations. The objective is to identify areas where system performance could be enhanced through establishing a "well-designed" interface (Bailey, 1982).

The intention of the interface design adopted in the proposed VE computer system was to use similar interface design practices implemented by common used Microsoft software products. There are two reasons behind this strategy. The first is that the VE system developed is implemented using MS Visual Basic and MS Access. The second reason is because Microsoft products are widely popular

and used by most people, which makes its style more known than any other software.

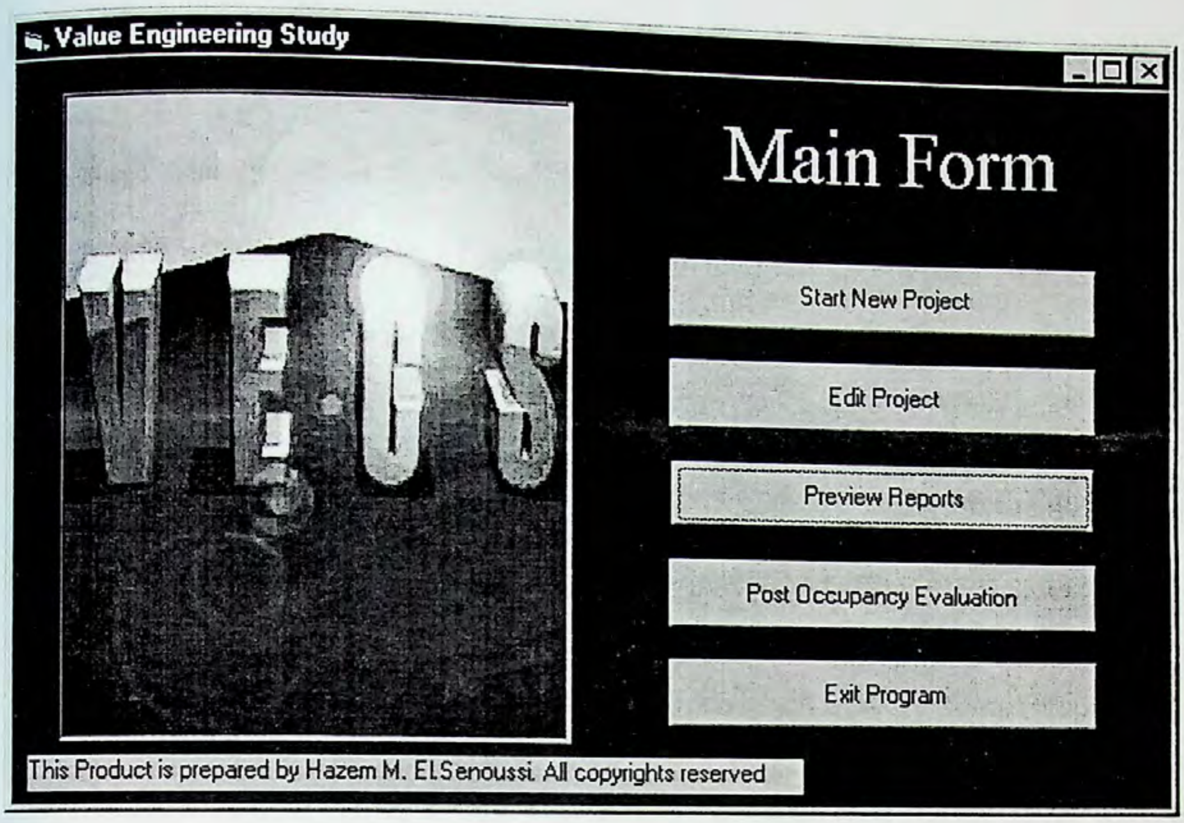


Figure 5.18 VECS Project Main Menu

For better project interaction and to provide greater simplicity. The system modules are all controlled from the (VECS) project main menu presented in Figure 5.18. Through this menu the VE practitioner can easily begin a new project VE study or edit an old one. The user can also provide post occupancy and feedback data for any old study. Moreover, different types of VE reports can be prepared whether these reports are proposals, analysis, or final post occupancy reports. The main menu represents the coordinator or administrator through which the VE practitioner can handle VE data whether this handling is an addition or retrieval.

5.4 System Operational limitations:

Although, the system proposed (VECS) has proven successful implementation, yet it has shown some limitations particularly concerning the level of life cycle cost (LCC) analysis application. LCC analysis is defined by Dell'Isola as "life cycle costing plus use of a non-economic tempering of results using weighted evaluation techniques". The key to life cycle costing is the "economic assessment" to bring up all money value whether future or past to only one time frame where all related data can be equally analyzed (Dell'Isola, 1982). LCC analysis involves a wide spectrum of parameters that if provided will help reach accurate results.

The proposed system accepts and calculates all the necessary cost data that formulate the LCC, which are the initial cost, salvage or replacement cost, operation and maintenance cost. However, the system is not designed to generate energy models that can help identify energy requirements for each part in a facility. Moreover, the system doesn't incorporate a maintenance data base file allocated for storing valuable maintenance data that could help support system users in their decision making. This could be attributed to the shortage in finding a comprehensive data base containing different life-cycle maintenance costs for each type of facility and for each level of use.

Another limitation is that the proposed system is a single user package that can not be concurrently accessed by more than one user. This limitation reduces the ability for more than one user to access the knowledge base section formed in the system by the various cases implemented. In other words, if a VE case is implemented using the VECS, it will help acquire additional knowledge that will not be accessed by another user using another platform unless he shares the same data base files.

Moreover, although the system incorporates electronic mail addresses corresponding to the different participants in a VE session, yet the system is not designed to directly go online to send related VE data. Such limitation increases the communication time anticipated between VE participants, which otherwise could have been significantly reduced.

5.5 Implementation and Validation

VE system modules are implemented using the software environment MS Visual Basic V.5. The database is structured in MS Access 97. Both softwares are integrated together to form the proposed VE system. This system can be installed on any PC or laptop as well as it can reside on the server for availability to more clients.

To validate the system and demonstrate its capabilities and benefits, two case studies were selected. One real case study was selected from a Master's Thesis prepared by El-Badry (1982) involving applying VE to a resort project in Sinai. The second case study chosen from a Ph.D. research prepared by Meetkees (1996) involving a VE study of El-Moneeb Bridge in Cairo.

5.5.1 Case I: Tourist Resort Project

The former case, a resort project in Sinai had a preliminary cost estimate of LE 1,888,743 which was above the allocated budget predetermined by the owner which was 1.5 Million Egyptian Pounds. After revising all project parameters and constraints, a VE study was implemented for the sake of "optimizing cost" and hopeful fulfillment of owner's budget. The study resulted in life cycle cost savings of

69% of project budget after mainly using a kind of brick that helps substitute substantial internal and external plastering and painting.

The project, located in Dahab, Egypt had a land area of 8000 sq.m and a total built area of 2200 sq.m. It was designed to offer 51 rooms but as budget was squeezed, the owner divided the project into two phases. The first phase included building 31 rooms and the rest 20 rooms were planned to be established later in a second phase. The project included other supporting facilities like a swimming pool, shopping area, administration building, reception building, stores, washing rooms, etc.

During the information phase of the VE study, the project had a number of constraints that were considered. The owner stated a number of constraints, which were:

- The style of resort should match "Bedouin Style"
- The material used should harmonize with the surrounding environment
- The components and material selected should withstand the surrounding whether conditions.
- Limit the budget by the offered 1.5 Million Egyptian Pounds loan and should finish within 8 months in order to catch the next coming season.

The project preliminary cost estimate was analyzed by the VE team members who were composed of:

- Architecture Engineer
- Owner representative
- Cost Engineer

- Construction Engineer
- Project management consultant

The analysis of the project preliminary cost estimate resulted in highlighting those high cost areas that are suggested for VE study which are the following:

- 31% of the total budget was located for brick works
- 16% of the total budget accounted for finishing works
- 12% of the total budget accounted for Utilities works

After presenting these potential areas to the owner representative and negotiating the final approval for VE implementation, it was concluded that only the brickwork and the finishing work items are the ones authorized for study. This was because the utility item that was left out was tied up with the future expansion plan allocated in the second phase and because the designer wanted to consider the whole project and not only for the first phase.

The design components that were selected for VE study were:

- Brick work
- Internal finishing (plaster and paint)
- External finishing (plaster and paint)
- Ceramic works (walls & floors)
- Carpentry

The author used the wall system to describe the brick, plaster, and paint elements that were chosen for VE study. Function analysis was applied to determine the basic functions of each component and to highlight those that are not cost.

After choosing items of poor value, generation of ideas and alternatives to substitute old ideas were welcomed. Analysis of the available ideas and studying their conformance with owner requirements, criteria development were inaugurated to result in preparation of 6 criteria as follows:

- Durability
- Maintainability
- Salability
- Design Style
- Matching Location
- Weather resistance

After ideas were evaluated and ranked, alternatives were developed and the weighted evaluation technique was ready for implementation. Three exercises were executed involving evaluating alternatives for internal wall finishing, external wall finishing, and internal flooring.

Finally life cycle cost (LCC) analysis was employed on the wall (50cm thickness) which involved three alternatives. Hollow loam brick wall as the original design, solid cement brick wall as alternative 1, and finally solid sand brick wall as alternative 2. The study included studying the initial cost of the different wall systems plus their replacement and annual costs.

Finally, the study resulted in using solid sand bricks (white 25x12x6cm) instead of the original proposal which was loam hollow bricks (25x12x6cm). This decision resulted in saving the cost of plastering and painting both internal and external since the suggested solid sand bricks would be utilized for its natural texture. This resulted in having smooth white brick texture for internal wall finishing and rough white brick texture for external wall finishing.

The proposed computer VE system was used for this project to explore the system's ability to improve VE implementation. The first step was to gather all necessary project data that will form the foundation for the system analysis. Like for example project identification information, cost summary, owner's constraints and VE team members involved in the study. After that, the system was able to demonstrate items of potential savings with the aid of graphical representations as illustrated in Figure 5.19 and Figure 5.20.

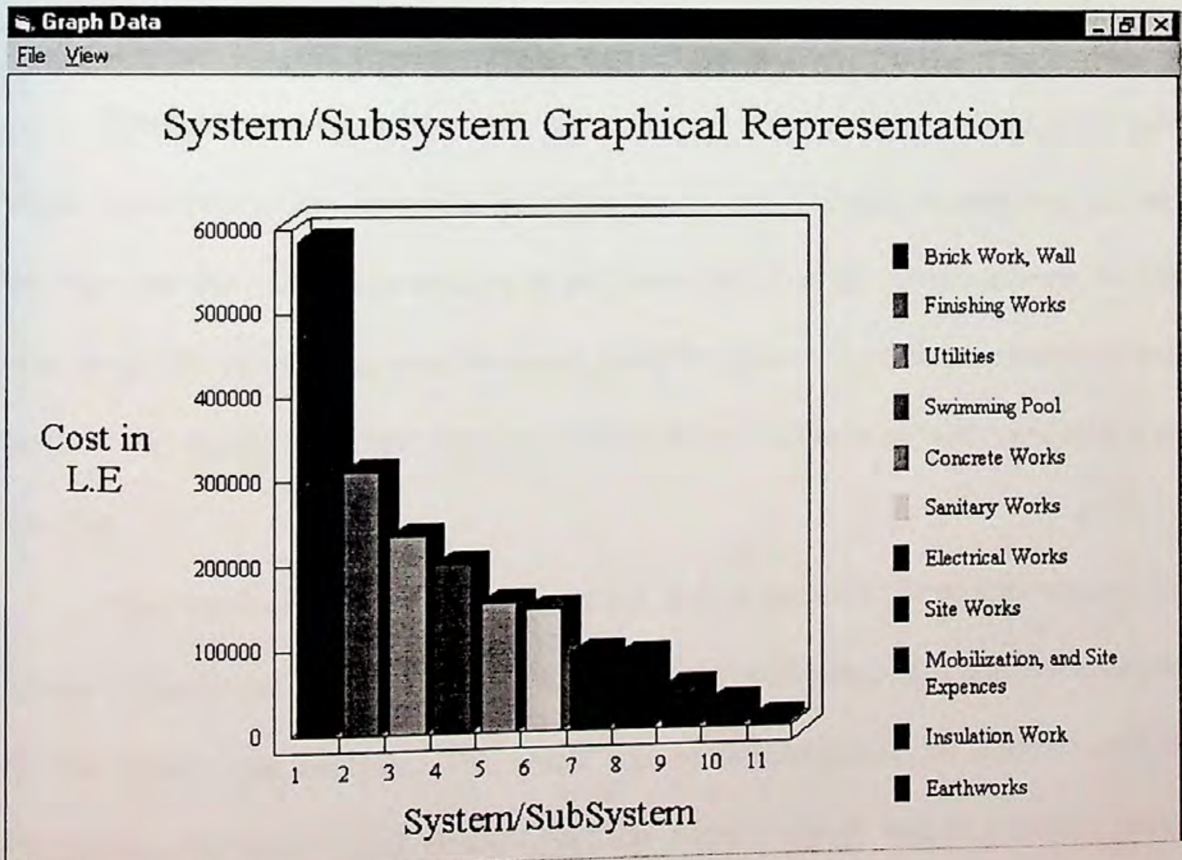


Figure 5.19 Tourist Resort VE Cost Summary Bar Chart

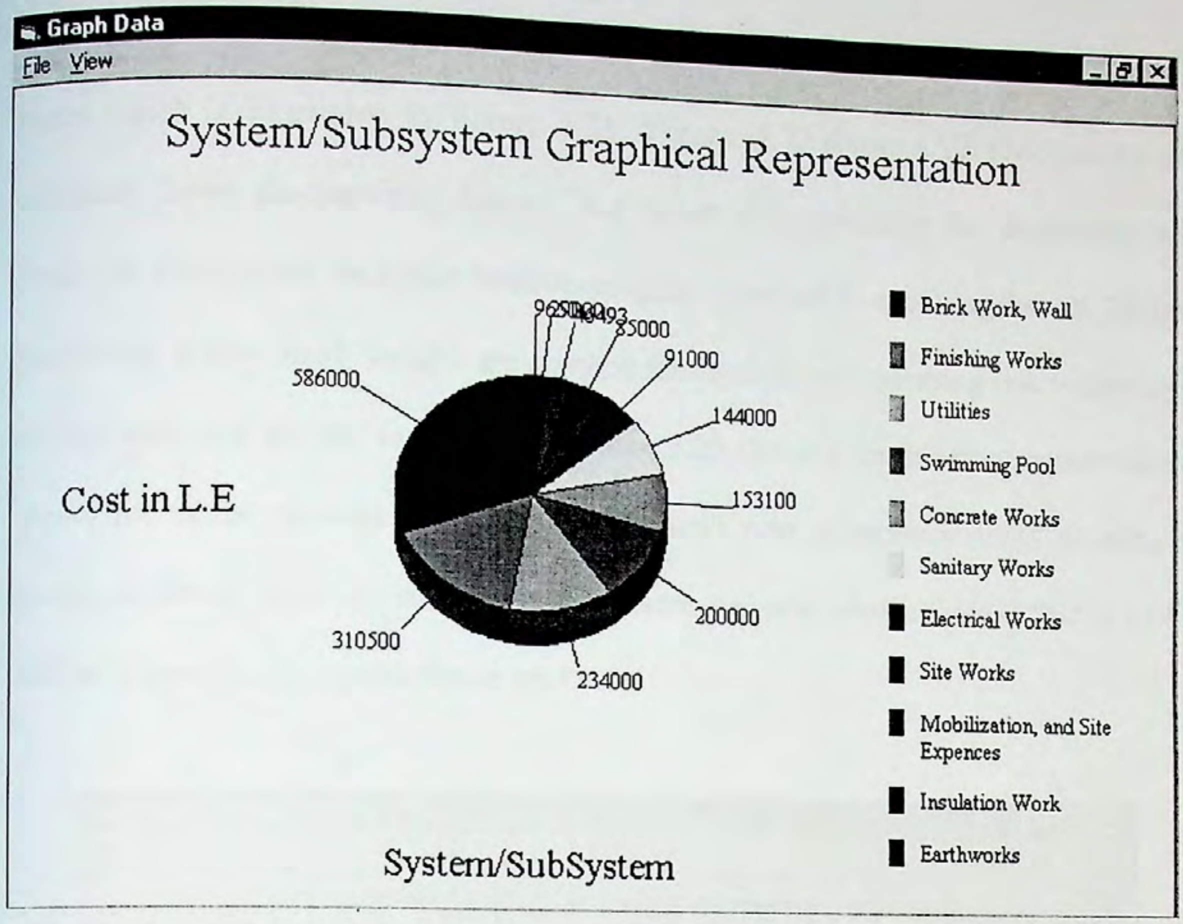


Figure 5.20 Tourist Resort VE Cost Summary Pie Chart

Three items were pinpointed for potential savings based on the 20/80 rule which were brickwork for walls, Finishing works, and Utilities. As indicated earlier, the user has the freedom to remove or add items based on the chosen scheme. In this case study the utility item was discarded based designer and owner requirements and most of the finishing works was interrelated to the wall item so both were joined as one item.

After performing the idea generation and alternative formulation exercise, criteria formulation and alternative weighting were established with detailed analysis of life cycle cost analysis. The result was recommendation for alternative # 3 representing the Solid Sand Brick (25x12x6 white), which will be used as a stand alone or in other words will be left with its natural face saving the cost of internal and

external wall finishing. All reports are prepared from the report development main menu which is illustrated in Figure 5.21. Figure 5.22 shows a VE proposal report activated from the previous figure. This report is responsible for displaying all proposed alternatives and their relative weights expressed in a ranking format. Those possessing higher total weight are ranked first and those possessing less weight are ranked next and so on. In addition, Figure 5.23 shows a sample final report which shows the actual construction cost together with post occupancy LCC forming a useful feedback. Any deviation from the estimated cost whether initial cost or LCC will help users in subsequent future studies.

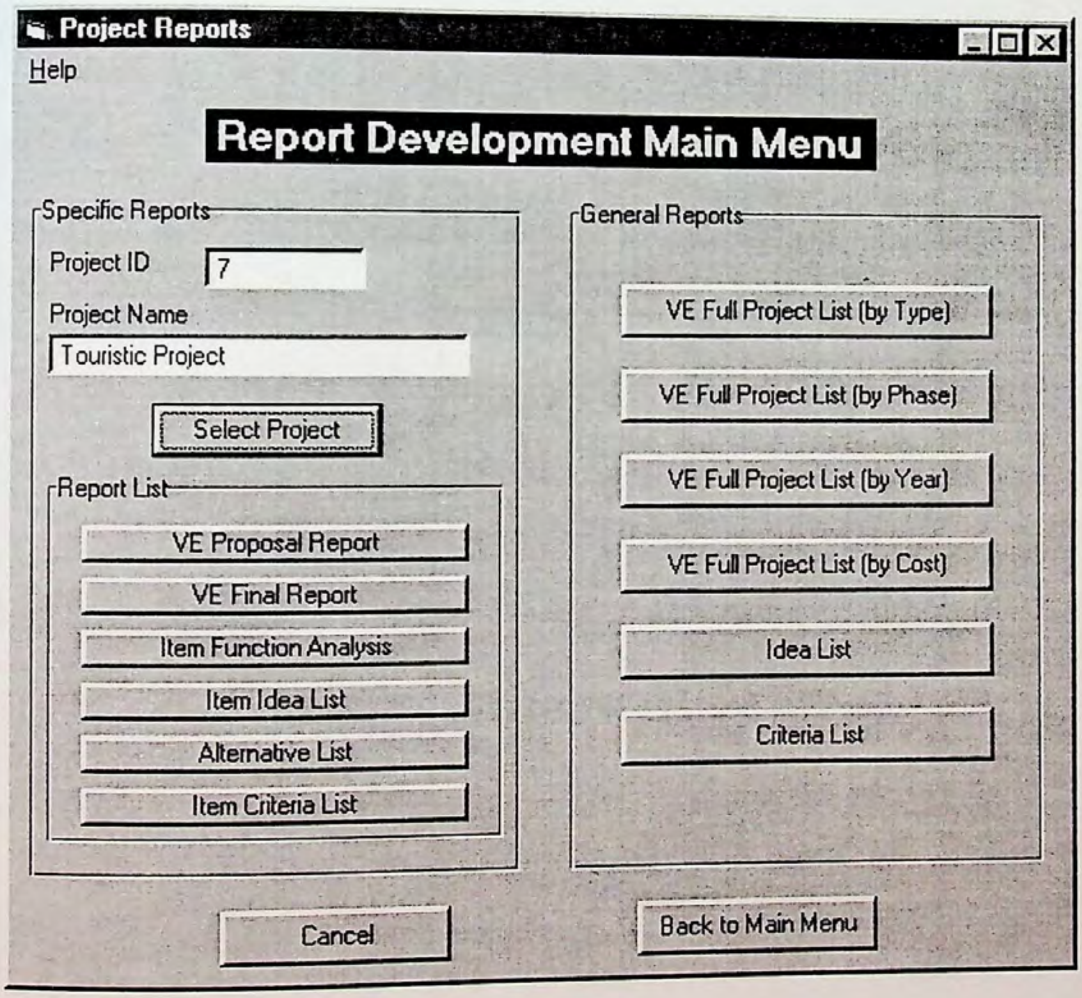


Figure 5.21 Report Development Main Menu

t Number: **7** Project Name: **Touristic Project**
D: **8** Item Name: **Brick Work, Wall**

5/2

ativeID	AltName	AltType	Rank	InitialCost	Salv. & Repl. Cost	AnnualCost	LCC
24	Solid Cement Bricks	New	2	197	448	25	670
25	Loam Hollow Bricks	Original	3	192	448	25	665
26	Sand Bricks	New	1	140	0	7	147

Figure 5.22 Touristic Project VE Proposal Report

VE Final Report

Project Number: **7** Project Name: **Touristic Project**
Item ID: **8** Item Name: **Sand Bricks** 5/27/00

AlternativeID	AltName	AltType	Rank	InitialCost	alv. & Repl. Cos	AnnualCost	LCC	BidPrice	PostOLCC	EvaluationDat
26	Sand Bricks	New	1	140	0	7	147	160	167	2/ 1/00

Comments: The bid cost was raised L.E 20 compared to the original preliminary price due to escalation conditions.

Figure 5.23 Tourist Project VE Final Repor

5.5.2 Case II: El-Moneeb Bridge

The second case involves El-Moneeb Bridge, which is one of the major long span bridges in Egypt and also one of the vital ones since it connects Greater Cairo Ring Road over the Nile. The erection tender price for the bridge was about L.E114,035,134. The bridge connects El-Maadi area at the south of Cairo with El-Moneeb area in Giza crossing El-Dahab Island. The distance between both ends is about 1030 m distributed across the Nile where 470m is the distance from El-Maadi to El-Dahab Island, 240m the width of El-Dahab Island, and 320m which is the distance between El-Dahab Island and El-Moneeb in Giza.

Three tender prices were presented in the research presented by Meetkees (1996). The analysis of the cost model provided by the least price tender showed the following:

System Breakdown

- ***Super Structure (58.667%)***
  - Top Slab 9.67%
  - Bottom Slab 7.06%
  - Long Beam 35.15%
  - Cross Beam 6.39%
  - Expansion Joints 0.397%

- ***Substructure (37.944%)***
  - Bearings 3.333%
  - Construction Wall 2.446%
  - Columns 6.043%

- Pile-caps
    - On Shore 2.294%
    - Off Shore 13.034%
- Piles
    - On Shore 1.516%
    - Off Shore 9.257%

Trade (Activity) Breakdown

- Reinforced Concrete 29.493%
- Normal Reinforcement 28.283%
- Pre-stressing Tendons 14.907%
- Excavation 12.767%
- Pre-stressing Bars 6.366%
- Bearings 3.333%

The above cost percentages represent the high cost elements of the bridge which is depicted using the both methods the system classification and the tradeoff classification. The system classification method shows that the bridge superstructure represents almost 59% of the project total cost while the substructure represents almost 38%. The two systems are thus chosen for VE analysis. The tradeoff classification method depicted these high cost activities that can be traced with respect to the different construction systems. As illustrated the highest cost activities are reinforced concrete, normal reinforcement, pre-stressing tendons, excavation and pre-stressing bars.

In this type of project, the author implemented VE analysis using three levels of alternative generation. These levels are, the "High Level", "Medium Level", and

"Low Level". In the "High Level" major alternatives related to the layout design and traffic planning were generated. Such alternatives involve Socio-Economic factors that can provide significant value if considered carefully. Secondly, the "Medium Level" was referred to analyzing construction systems and suggesting alternatives for significant improvement. Thirdly, the "Low Level" was for solving specific problems and studying low cost items.

The three levels specified were applied through three cycles. In the first cycle, the author presented three new alternatives to compare with the original design. These alternatives encompass different planning scenarios, different spans, materials, traffic systems, etc. The original design consisted of 6 ramps serving traffic from all sides, while alternative number (1) had 4 ramps. Alternatives number (2) and (3) proposed 8 ramps for each one.

The unified scale method was used to evaluate the different alternatives. The intention was to use a method that depends on subjective judgement as possible. Each component is evaluated separately then the algebraic sum of all values result in the unified evaluation.

The criteria used for evaluation were as follow:

1- Construction Cost

2- Land Acquisition Cost

3- Maintenance Cost

4- Level of Traffic Service

The fourth criterion is further broken down to 4 criteria in order to relate it to cost which are the following:

1- Cost of Passengers' delay

2- Cost of Vehicles' operation

3- Cost of accidents

4- Aesthetics (Cost of psychic stress)

The different alternatives are evaluated choosing the cost as a common scale and moving all future and annual costs to present time.

- Hourly cost of vehicle's operation = L.E. 4.00/hr.
- Average yearly maintenance after 10 years = L.E. 97.90/year
- Average yearly maintenance after 20 years = L.E. 146.85/year
- Average yearly maintenance after 25 years = L.E. 171.33/year
- Land Acquisition (Agricultural land) = L.E. 220.00/sq.m
- Land Acquisition (land designated for building) = L.E. 980.00/sq.m
- Construction cost (on land) = L.E. 934.00/sq.m
- Construction cost (above river) = L.E. 1106.00/sq.m

The present value for each alternative with respect to the chosen criteria was calculated for different yearly interest rates 0.0%, 5.0%, 10.0%, 15%, 20%.

The study resulted in lower present value for alternative 2 that encompasses 8 ramps which serves four traffic directions and consequently increases the level of traffic service. This alternative shows higher construction, maintenance, and land acquisition costs but serves more traffic which reduces delays significantly. The second best ranking alternative was alternative 3 which also encompassed 8 ramps. The alternative has lower acquisition cost but higher construction and maintenance costs. The third best was the original design, which encompass 6 ramps. It has lower land acquisition cost as well as lower construction and maintenance costs which

significantly reduces initial cost, yet its annual costs is relatively high due to costs of delay and vehicles' operation. Finally, alternative 1 encompassing 4 ramps had the highest total cost due to higher delay and vehicles' operation costs because of reduced traffic services.

The proposed VE system was used for this case to examine the system's ability to demonstrate effective and reliable VE implementation. The first thing was to add all necessary project data where the system will work on. All constraints, project identification, cost summaries, etc. were added to the system through the allocated modules that were discussed earlier. Cost analysis was executed based on the Pareto's Law where graphical cost representations easily identified major cost items which were in this project, the reinforced concrete 29%, normal reinforcement 28%, and the prestressing tendons 17% as illustrated in Figure 5.24 and Figure 5.25.

The research done by Meetkees concentrated on the effect of bridge planning and traffic flow on the delay cost from a Socio-economic point of view. Due to the system's flexibility, incorporation of an external study item is easily performed from the Item Selection Module Figure 5.8. Through the system's life cycle cost analysis procedure, the maintenance and operation costs were easily introduced as well as the cost of delay and cost of operating vehicles. As mentioned earlier users can easily perform life cycle cost analysis to calculate the total owning cost of facilities during alternative formulation which is materialized in the Life Cycle Cost Module Figure5.13.

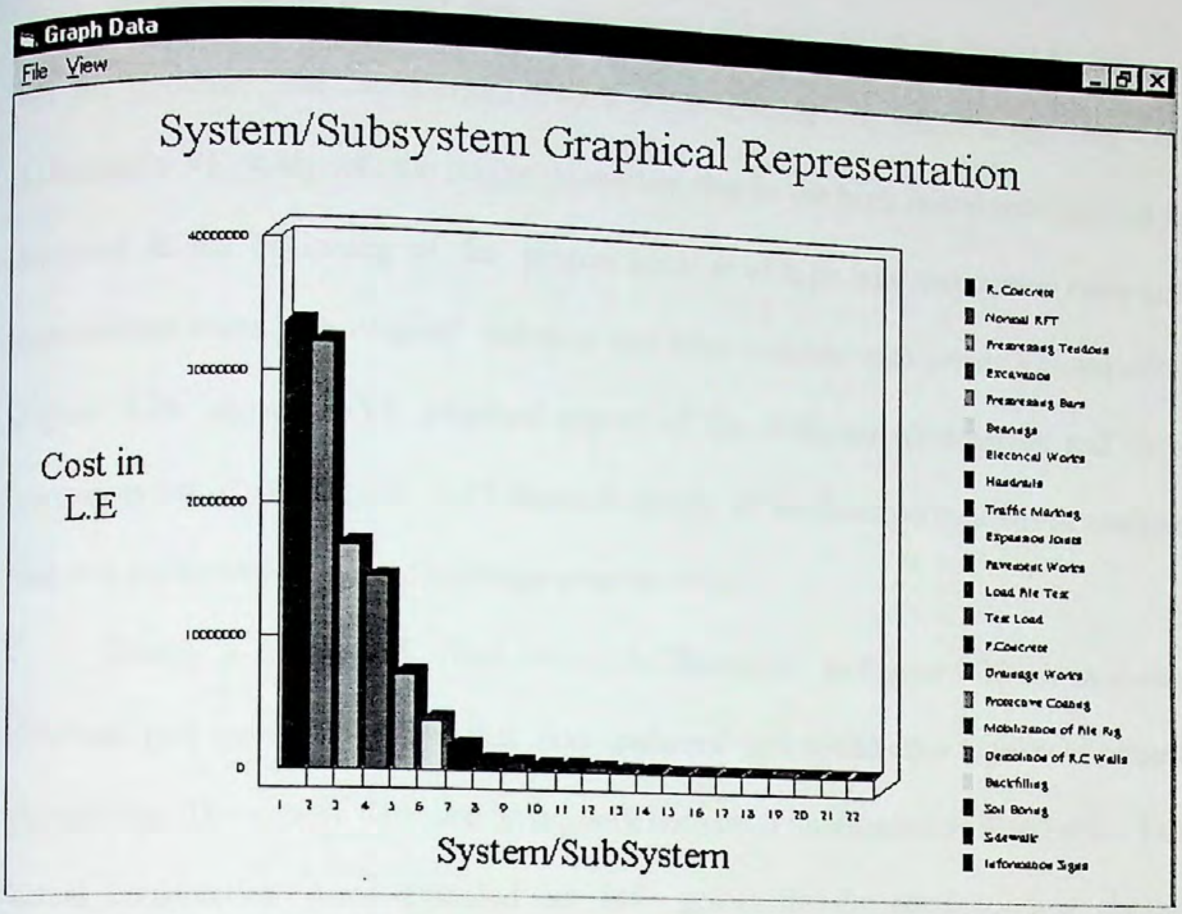


Figure 5.24 El-Moneeb Bridge VE Cost Summary Bar Chart

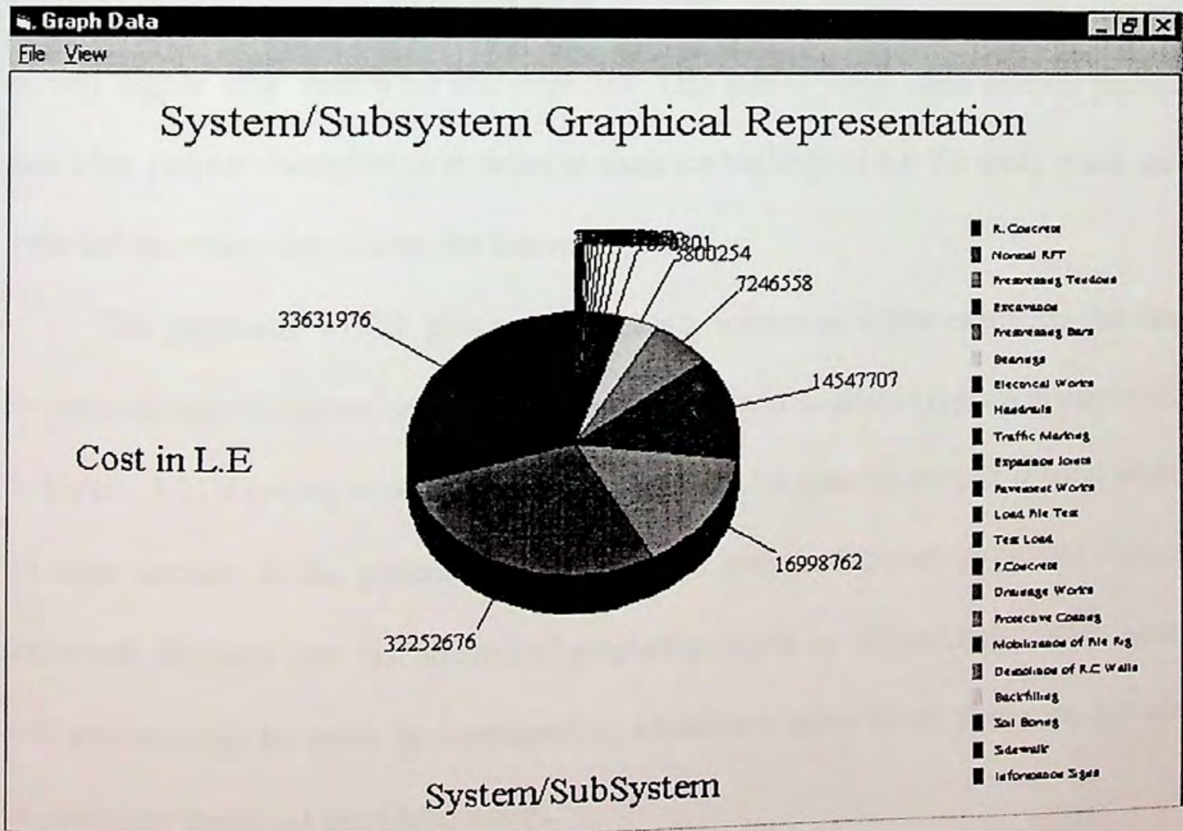


Figure 5.25 El-Moneeb Bridge VE Cost Summary Pie Chart

System results showed that the original planning solution for the bridge was not the optimum and that alternative #2 was the suitable one, which is agreeing with Meetkees's VE study of the bridge. However, due to the high initial cost that had to be spent in the beginning of the project because of high land acquisition costs and construction costs, the original solution was most suitable with owner's constraints. Figure 5.26 shows a VE proposal report of the different alternatives and their corresponding costs. Figure 5.27 shows a sample of the function cost/worth analysis that was performed on the main bridge over the Nile.

Finally a sample VE final report is illustrated in Figure 5.28 which shows feedback post occupancy data that was gathered and added after 5 years of project completion. These cost data are imaginary data used for reasons of illustration. The actual construction price (labeled as bid price) for the corresponding chosen alternative were recorded where it shows higher cost than what was formerly estimated. The LCC also were recorded 5 years after project completion where it showed higher cost than what was expected. This feature helps users analyze project data after project completion in order to track the validity of the VE study made and make the necessary corrections for future studies.

The proposed VECS also encompasses a number of different reports that can be prepared and displayed upon user request. The list of available reports is displayed in Figure 5.21 showing two sections. One section is for specific project reports while the other section is for general reports that are prepared for all up to date studies performed. Reports that list all studied projects grouped by project type, phase, year, and total cost can be easily demonstrated in addition to other types of reports that can be customary designed upon user needs.

VE Proposal Report

Project Number: **8** Project Name: **El-Moneeb Bridge**

Item ID: **13** Item Name: **Main Bridge Over the Nile (Planning)**

5/27/00

AlternativeID	AltName	AltType	Rank	InitialCost	Salv. & Repl. Cost	AnnualCost	LCC
31	Alternative # 1	New	4	12,067,280	0	44,266,580	56,333,86(
32	Alternative # 2	Original	1	24,896,080	0	6,535,400	31,431,48(
33	Alternative # 3	New	3	31,485,960	0	1,846,950	33,332,91(
34	Alternative # 4	New	2	34,069,220	0	1,986,410	36,055,63(

Figure 5.26 El-Moneeb Bridge VE Proposal Report

Project Number 8 Project Name: **El-Moneeb Bridge**

Item ID: 13 Item Name: **Main Bridge Over the Nile (Planning)**

5/22/00

ComponentID	ComponentName	Cost	Worth	Quantity	Kind	Function
183	Piles (On Shore)	1,610,322.00	0.00	1.00	Secondry	Transfer Loads
184	Piles (Off Shore)	11,048,231.00	0.00	1.00	Secondry	Transfer Loads
185	Pilecaps (On Shore)	2,863,779.00	0.00	1.00	Secondry	Distribute Loads
186	Pilecaps (Off Shore)	17,472,788.00	0.00	1.00	Secondry	Distribute Loads
187	Columns	6,721,069.00	0.00	1.00	Secondry	Collect/Transfer Loads
187	Columns	6,721,069.00	0.00	1.00	Secondry	Set Clearance
188	Construction Walls + Fenders	3,064,469.00	0.00	1.00	Secondry	Provide Stability
188	Construction Walls + Fenders	3,064,469.00	0.00	1.00	Secondry	Protect Columns
189	Bearings	6,015,362.00	0.00	1.00	Secondry	Support Structure
189	Bearings	6,015,362.00	0.00	1.00	Secondry	Allow/Prevent Movem
190	Top Slab (Bridge Deck)	9,088,095.00	9,088,095.00	1.00	Basic	Support Traffic
191	Long Beams	45,639,232.00	0.00	1.00	Secondry	Support Deck
192	Cross Beams	5,958,734.00	0.00	1.00	Secondry	Support Deck
192	Cross Beams	5,958,734.00	0.00	1.00	Secondry	Collect/Distribute Loa
192	Cross Beams	5,958,734.00	0.00	1.00	Secondry	Connect Long Beams
193	Bottom Slab	6,445,702.00	0.00	1.00	Secondry	Increase X -sec Resist.
193	Bottom Slab	6,445,702.00	0.00	1.00	Secondry	Enhance Appearance
194	Expansion Joints	1,571,824.00	0.00	1.00	Secondry	Allow Movements
195	Rain Water Drainage	127,043.00	0.00	1.00	Secondry	Reduce Maintenance
195	Rain Water Drainage	127,043.00	0.00	1.00	Secondry	Protect Traffic
195	Rain Water Drainage	127,043.00	0.00	1.00	Secondry	Maintain Operation
196	Sidewalk & Curb	116,816.00	116,816.00	1.00	Required Secondry	Support Pedestrian
196	Sidewalk & Curb	116,816.00	116,816.00	1.00	Required Secondry	Protect Traffic
196	Sidewalk & Curb	116,816.00	116,816.00	1.00	Required Secondry	Enhance Appearance
196	Sidewalk & Curb	116,816.00	116,816.00	1.00	Required Secondry	Protect Pedestrians
197	Handrails	643,739.00	0.00	1.00	Secondry	Protect Pedestrians
197	Handrails	643,739.00	0.00	1.00	Secondry	Enhance Appearance
198	Pavement Works	428,249.00	0.00	1.00	Secondry	Protect Structure
198	Pavement Works	428,249.00	0.00	1.00	Secondry	Enhance Appearance
198	Pavement Works	428,249.00	0.00	1.00	Secondry	Maintain Operation
199	Traffic Marking & Information	325,668.00	0.00	1.00	Secondry	Guide Drivers
200	Electrical Works	870,468.00	0.00	1.00	Secondry	Protect Traffic
200	Electrical Works	870,468.00	0.00	1.00	Secondry	Maintain Operation
200	Electrical Works	870,468.00	0.00	1.00	Secondry	Enhance Appearance
		8,021,367.00	9,555,359.00			

Figure 5.27 El-Moneeb Bridge Function Analysis 1

VE Final Report

Project Number: **8** Project Name: **El-Moneeb Bridge**

Item ID: **13** Item Name: **Main Bridge Over the Nile (Planning) Alternative # 2** 5/27/00

AlternativeID	AltName	AltType	Rank	InitialCost	Salv. & Repl. Cost	AnnualCost	LCC	BidPrice	PostOLCC	EvaluationDate
32	Alternative # 2	Original	1	24,896,080	0	6,535,400	1,278,360,283	26,000,000	7,000,000	3/ 3/04

Comments: Both the actual construction cost and the reported LCC for 5 years showed higher costs due to escalation reasons.

1

Figure 5.28 El-Moneeb Bridge VE Final Report

Chapter 6: Summary and Conclusions

6.1 Introduction

This chapter represents the foremost outcome of the research. It presents a brief overview of what have been investigated and discussed throughout the research including drawbacks and future recommendations.

The chapter commences with a reiteration of the thesis objectives. Then a brief on the questionnaire survey results and findings. Development of the computer VE system is subsequently outlined with its limitations. Finally, recommendations for future research are presented.

6.2 Study Overview

This research introduces the VE technique and its application to the construction industry with focus on the Egyptian construction industry. It investigates the VE current practice and the extent of awareness between practitioners. The main objectives of the research are namely:

- Investigate the application of the VE concept and explore its existing practice in the construction industry in Egypt by addressing a number of construction firms involved in relatively large size construction projects.
- Utilize the available computer technology to develop a VE computer system that will help improve and enhance the VE implementation process within the construction industry.

- Provide a database management system encompassing all previous VE studies that can aid in upcoming decision making of similar subsequent projects and can provide good training tool for tutoring users.

These objectives were materialized through three stages. The first stage focused on approaching the Egyptian construction industry using a survey questionnaire. The first part of the questionnaire presented general information about the firm like the nature of service offered, volume of yearly work, types of projects constructed, etc. The second part of the questionnaire covered a number of multiple type questions involving the application of the VE technique. The questions highlighted on the nature of practice followed in each study, the personnel often involved in the study and the frequency of involvement, the timing of the study, the party requesting the study, and the approximate average savings resulting from VE studies. Moreover, an optional question requesting offering a VE case, to help present the real practice followed, was introduced at the end of the questionnaire.

The second stage of the research focuses on analyzing the survey together with the VE principles and techniques employed to come up with a real picture of the system requirements. Relevant VE worksheets used and suggested by VE professionals and consultants were considered. The type and nature of data input required and output generated in a VE study were then defined in order to adequately determine the system capabilities and requirements. Subsequently, the system basic parts were ready where each part was transformed to a working module participating in the operation of the system.

The third and final stage of the research focuses on the implementation and validation of the VE system. Both Microsoft Visual Basic V5.0 and Microsoft Access97 were used in the system implementation. The proposed modules were

supported by database tables prepared on the MS Access software and linked with MS Visual Basic software. The system validation was inaugurated through applying it to two real VE cases, one was a tourist resort in Sinai and the other was Al-Moneeb Bridge. The system demonstrated successful and effective implementation where the system was able to acquire and record project data and reliably pinpoint items for potential savings. The system helped perform the weighted evaluation exercise efficiently and all resulting data were directly stored for future support. Finally, various reports were generated as well as preparing analysis reports on previous studies for useful feedback.

6.3 Conclusion

Based on the survey made it is found that the utilization level of VE among firms involved in construction activities in Egypt is relatively high. However, the true understanding of the concept and its different techniques is not well known. In other words, the VE methodology is not properly implemented. Most firms surveyed didn't have standard VE worksheets to record the different steps taken. None of the VE studies performed included function analysis or life cycle analysis except for one firm that invited a US VE consultant to one of its projects. Many studies ignored the application of a job plan where several VE techniques could be implemented.

The application of the VE concept is very limited within public owners when compared to private owners. None of the firms involved in construction projects with public owners used VE study. The reason is mainly due to the unawareness of the government and the government agencies that represent the largest customer of VE and evidently the lack of incentives placed by the government that encourages the use

of this technique. Moreover, the lack of qualified personnel or value specialists is also essential to coordinate a successful VE study.

As for private owners, VE is significantly introduced in many construction projects ranging from commercial and hotel buildings to industrial and power plants. This wide spread in its application is due to the recent owner awareness of the major benefits that could be achieved using such a technique. Again although VE is showing continuous increase and wider application, yet its true implementation is missing many vital elements making its procedure largely informal. These elements are significantly important for the process to succeed. One of these elements is the function analysis technique, which if not employed in the study would turn the process into a cost cutting technique rather than a VE technique.

The wide spread of VE technique, within private owners engaged in relatively large projects, could be traced to the introduction of professional construction management firms. These firms present new tools and management techniques like VE. However, the greatest bulk is laid on both the participating A/E and contractor who lack proper knowledge of the technique. Moreover, the fail to provide adequate incentives to contractors escalates the problem since it reduces the efforts made to come up with the best solutions and most effective alternatives.

Finally, the adoption of standard VE worksheets is essential for guaranteed success. Worksheets should be easy to understand and easy to fill by regular personnel so that misunderstanding could be as much possibly minimized. It should also be comprehensive enough to cover all necessary data crucial to the analysis. A systematic VE procedure would definitely help in further analysis and future enhancement of the study. The standardized worksheet would certainly help pinpoint any errors since every step is recorded clearly. Moreover, the worksheet would clearly

help make sure that all the techniques utilized by the VE study like function analysis, life cycle analysis, etc. is implemented and that none are dropped without knowledge. From the survey made it can be concluded that:

1- Value engineering is limited within most publicly owned projects while it is starting to show wide spread within privately owned projects in Egypt adding that the process is often informally executed.

2- The VE concept is unfamiliar to most engineers where it is hard to find a qualified certified personnel.

3- Government regulations do not encourage the utilization of VE, where there are no incentives presented to contractors or consultants involved in any work with the government or even with private owners.

4- Therefore, training programs and workshops are strongly needed in Egypt since there are very few personnel qualified to apply VE concept.

5- Standard worksheets are essential for a successful organized VE study and most important for easy and efficient retrieval of previous project information.

The proposed VE computer system represents a support decision tool that will definitely contribute to the ever growing construction industry. The core idea of the system is to provide a comprehensive and flexible VE computer tool capable of supporting VE studies efficiently and reliably. It offers users continuous decision support along the different VE modules; plus, it possesses stronger ability to dig up throughout long tedious cost estimates to pinpoint those areas for potential savings. Moreover, with the potential capabilities of computer technology, various graphical cost representations are furnished upon user request for better visualization and faster decision making.

Overall, considerable amount of time and money will be saved through this system leading to higher demand for VE application especially during short available periods like during pre-contract periods for instance where time is very crucial. The utilization of database structures to manage VE data forms a reliable base for the tremendous data expected in every VE study. The system also improves the cost estimate and cost-worth analysis, which are crucial to the VE study, by providing up to date related cost and worth data consequently leading to accurate results. Furthermore, the need for VE experts or specialists will be less important since the system is designed for average staff who can easily use it without prior long experience. This way, personnel can be trained on acquiring VE principles at any time with less cost.

The rational behind the system design offers a systematic and standard VE procedure that helps reduce subjectivity and ambiguity as much as possible particularly within the Egyptian construction environment where VE is not widely used. Such standardization can readily open the opportunity for integrated future research in various fields of the industry that can ultimately lead to ideal industry performance and hopefully increase the ultimate value of its products.

6.4 Suggestions for Future Studies:

As an outcome of the survey conducted in the current construction industry, it was found that function analysis technique which represents the essence of VE is completely forgotten and ignored. This could result in unnoticeable deviation from the real VE goal, which is to reduce cost without compromising the quality. One reason is that function analysis is difficult and requires a great deal of time and expertise.

However, if efforts are spent to prepare a list of most common elements, items, systems, or components and their corresponding functional data such as function, cost, worth, etc. then it would greatly contribute to the VE process especially if this list was embedded in a database. This way subjective judgements would be significantly reduced and system effectiveness could be tremendously increased through standardization and reduction of time required for gathering these functional data.

Further development of the system's electronic connection capabilities could significantly enhance the communication capabilities particularly if connected to the internet. This is because the success of any VE session is tied to the involvement of the various disciplines and personnel who share their thoughts, suggestions, and ideas. Therefore, if the process to improve this communication is enhanced, it will substantially contribute to the system overall performance and eventually to the VE study.

Another potential area is life cycle maintenance and energy cost analysis, which represents a potential area for significant savings especially in the Middle East where little research has been done. More emphasis on building maintenance is expected and with the continuous increase in energy costs, further life cycle cost analysis will be essential. In addition, if reliable databases are developed, tremendous savings in money and effort will be achieved. Such databases would help accurately identify life cycle costs and subsequently aid in improving building designs to reduce annual costs. Further enhancement could be realized if such database is integrated with VE computer systems to ultimately help optimize the cost of owing and running any type of facility.

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Appendix A

(Sample Questionnaire)
&
(List of Companies Surveyed)

Research Questionnaire

Name of consultant office/firm	:
Address	:
Phone #	:
Person filling out questionnaire	:
Position	:

Introduction: Value Engineering is a creative, organized approach whose objective is to optimize cost and performance of a facility or system. This is done through a system of investigation, unnecessary expenditures are avoided, resulting in improved value and economy.

1- What is the type of service/s offered by your office/firm?

2- Does your office use value engineering study?

If yes, when is the study made:

a- During early and final design phase ( )
b- After the design is completed but before initiation to bid ( )
c- After the award of the contract ( )

If no, what are the methods used in conducting cost reduction studies and when?

Method :
When :

3- What is the annual volume of work done by your office/ firm?

a- From L.E 50 K- 100 K ( )
b- From L.E 100 K- 1 M ( )
c- From L.E 1 M- above ( )

4- What type of projects did your office conduct value engineering study on, and how often is it applied?

Type	**Always**	**Often**	**Sometimes**	**Never**
Residential	( )	( )	( )	( )
Office Buildings	( )	( )	( )	( )
Hospitals	( )	( )	( )	( )

Schools	( )	( )	( )	( )
Factories	( )	( )	( )	( )
Power Plants	( )	( )	( )	( )
Others	( )	( )	( )	( )

5- By whom was value engineering study required?

- Owner requirements ( )
- Consultant requirements ( )
- Others (please specify) ____________________

6- What are the phases followed in each study?

- Information phase ( )
- speculative phase ( )
- analytical phase ( )
- proposal phase ( )

7- Approximate duration taken to perform the study:

- Less than two weeks ( )
- Between 2-3 weeks ( )
- More than one month ( )

8- Who are the personnel often involved in the study?

Personnel	Always	Often	Sometimes	Never
- Owner	( )	( )	( )	( )
- Consultant	( )	( )	( )	( )
- Project manager	( )	( )	( )	( )
- Others ____________	( )	( )	( )	( )

9- What is the organization's savings on the total project cost as a result of value engineering:

a- less than 1% ( )
b- 2-5 % ( )
c- 6-10% ( )
d- 11-20 % ( )
e- Over 20%, please specify
Comments ____________________

10- Could you give an actual case/s where your office applied value engineering study on?

a- Case Type:

b- Elements of project under study:

c- Number of alternatives:

d- Criteria of selection:

e- Cost reduction amount:

f- Reason behind the study:

g- Major problems faced during the study:

List of companies surveyed and the type of service offered

Company Name	CM Services	A/E Services	Contractor
Kvaerner Construction	*		
International Bechtel	*	*	
Egydan	*		
Turner (SODIC)	*		
PGESCo – Power Generation and Services Company	*	*	
Arab Consulting Engineers - Moharam Bakhoum	*	*	
Mena Touristic & real Estate Investments	*		
Dar Al-Handassah Consultants Shair & Partners	*	*	
Pacer Consultant Office	*	*	
Bin Ladin International Egypt			*
Orascom Construction			*
Arab Consulting Group		*	
Laing - CRC Dorra			*
CH2MHill	*		
Sabbour Associates	*	*	
Arabian International Construction			*
Arab Contractors			*
Morrison Knudsen Corporation			*
Total participating firms	11	7	6
Total firms applying VE	7 (64%)	5 (71.4%)	5 (83.3%)

Appendix B

(Sample Visual Basic Code)

- Part of the code responsible for initializing the Project Identification Module once it has been activated.

```
Private Sub Form_Load()
Dim Mydate
Mydate = Date
Dim temp As String
Dim StrSQLA As String, StrSQL As String
Dim StrKeyA As String, StrSQLB As String
Dim StrSQLC As String, StrSQLD As String
Dim StrSQLE As String
'Dim ProjectID As Integer
'Data1.Recordset.AddNew
StrSQLB = "Select * From Project"
Data1.RecordSource = StrSQLB
Data1.Refresh
'
StrSQLC = "Select * From Project"
Data3.RecordSource = StrSQLC
Data3.Refresh
'
If Flag = 1 Then
Command6.Enabled = True
Text3.Text = ProjectID
StrKeyA = Trim(Text3.Text)
StrSQL = "Select * From Project where ProjectID=" & StrKeyA
Data1.RecordSource = StrSQL
Data1.Refresh
StrSQLA = "Select * From Consultants where ProjectID=" & StrKeyA
Data2.RecordSource = StrSQLA
Data2.Refresh
Text11.Text = Data1.Recordset("ProjectEconomicLife")
Text2.Text = Data1.Recordset("ProjectName")
Text10.Text = Data1.Recordset("TotalCost")
```

```
Text4.Text = Data1.Recordset("StudyDate")
Text13.Text = Data1.Recordset("VEConsultant")
Text12.Text = Data1.Recordset("ProjectDescription")
Text16.Text = Data1.Recordset("ProjectProblem")
Text15.Text = Data1.Recordset("Owner")
Text14.Text = Data1.Recordset("MainContractor")
Text6.Text = Data1.Recordset("Street")
Text8.Text = Data1.Recordset("City")
Text7.Text = Data1.Recordset("Country")
Text9.Text = Data1.Recordset("PostalCode")
Combo1.Text = Data1.Recordset("ProjectPhase")
Combo2.Text = Data1.Recordset("ProjectType")
If Data2.Recordset.RecordCount <> 0 Then
Text5.Text = Data2.Recordset("ConsultantName")
Else
Command3.Enabled = False
End If
'
Else
Command6.Enabled = False
Text4.Text = Mydate
Data3.Recordset.MoveLast
Text3.Text = Data3.Recordset("ProjectID") + 1
Command3.Enabled = False
'Data2.Recordset.AddNew
'
End If
'
StrSQLD = "Select * From Consultants where ProjectID =" & Text3.Text
Data2.RecordSource = StrSQLD
Data2.Refresh
End Sub
```

- Code responsible for adding the cost elements of the project and the corresponding total cost but after checking that there are no duplicates.

```
Private Sub Insert_Click(Index As Integer)
Dim Store As String, Storetemp As String, S As String
Dim Stemp As String, F As String, B As String
B = 0
If Text1(1).Text = "" Or DBCombo1.Text = "" Or DBCombo2.Text = "" Or
Text8.Text = "" Or Text7.Text = "" Then
intmsg = MsgBox("Fields marked by (*) can not contain a null.", _
vbOKOnly + vbCritical, "Error")
Exit Sub
End If
'
If Combo1.Text = "" Then
intmsg = MsgBox("You must specify a system type.", _
vbOKOnly + vbCritical, "Error")
Exit Sub
End If
On Error GoTo errFind
'
Data7.Recordset.FindFirst "SystemType= " & "'" & Combo1.Text & "'"
If Data7.Recordset.NoMatch = False Then
B = 1
End If
If temp = 1 Or B <> 1 Then
Text4.Text = temp
Store = Combo1.Text
Storetemp = Mid(Store, 1, 1)
Text5.Text = Storetemp
F = Trim(Text1(1).Text)
Stemp = Storetemp + F
Text9.Text = Stemp
Text1(1).Text = Stemp
```

```
Data6.Recordset.AddNew
Data6.Recordset("SystemID") = Stemp
Data6.Recordset("SystemName") = DBCombo1.Text
Data6.Recordset("SystemType") = Combo1.Text
Data6.UpdateRecord
Data6.Recordset.Bookmark = Data6.Recordset.LastModified
End If
'
Data1.Recordset.AddNew
Data1.Recordset("ProjectID") = Text6.Text
Data1.Recordset("SystemID") = Text1(1).Text
Data1.Recordset("SystemName") = DBCombo1.Text
Data1.Recordset("Quantity") = Text8.Text
Data1.Recordset("Unit") = DBCombo2.Text
Data1.Recordset("Cost/Unit") = Text7.Text
Data1.Recordset("SystemCost") = Text2(2).Text
'
Data1.UpdateRecord
Data1.Recordset.Bookmark = Data1.Recordset.LastModified
Text1(1).Text = ""
DBCombo1.Text = ""
Text8.Text = ""
DBCombo2.Text = ""
Text7.Text = ""
Text2(2).Text = ""
'
'
Dim StrSQL As String
Dim StrKey As String
Remove(1).Enabled = True
errFind:
  If Err = 3022 Then
  intmsg = MsgBox("This record already exist.", _
  vbOKOnly + vbCritical, "Error")
```

```
    Exit Sub
    '
    ElseIf Err <> 0 Then ' another error
      MsgBox "Unexpected Error: " & Err.Description
      End
    ElseIf Err = 0 Then
      Exit Sub ' just go on
    End If
End Sub
```

- Code prepared for initializing all the necessary data in the Function Cost/Worth Module. All components and verb-noun functions are added to the corresponding data bound combo box.

```
Private Sub Form_Load()
Dim StrSQL As String, StrSQLB As String
Dim StrKey As String, StrKeyB As String
Dim StrSQLTemp As String
Dim StrKeyTemp As String
Dim mNode As Node
Set tvwDB.ImageList = ImageList1 'imlSmallIcons
Text1.Text = ProjectID  ' 4
Text3.Text = ProjectType
Text7.Text = Text6.Text
'
If Text1.Text = "" Then
  StrKey = "0"
Else
  StrKey = Trim(Text1.Text)
End If
StrSQL = "Select ItemID,RefNo,ItemName,ProjectID FROM Item where ProjectID=" & StrKey
Data1.RecordSource = StrSQL
Data1.Refresh
```

```
'
Do Until Data1.Recordset.EOF
   Set mNode = tvwDB.Nodes.ADD() '(1, tvwChild)
   mNode.Text = Data1.Recordset("ItemName")
   mNode.Image = "close" ' "closed"
   mNode.Tag = Data1.Recordset("ItemID")
   'Text8.Text = Data1.Recordset("ItemID")
   Data1.Recordset.MoveNext
Loop
tvwDB.Nodes(1).Image = "Edit"
Data1.Refresh
'
Text7.Text = Text6.Text
StrKeyTemp = Trim(Text6.Text)
StrSQLTemp = "Select FunctionID,Function,ItemID FROM ItemFunctions
WHERE ItemID =" & StrKeyTemp
Data2.RecordSource = StrSQLTemp
Data2.Refresh
DBGrid1.ReBind
If Data2.Recordset.RecordCount = 0 Then
Remove.Enabled = False
Else
Remove.Enabled = True
End If
'Data2.Recordset.AddNew
'
DBCombo2.Text = " "
StrKeyA = Trim(Text2.Text)
StrKeyB = Trim(Text3.Text)
StrSQL = "SELECT DISTINCT ComponentName FROM DistComponents Where
ItemName = " & " '" & StrKeyA & "'" & " AND ProjectType =" & " '" & StrKeyB
& "'"
Data5.RecordSource = StrSQL
Data5.Refresh
```

```
'
StrKeyTempa = Trim(Text6.Text)
StrSQLTempa = "Select * FROM Components WHERE ItemID =" &
StrKeyTemp 'a
Data4.RecordSource = StrSQLTempa
Data4.Refresh
DBGrid2.ReBind
If Data4.Recordset.RecordCount = 0 Then
Remove2.Enabled = False
Text8.Text = 0
Else
Remove2.Enabled = True
Text8.Text = Data4.Recordset.Fields("ComponentID")
End If
StrKeyB = Trim(Text8.Text)
StrSQLB = "Select * FROM ComponentFunctions WHERE ComponentID =" &
StrKeyB
Data7.RecordSource = StrSQLB
Data7.Refresh
DBGrid3.ReBind
If Data7.Recordset.RecordCount = 0 Then
Remove3.Enabled = False
Else
Remove3.Enabled = True
End If
'
End Sub
```

- Below is the code responsible for formulating a list of items to be displayed in a tree format for further analysis. The idea table is populated from the data base and the alternative data bound combo box will also be populated with the same list. If the user decides to use the same idea name as the chosen alternative then he/she can easily choose that from the combo box list without having to retype it.

```
Private Sub Form_Load()
Dim lngNumPoints As Integer
Dim X As Integer, Q As Integer
Dim StrSQL As String
Dim StrSQLA As String, StrSQLD As String
Dim StrSQLB As String, StrSQLC As String
Dim StrKey As String, StrKeyB As String, StrKeyC As String
Dim StrKeyD As String
Dim mNode As Node
Set tvwDB.ImageList = ImageList1
Dim FirstArray() As String
Dim SecondArray() As String
Sum = 0
SumTwo = 0
Q = 0
Text1.Text = ProjectID
Text3.Text = ProjectType
If Text1.Text = "" Then
   StrKey = "0"
Else
   StrKey = Trim(Text1.Text)
End If
StrSQLB  = "Select ItemID,RefNo,ItemName,[Cost/Worth],ProjectID FROM Item
where ProjectID=" & StrKey & "AND [Cost/Worth] > 2"
Data1.RecordSource = StrSQLB
Data1.Refresh
Do Until Data1.Recordset.EOF
   Q = Q + 1
   Set mNode = tvwDB.Nodes.ADD() '(1, tvwChild)
   mNode.Text = Data1.Recordset("ItemName")
   mNode.Image = "close" ' "closed"
   mNode.Tag = Data1.Recordset("ItemID")
   Data1.Recordset.MoveNext
Loop
```

```
Text7.Text = Q
tvwDB.Nodes(1).Image = "Edit"
Text2.Text = tvwDB.Nodes(1).Tag
'Text6.Text = tvwDB.Nodes(1).Text
Data1.Refresh
'
StrKeyD = Trim(Text2.Text)
StrKeyC = Trim(Text1.Text)
StrSQLD="SelectProjectID,ProjectName,ProjectEconomicLife,ItemID,Unit,[Cost/
Unit],Quantity FROM ItemProjectSystem WHERE ProjectID=" & StrKeyC & "
AND ItemID=" & StrKeyD
Data4.RecordSource = StrSQLD
Data4.Refresh
'
StrKeyA = Trim(Text2.Text)
'Text6.Text = Node.Text
StrSQLA  = "Select IdeaID,Idea,Score,ItemID FROM Ideas WHERE ItemID =" &
StrKeyA & " Order By Score Desc"
StrSQL = "Select * FROM Alternatives WHERE ItemID =" & StrKeyA
Data2.RecordSource = StrSQLA
Data2.Refresh
DBGrid1.ReBind
Data3.RecordSource = StrSQL
Data3.Refresh
DBGrid2.ReBind
Combo1.Text = Combo1.List(0)
'DBCombo1.Text = DBCombo1.ListField
End Sub
```

- Code responsible for selecting unique Constraint Type from the constraint table found in the data base:

SELECT DISTINCT constraint.ConstraintType
FROM [constraint];

- Code responsible for selecting unique discipline for each participant to be displayed in the data bound combo box is the following:

```
Private Sub Form_Load()
Dim StrKey As String, StrSQL As String
Dim StrSQLA As String, StrSQLD As String
Text3.Text = ProjectID
Text2.Text = ProjectName
StrKey = Trim(ProjectID)
StrSQL = "Select * From VETeamMembers where ProjectID=" & StrKey
Data1.RecordSource = StrSQL
Data1.Refresh
StrSQLA = "Select Distinct Discipline From VETeam"
Data2.RecordSource = StrSQLA
Data2.Refresh
StrSQLD = "Select * From VETeam"
Data6.RecordSource = StrSQLD
Data6.Refresh
StrSQLB = "Select * From VETeamMembers where ProjectID=" & StrKey
Data4.RecordSource = StrSQLB
Data4.Refresh
End Sub
```

- Two modules responsible for calculating the system total cost through multiplying the unit cost by the quantity.

Module (1)

```
Private Sub Text7_LostFocus()
If Text8.Text <> "" And Text7.Text <> "" Then
Text2(2).Text = (Text8.Text * Text7.Text)
End If
End Sub
```

Module (2)

```
Private Sub Text8_LostFocus()
If Text7.Text <> "" And Text8.Text <> "" Then
Text2(2).Text = (Text8.Text * Text7.Text)
End If
End Sub
```

- Below is the module responsible for preparing the cost summary graph which displays the cost data in a Bar, Pie, Line, or Area chart depending on the user selection. The query responsible to choose the cost data corresponding to the project under study is shown in bold. Moreover, the cost data are listed in descending order.

```
Private Sub Command3_Click()
Dim objDG As Object
Dim StrSQL As String
Dim StrKey As String
If Text6.Text = "" Then
StrKey = "0"
Else
StrKey = Trim(Text6.Text)
End If
Set objDG = New DataGraph
'
objDG.DatabaseName = "D:\HazemThesis\VB1\ThesisII.mdb"
objDG.SQLSelect= "SELECT PojectID,SystemID,SystemName,Unit,SystemCost FROM ProjectSystem WHERE ProjectID =" & StrKey & " ORDER BY SystemCost DESC"
objDG.GraphField = "SystemCost"
objDG.GraphTitle = "System/Subsystem Graphical Representation"
objDG.LeftTitle = "Cost in L.E"
objDG.BottomTitle = "System/SubSystem"
objDG.LegendField = "SystemName"
objDG.ShowGraph
End Sub
```

- Below is the module responsible for selecting the high cost items representing 80% of the total cost.

```
lngNumPoints = Data1.Recordset.RecordCount
  ReDim FirstArray(lngNumPoints)
  ReDim SecondArray(lngNumPoints)
  ' Text5.Text = lngNumPoints
Data1.Recordset.MoveFirst
For X = 1 To lngNumPoints
  FirstArray(X) = Data1.Recordset.Fields("SystemCost")
  Sum = Sum + FirstArray(X)
  Data1.Recordset.MoveNext
Next X

'Text2.Text = Sum 'FirstArray(0) 'FirstArray(0)
Data1.Recordset.MoveFirst
For Y = 1 To lngNumPoints
  FirstArray(Y) = Data1.Recordset.Fields("SystemCost")
  SecondArray(Y) = (FirstArray(Y) / Sum)
  Data1.Recordset.Edit
  Data1.Recordset.Fields("SystemCostPer") = SecondArray(Y)
  Data1.UpdateRecord
  Data1.Recordset.MoveNext
Next Y
n = 0
SumCostPer = 0
Data1.Recordset.MoveFirst
While SumCostPer < 0.8
    n = n + 1
    FirstArray(n) = Data1.Recordset.Fields("SystemCost")
    SecondArray(n) = (FirstArray(n) / Sum)
    SumCostPer = SumCostPer + SecondArray(n)
    Data1.Recordset.MoveNext
  Wend
```

```
Text2.Text = n
Text3.Text = SumCostPer
StrSQLF = "Select ItemID,RefNo,ItemName,ProjectID FROM Item where
ProjectID=" & StrKey '& " ORDER BY SystemCost DESC" ' & StrKey
Data4.RecordSource = StrSQLF
Data4.Refresh
While Data4.Recordset.EOF = False
  With Data4.Recordset
    .Delete
    .MoveNext
End With
Wend
StrSQLC = "Select ItemID,RefNo,ItemName,ProjectID FROM Item" ' where
ProjectID=" & StrKey '& " ORDER BY SystemCost DESC" ' & StrKey
Data2.RecordSource = StrSQLC
Data2.Refresh
Data2.Recordset.MoveLast
Data1.Recordset.MoveFirst
temp = Data2.Recordset("ItemID")
'
If temp = " " Then
  strID = 1
Else
  strID = temp + 1
End If
For Y = 1 To n
  Data2.Recordset.AddNew
  Data2.Recordset("ProjectID") = Text1.Text
  Data2.Recordset("ItemID") = strID
  Data2.Recordset("ItemName") = Data1.Recordset("SystemName")
  Data2.Recordset("RefNo") = Data1.Recordset("SystemID")
  Data2.UpdateRecord
  Data1.Recordset.MoveNext
  Data2.Recordset.MoveNext
```

```
strID = strID + 1
Next Y
StrSQLTemp = "Select ItemID,RefNo,ItemName,ProjectID FROM Item where ProjectID=" & StrKey '& " ORDER BY SystemCost DESC" ' & StrKey
Data3.RecordSource = StrSQLTemp
Data3.Refresh
DBGrid2.ReBind
```

- The query responsible to select distinct (Verb-Noun) functions from previous cases found in the database.

SELECT DISTINCT ItemFunctions.Function
FROM ItemFunctions;

- Below is the query responsible to select historical cost-worth data that help the user in his decision making. The query is activated once the form is loaded based on the project type.

```
Private Sub Form_Load()
Dim StrKeyA As String
Dim StrKeyB As String
Dim StrSQLTemp As String
Text1.Text = ItemName
If Text1.Text = "" Then
Text1.Text = "Empty"
End If
Text2.Text = ProjectType
StrKeyA = Trim(Text1.Text)
StrKeyB = Trim(Text2.Text)
StrSQLTemp="SelectProjectID,ProjectName,ProjectType,ItemName,ComponentName,Cost,Worth FROM DistComponents WHERE ItemName= " & "'" & StrKeyA & "'" & " AND ProjectType=" & "'" & StrKeyB & "'"
Data1.RecordSource = StrSQLTemp
Data1.Refresh
```

```
DBGrid1.ReBind
End Sub
```

- Below is the code that calculates the Cost/Worth ratio which helps determine areas of potential savings particularly when the ratio is above 2 according to Dell'Isola (1982).

```
Private Sub Form_Load()
Dim lngNumPoints As Integer
Dim Sum As Single
Dim SumTwo As Single
Dim StrOne As String
Dim X As Integer, Q As Integer
Dim StrSQL As String
Dim StrSQLA As String, StrSQLD As String
Dim StrSQLB As String, StrSQLC As String
Dim StrKey As String, StrKeyB As String, StrKeyC As String
Dim StrKeyD As String
Dim mNode As Node
Set tvwDB.ImageList = ImageList1 'imlSmallIcons
Dim FirstArray() As String
Dim SecondArray() As String
Sum = 0
SumTwo = 0
StrOne = 0
Q = 0
lngNumPoints = 0
Text1.Text = ProjectID
Text3.Text = ProjectType '"Buildings"
If Text1.Text = "" Then
   StrKey = "0"
Else
   StrKey = Trim(Text1.Text)
End If
```

```
StrSQL = "Select ItemID,ItemName,[Cost/Worth] From Item where ProjectID=" &
StrKey & " ORDER BY ItemID Asc"
Data1.RecordSource = StrSQL
Data1.Refresh
While Data1.Recordset.EOF = False
  StrOne = Data1.Recordset("ItemID")
  StrSQLA = "Select ComponentID,ComponentName,Cost,Worth FROM
Components WHERE ItemID=" & StrOne
  Data3.RecordSource = StrSQLA
  Data3.Refresh
  'lngNumPoints = Data3.Recordset.RecordCount
  lngNumPoints = 8
  ReDim FirstArray(lngNumPoints)
  ReDim SecondArray(lngNumPoints)
  Data3.Refresh
  Sum = 0
  SumTwo = 0
  If Data3.Recordset.EOF = False Then
' Calculate the cost/worth ratio
For X = 1 To lngNumPoints
  FirstArray(X) = Data3.Recordset.Fields("Cost")
  SecondArray(X) = Data3.Recordset.Fields("Worth")
  Sum = Sum + FirstArray(X)
  SumTwo = SumTwo + SecondArray(X)
  Data3.Recordset.MoveNext
Next X
  If SumTwo = 0 Then
    Data1.Recordset.Edit
    Data1.Recordset("[Cost/Worth]") = 0
    Data1.UpdateRecord
    Data1.Recordset.MoveNext
  Else
    Data1.Recordset.Edit
    Data1.Recordset("[Cost/Worth]") = (Sum / SumTwo)
```

```
    Data1.UpdateRecord
    Data1.Recordset.MoveNext
  End If
  Else
  Data1.Recordset.MoveNext
  End If
Wend
'
StrSQLB  = "Select ItemID,RefNo,ItemName,[Cost/Worth],ProjectID FROM Item
where ProjectID=" & StrKey & "and [Cost/Worth] > 2"
Data1.RecordSource = StrSQLB
Data1.Refresh
'
Do Until Data1.Recordset.EOF
   Q = Q + 1
   Set mNode = tvwDB.Nodes.ADD() '(1, tvwChild)
   mNode.Text = Data1.Recordset("ItemName")
   mNode.Image = "close" ' "closed"
   mNode.Tag = Data1.Recordset("ItemID")
   Data1.Recordset.MoveNext
Loop
Text7.Text = Q
tvwDB.Nodes(1).Image = "Edit"
Text2.Text = tvwDB.Nodes(1).Tag
Text6.Text = tvwDB.Nodes(1).Text
Data1.Refresh
'
StrKeyD = Trim(Text2.Text)
StrSQLD="SelectIdeaID,Idea,StateOfTheArt,CostToDevelop,TimeToExcute,Potentia
lBenefits,ProblemOfAcceptance,Comment,Score,ItemID  FROM  Ideas  WHERE
ItemID =" & StrKeyD
Data2.RecordSource = StrSQLD
Data2.Refresh
DBGrid1.ReBind
```

```
'
StrKeyB = Trim(Text6.Text)
StrKeyC = Trim(Text3.Text)
StrSQLC  = "SELECT DISTINCT Idea FROM DistIdeas Where ItemName = " & " '"
& StrKeyB & "'" & " AND ProjectType =" & " '" & StrKeyC & "'"
Data4.RecordSource = StrSQLC
Data4.Refresh
'
End Sub
```

- Below is the code that selects unique ideas generated from previous studies as a decision support mechanism where the user can build new ideas on such former suggested ideas similar to what Dell'Isola (1982) mentioned in his book concerning "Piggybacking."

```
StrKeyB = Trim(Text6.Text)
StrKeyC = Trim(Text3.Text)
StrSQLC  = "SELECT DISTINCT Idea FROM DistIdeas Where ItemName = " & " '"
& StrKeyB & "'" & " AND ProjectType =" & " '" & StrKeyC & "'"
Data4.RecordSource = StrSQLC
Data4.Refresh
```

- Below is the code showing the formula used for calculating the present value whether it is at a certain time in the future or annually like the case with maintenance expenses. The formula for calculating expected escalation rates is also displayed.

```
If Text11.Text = "" Or Text11.Text = " " Then
Text10.Text = 0
Exit Sub
End If
If Z = 1 Then
Text11.Text = ""
Z = 0
```

```
Exit Sub
End If
If Text11.Text = 0 Then
Text10.Text = 0
Exit Sub
End If
y1 = Text11.Text
Text10.Text = 1 / ((1 + (i / 100)) ^ y1)
```

```
If Z = 1 Then
Text24.Text = ""
Z = 0
Exit Sub
End If
y1 = Text24.Text
If y1 = i Then
Text23.Text = (n / (1 + (i / 100)))
Else
Text23.Text = ((1 - (((1 + (y1 / 100)) ^ n) * ((1 + (i / 100)) ^ (-n)))) / ((i / 100) - (y1 / 100)))
End If
End If
```

- Below is the code responsible for performing the paired comparison for the corresponding criteria added and normalizing the total weight for each criterion.

```
Private Sub Next3_Click()
Dim StrSQLB As String, StrKey As String
Dim StrSQLA As String, StrKeyA As String
Dim StrSQLC As String
Dim StrSQLD As String
Dim Z As String
Dim lngNumPoints As Integer
```

```
Dim FirstArray() As String
Dim SecondArray() As String
Dim Sum As Integer, S As Integer, Q As Integer
 If Text1.Text = "" Then
   StrKey = "0"
Else
   StrKey = Trim(Text1.Text)
End If
' Select those Items that correspond to the project ID # and that have a Cost/Worth > 2
StrSQLB  = "Select ItemID,RefNo,ItemName,[Cost/Worth],ProjectID FROM Item
where ProjectID=" & StrKey & "AND [Cost/Worth] > 2"
Data1.RecordSource = StrSQLB
Data1.Refresh
lngNumPoints = Data1.Recordset.RecordCount
   ReDim FirstArray(lngNumPoints)
   ReDim SecondArray(lngNumPoints)
Data1.Recordset.MoveFirst
For X = 1 To lngNumPoints
   FirstArray(X) = Data1.Recordset.Fields("ItemID")
   Data1.Recordset.MoveNext
Next X
'
'Sum = 0
For n = 1 To lngNumPoints
'The proceeding code selects all Criteria
'in order to start calculating row scores
'for each criterion
StrSQLA = "Select * FROM Criteria where ItemID=" & FirstArray(n)
Data3.RecordSource = StrSQLA
Data3.Refresh
While Data3.Recordset.EOF = False
'The Criterion ID # is stored in Z in order
'to compare it to the different criteria
Z = Data3.Recordset("CriteriaID")
```

```
'
StrSQLC = "Select * FROM CriteriaScoring"
Data5.RecordSource = StrSQLC
Data5.Refresh
'Data5.Recordset.MoveFirst
Sum = 0
 While Data5.Recordset.EOF = False
'If the first criteria ID # in the Criteria Scoring table
'is equal to the criteria ID # stored in Z then
'the criteria importance is summed up.
  If Data5.Recordset("ChosenCriteriaID") = Z Then
   S = Data5.Recordset("Importance")
   Sum = Sum + S
  End If
'In the case both criteria are chosen then either
'the first criteria ID # equals Z or the second
'criteria ID # equal Z.
  If Data5.Recordset("ChosenCriteriaID") = 0 Then
   IfData5.Recordset("FirstCriteriaID")  = Z Or Data5.Recordset("SecondCriteriaID")
= Z Then
'The importance is also added to the sum.
   S = Data5.Recordset("Importance")
   Sum = Sum + S
   End If
  End If
  Data5.Recordset.MoveNext
 Wend
'The sum is entered in the field Row Score.
 Data3.Recordset.Edit
 Data3.Recordset("RowScore") = Sum
 Data3.UpdateRecord
 'Data3.Recordset.Bookmark = Data3.Recordset.LastModified
 Data3.Recordset.MoveNext
Wend
```

```
Next n
'
For n = 1 To lngNumPoints
'The proseeding code arranges the Criteria in
'Descending order in order to normalize each
'Criteria Row Score.
StrSQLA = "Select * FROM Criteria where ItemID=" & FirstArray(n) & " ORDER
BY RowScore DESC"
Data3.RecordSource = StrSQLA
Data3.Refresh
Q = Data3.Recordset("RowScore")
While Data3.Recordset.EOF = False
  R = (Data3.Recordset("RowScore") / Q) * 10
  Data3.Recordset.Edit
  Data3.Recordset("CriteriaWeight") = R
  Data3.UpdateRecord
  'Data3.Recordset.Bookmark = Data3.Recordset.LastModified
  Data3.Recordset.MoveNext
Wend
Next n
```

- Below is the code responsible for performing matrix multiplication for the different alternatives generated and their corresponding criteria previously added. The total weight is calculated for each alternative in order to separate the best and optimum alternative.

```
Private Sub Next2_Click()
Dim StrKeyA As String, StrKeyB As String
  I.  Dim StrSQL As String, StrKey As String
Sum = 0
Dim X As Integer
Dim StrSQLE As String, StrKeyE As String
If Combo1.Text = "" Then
 intmsg = MsgBox("You didn't enter the rank", vbOKOnly + vbCritical, "Error")
```

```
  Exit Sub
End If
'
StrKeyA = Text9.Text
StrKeyB = Text10.Text
'
Data5.Recordset.FindFirst "AlternativeID = " & StrKeyA & " AND CriterialD=" &
StrKeyB
  If Data5.Recordset.NoMatch = False Then
    Data5.Recordset.Edit
    Data5.Recordset("AlternativeID") = Text9.Text
    Data5.Recordset("CriterialD") = Text10.Text
    Data5.Recordset("WeightedScore") = Combo1.Text
    Data5.Recordset("CriteriaWeight") = Text8.Text
    Data5.Recordset("Result") = Text7.Text * Combo1.Text
    Data5.Recordset("ItemID") = Text2.Text
    Data5.Recordset("ProjectID") = Text1.Text
    Data5.UpdateRecord
    Data5.Recordset.Bookmark = Data5.Recordset.LastModified
Else
Data5.Recordset.AddNew
Data5.Recordset("AlternativeID") = Text9.Text
Data5.Recordset("CriterialD") = Text10.Text
Data5.Recordset("WeightedScore") = Combo1.Text
Data5.Recordset("CriteriaWeight") = Text7.Text
Data5.Recordset("Result") = Text7.Text * Combo1.Text
Data5.Recordset("ItemID") = Text2.Text
Data5.Recordset("ProjectID") = Text1.Text
Data5.UpdateRecord
Data5.Recordset.Bookmark = Data5.Recordset.LastModified
End If
'
'To get the next criterion in Text10.text
Combo1.Text = ""
```

```
Back2.Enabled = True
Data4.Recordset.MoveNext
If Data4.Recordset.EOF = False Then
Text6.Text = Data4.Recordset("CriteriaName")
Text10.Text = Data4.Recordset("CriteriaID")
Text7.Text = Data4.Recordset("CriteriaWeight")
Else
'If it is EOF then calculate the sum of weights
StrKey = Text9.Text
StrSQL = "Select * FROM AltCriteria where AlternativeID=" & StrKey
Data7.RecordSource = StrSQL
Data7.Refresh
While Data7.Recordset.EOF = False
Sum = Sum + Data7.Recordset("Result")
Data7.Recordset.MoveNext
Wend
Data6.Recordset.FindFirst "AlternativeID = " & Text9.Text
'Insert the sum in the Alternative Table
   If Data6.Recordset.NoMatch = False Then
      Data6.Recordset.Edit
      Data6.Recordset("AlternativeWeight") = Sum
      Data6.UpdateRecord
      Data6.Recordset.Bookmark = Data6.Recordset.LastModified
   End If
Data2.Recordset.MoveNext
If Data2.Recordset.EOF = False Then
'If there is still alternatives then extract them
'and place them in the corresponding Text Box
Text5.Text = Data2.Recordset("AltName")
Text9.Text = Data2.Recordset("AlternativeID")
Data4.Recordset.MoveFirst
Text6.Text = Data4.Recordset("CriteriaName")
Text10.Text = Data4.Recordset("CriteriaID")
Text7.Text = Data4.Recordset("CriteriaWeight")
```

```
Else
'
Finish2.Enabled = True
Next2.Enabled = False
End If
End If
End Sub
```

- Below is the code responsible for selecting the alternative that have been selected for implementation after successful VE study for the purpose of post occupancy feedback.

```
Private Sub tvwDB_NodeClick(ByVal Node As ComctlLib.Node)
Dim StrKeyC As String
Dim StrSQL As String
Dim StrKeyA As String, StrKeyD As String
Dim mNode As Node
Dim StrSQLA As String, StrSQLD As String
Node.Image = "Edit"
Text2.Text = Node.Tag
StrKeyA = Trim(Text2.Text)
StrSQL = "Select * FROM Alternatives WHERE ItemID =" & StrKeyA & " Order by
AlternativeWeight Desc"
Data3.RecordSource = StrSQL
Data3.Refresh
While Data3.Recordset.EOF = False
If Data3.Recordset("Action") = "Accepted" Then
   intmsg = MsgBox("This item has already been updated. Would you like to edit it?",
_
   vbYesNo + vbCritical + vbDefaultButton2, "Question")
   If intmsg = 7 Then
   Exit Sub
   End If
```

```
End If
Data3.Recordset.MoveNext
Wend
StrSQL = "Select * FROM Alternatives WHERE ItemID =" & StrKeyA
Data2.RecordSource = StrSQL
Data2.Refresh
DBGrid1.ReBind
End Sub
```

Appendix C

(Sample VE Proposals)

VALUE ENGINEERING CHANGE PROPOSAL FORM

General Contract 21800-CP-02

To : INTERNATIONAL BECHTEL INC

Date : 12 / 11 / 94

From : LAING/CRC

Value Engineering Change proposal No 29.00 Rev (0).

Subject: OMISSION OF LOCKER / CHANGING ROOM FROM TOWER (B).

Summary of Change: *(Description-Compare advantages and disadvantages)*

(1)BEFORE(Sketch where applicable)

Locker, changing room and their facilities are at present located in tower "B" pool terrace level.

SHAKER comments :
* (1) Nothing mentioned about omitting HVAC, Fire Fighting and Electrical services.
(2) What about future use of this omitted Area in Tower B.
Should it be connected to MEP services or Not ?
(3) What about MEP services for the New location of locker/changing Room in Tower A
* Pls Revise and Resubmitt with associated MEP Revisions

LAING - CRC
RECEIVED 21.11.94

DISTRIBUTION	ORIG	ACT
FM		
PM/DPM		
CM/DCM		
PURCHASE		
PLANNING		
QC/SAFE		
DESIGN		
CRC		
SENT	[illegible]	

Laing/CRC must Revise and Resubmit

(2)AFTER(Sketch where applicable)

Omit locker and changing room and their facilities from tower "B" pool terrace level

Area to be left as for shops.

No Allowance has been made for sanitary / water connections in ex locker / changing room of tower (B).

Tower (A) will be left with (T) connection for future instalations . No other provisions for future connection have been taken.

* These areas have to be redisign before final acceptance.
+ Acceptable in princable SPACE / ASS. C

Estimated Cost Summary

Cost shall be estimated in accordance with the change provisions. Attached detailed estimate of savings.)	No of units	unit cost (in L.E)	Total (L.E)	Tax & C.Duties Included (L.E)
A.ORIGINAL	1			
B.PROPOSED	1			
C.GROSS SAVINGS				
D.PERCENT SAVINGS				
	Duration	Start	Finish	
E.ORIGINAL SCHEDULE		FEB. 95	APR. 95	
F.PROPOSED SCHEDULE		17 / 12 / 94	FEB. 95	

DATE BY WHICH A CHANGE ORDER MUST BE ISSUED SO AS TO OBTAIN MAXIMUM COST REDUCTION : 15 / 12 / 94

Transmittal Routing	Date	Initial
Received by : BECHTEL	13 NOV 94	[signature]
Received by : OVE ARUP	N/A	
Received by : SHAKER	21/11/94	[signature]
Received by : SPACE/ASSOC	20-11-94	[signature]
Received by : BECHTEL	21 NOV 94	[signature]
Received by : CONTRACTOR		

[redacted]

FIRST RESIDENCE AT GIZA 13-Nov-94

Value Engineering proposal No 29.00 rev(1)

PROPOSAL: Shift locker and changing room from tower "B" pool terrace level to health club of tower "A".

SERIAL NO	BQ CODE	DESCRIPTION	QUANTITY	UNIT	RATE	ADD	OMIT
1	15440.1 c&s	Omitting wash hand basins.	4.00	No			
2	15440.1 c&s	Omitting water closets (w.c).	4.00	No			
		omitting urinals	2.00	NO			
(3)	15440.1 c&s	Omitting shower tray.	6.00	No			
4	8210.6 c&s	Omitting wood doors "type L" (size 0.8m x 2.0m).	4.00	No			
5	8210.6 c&s	Omitting wood doors "type E" (size 0.9m x 2.2m).	2.00	No			
6	8110.18 c&s	Omitting metal doors "type F" (size 1.0m x 2.0m).	1.00	No			
7	8710.9 c&s	Omitting hardware set no. 12	4.00	No			
8	8710.9 c&s	Omitting hardware set no. 8	2.00	No			
9	8710.9 c&s	Omitting hardware set no. 1	1.00	No			
10	9900.3 c&s	Omitting paint to wood or metal doors.	7.00	No			
11	8415.2 c&s	Omitting operable aluminium top hinged (size 1.0m x 0.7m) windows at plumbing well.	2.00	No			
12	4220.1 c&s	Omitting interior concrete blockwork (100mm thick.).	99.55	M2			
13	4220.2 c&s	Omitting interior concrete blockwork (200mm thick.).	12.76	M2			
14	4220.2 c&s	Adding interior concrete blockwork (200mm thick.).	5.36	M2			
15	9310.4 c&s	Omitting ceramic "type C5" on wall (size 200mm x 250mm)	268.95	M2			
16	9310.1 c&s	Omitting ceramic "type C2" on floor (size 200mm x 200mm)	70.73	M2			
17	9600.4 c&s	Omitting marble vanities (size 1.9m x 0.7m - two sinks cut-out)	2.00	No			
18							
(19, 20, 21)		where the missing items					
22	9220.2 c&s	Omitting metal lath and three coats of plaster to ceilings.	72.00	M2			
7	16500	Recessed downlight florescent type D1	30	NO			
8		Recessed downlight but metol halid type D3	18	NO			
12		Energercy lumunate type E3	2	NO			

* pls omitt the mains inside the lockers for the following services :-

- Cold water
- Hot water
- S&W.
- Vent

(Cold water, Hot water, S&W. and Vent are bracketed together: Plumbing mains)

Net saving

Description	Item	Sector 1 & 2			Sector 3		Sector 4 & 5	
		Main	Option 1	Option 2	Main	Option	Main	Option 1
<u>**Public serveces**</u>								
Main entrance	Stairs Lobby	Granite Pattern Flet./local marble	Fletto		Granite Pattern Flet./local marble	Fletto	Fletto Pattern Flet./local marble	
Typical lobby & corridor	Floor+skirt.	Galala	Marbled tiles	Porceline	Marbled tiles	Terrazzo	Terrazzo	
Typical stair	Treads Riser+skirt.	Granite Granite	Fletto, Hassana Fletto, Hassana		Fletto,Hassana Fletto,Hassana	Galala Galala	Perlatto Perlatto	
Terraces fl..		Fletto			Fletto		Perlatto	
<u>**Doors**</u>								
Internal doors	Doors Frames Architrave	Honney comb Soft wood Soft wood	 M.D.F.		Honney comb Soft wood Soft wood	Ply wood veneer M.D.F.	Honney comb Soft wood Soft wood	Ply wood veneer
Ext. Doors		Veneered oak	Oak massive	Imported	Soft wood		Soft wood	
Aluminum Doors ***Aluminum Windows with metal screen***		Shucco Shucco			Shucco Shucco	Technal Technal	El-saad or equal El-saad or equal	Shucco Shucco
<u>**Wet areas**</u>								
Ceramic		As approved mock-up			As approved mock-up		As approved mock-up	
Stello		3D & 2 Rows	1 Row		1 Row		Without	
Fitting Private bath room (master bed room) Bath room Guest bath room		 Conca,new capri,Kimera Diagonal,Emirama Rogiada			 Conca,new capri,Kimera Conca,new capri,Kimera Rogiada		 Rogiada Conca,new capri,Kimera Rogiada	
Reception flooring+Skirting Terraces flooring+Skirting		Carrara marble Porcelain pattern	Oak parquet		Fletto Ceramic		Porcelain Ceramic	

Notes :
Clay roof tile cornice will be painted plaster on metal lath

تقرير عن أفضل الأنظمة لتغذية المياة

لوحدة سكنية بقرية مينا ٢

هناك ثلاثة أنظمة لتنفيذ تغذية المياه الداخلية للوحدة السكنية وهم النظام التقليدي « الحديد والثرموبايب والألفابكس.

ويتم إستخدام التقييم المعياري لتحديد أفضلية المعاييرذات القيمة غير المادية :

١ ـ١ ـ تحديد المعايير الهامة للتفضيل بين البدائل كما يلي :

١ـ ٢ـ تحديد درجات الأفضلية :

أ ـ مقارنة المعايير مع بعضها لتحديدالأفضلية :

المتطلبات	التكلفة
٣	٢

المتطلبات	الجودة
٣	٢

التكلفة	الجودة
٢	٢

المتطلبات	الإنجاز
٣	١

التكلفة	الإنجاز
٢	١

الجودة	الإنجاز
٢	١

المتطلبات	[illegible]
٣	-

التكلفة	[illegible]
٢	-

الجودة	[illegible]
٢	-

الإنجاز	[illegible]
١	-

ب ـ تحديدالوزن المعياري

المعيار	عدد تكراره	الوزن المعياري «نسبة مئوية»
تلبية المتطلبات	١٢	٪٣٠
أقل تكلفة	٨	٪٢٠
الجودة والعمر	٨	٪٢٠
سرعة الإنجاز	٤	٪١٠
[illegible]	[illegible]	٪[illegible]
المجموع	٤٠	٪١٠٠

ج ـ إختيار أفضل البدائل :

نعطي كل بديل درجه أفضلية حسب الآتى :

ممتاز ١٠ درجات جيد جدا ٨ درجات جيد ٦ درجات مقبول ٥ درجة

١ ـ تقييم نظام التغذية بمواسير الحديد المجلفن :

المعيار	الدرجة	النسبة المئوية	مقياس المعيار
تلبية المتطلبات	٧	٪٣٠	٢١٠
أقل تكلفة	٩	٪٢٠	١٨٠
الجودة والعمر	٥	٪٢٠	١٠٠
سرعة الإنجاز	٥	٪١٠	٥٠
[illegible]	[illegible]	[illegible]	
مقياس المعيار			٦٤٠

٢ ـ تقييم نظام التغذية بالترموبايب :

المعيار	الدرجة	النسبة المئويه	مقياس المعيار
تلبية المتطلبات	٩	٣٠٪	٢٧٠
أقل تكلفة	٨	٢٠٪	١٦٠
الجودة والعمر	٨	٢٠٪	١٦٠
سرعة الإنجاز	٨	١٠٪	٨٠
[illegible]	[illegible]	[illegible]	[illegible]
مقياس المعيار			٨١٠

٣ ـ تقييم نظام التغذية بالألفـابكس:

المعيار	الدرجة	النسبة المئوية	مقياس المعيار
تلبية المتطلبات	٨	٣٠٪	٢٤٠
أقل تكلفة	٦	٢٠٪	١٢٠
الجودة والعمر	٩	٢٠٪	١٨٠
سرعة الإنجاز	٧	١٠٪	٧٠
[illegible]	٦	[illegible]	[illegible]
مقياس المعيار			٧٣٠

* نتائج التقييم بين البدائل الثلاثة كالآتي :

١ـ نظام التغذية بمواسير الحديد المجلفن ٦٤٠

٢ـ نظام التغذية بالترموبايب ٨١٠

٣ـ نظام التغذية بالألفـابكس ٧٣٠

* نتائج التقييم من ناحية التكاليف :

النظـام	مقياس المعيار	التكلفة	مقياس القيمة
مواسير الحديد المجلفن	٦٤٠	٢٥٨جنية	٢,٤٨
الترموبايب	٨١٠	٣٤٣جنية	٢,٣٦
الألفـابكس	٧٣٠	٤٧٢جنية	١,٥٤

لحظ أهمية التكلفة

* يتضح أن :

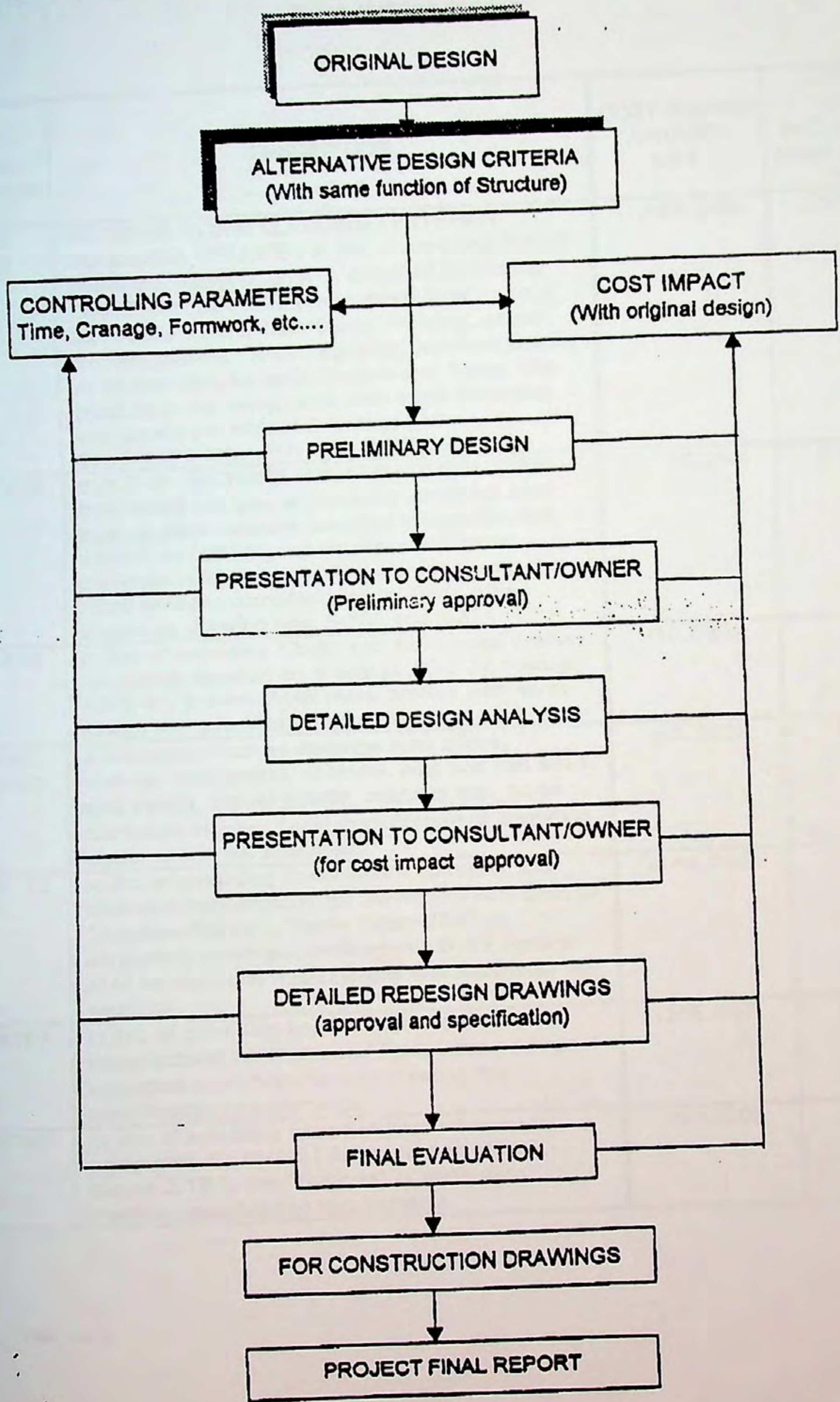
ـ نظام التغذية بالترموبايب هو أعلاها قيمة غير مادية .

ـ نظام التغذية بالحديد المجلفن هي أعلاهم قيمه مادية .

* التـوصيات :

نوصي بإستخدام التغذية بالترموبايب وتخفيض السعر إلي ٣٢٥ جنية حتي يكون هذا النظام أعلاها قيمة مادية وغير مادية

VALUE ENGINEERING PROCEDURE



Four Seasons Hotel Cairo at Nile Plaza
Cost Saving Items

ITEM NO.	Spec. Reference	DESCRIPTION	COST SAVING AMOUNT US$	DUTIES & TAXES INCLUDED IN COST SAVING US$
1	04465 04466	**EXTERIOR STONE CLADDING - EGYPTIAN JUPARANA GRANITE :** In lieu of providing French limestone cladding, STN-1, specified In Section 04465, for the Podium from street level up to + 32700and STN-2, Cast Stone, cladding, as per Section 04466. Provide Egyptian Juparana Granite at 35mm thick for both Podium and Tower and must be in full compliance with stone thickness and details per WZMH Drawings and Specifications for STN-1 and STN-2	(1,486,143)	(722,638)
2	05120	**BUILT-UP SECTIONS FOR STRUCTURAL STEEL COLUMNS :** In Lieu of providing structural steel built up plate columns specified In Specification section No. 05120 and details on structural drawings prepared by Yolles, provide the steel rolled sections manufactured by Trade Arbed shown on drawing nos. S-101 and S-314.	(1,138,286)	(71,465)
3	05510	In lieu of providing 12x60 and 8x60 metal profiles for railings detailed on drawings AD-5-26 through AD-5-41, provide 8x48 metal profiles with same design and specifications for fixing.	(40,089)	
4	11000, 11400	Accessories such as stainless steel tables, shelves, floor grates, cabinets, pots and pan sinks, wall panels, corner guards, counters etc. to be fabricated locally. Local manufacture of operating equipment is not accepted.	(65,662)	(16,074)
5	Div. 13	In lieu of providing Krnloch-USA specified, use alternate manufacturer for Swimming Pool such as "Aqualux-France". "Purex Triton-USA" or equivalent meeting specifications. Entire system shall be from one manufacturer and submitted for approval.	(143,092)	(16,599)
6	15250	In lieu of providing specified Insulation manufacturer for Ducts and Pipes , use equivalent insulation manufacturer fully meeting the specification requirements.	(205,607)	(18,482)
7	15700	In lieu of providing specified Water Treatment equipment for HVAC (Spec. section 15700, clause 2.15), use "Culligan" or equivalent meeting specification requirements.	(41,970)	(11,320)

ITEM NO.	Spec. Reference	DESCRIPTION	COST SAVING AMOUNT US$	DUTIES & TAXES INCLUDED IN COST SAVING US$
8	16525	In lieu of providing specified Dimmer System , use Helvar, Lutron or equivalent meeting specification requirement.	(91,597)	(14,197)
9	13700	In lieu of providing specified Security System , use "Infographics" , "Phillips" or equivalent manufacturer and submit for approval.	(225,938)	(20,419)
10	04466, 09200	**Exterior Stone Cladding** Use exterior stucco scored to appear as stone panels on recessed balcony walls in lieu of stone cladding 7th floor and above except for balconies located at B1/2 &3, B/28 &29; E1/6&8, F1/43 &45 and E/23&25. Details at intersections with granite cladding and window system & curtainwall to be submitted for approval.	(1,109,359)	111,010
11	15500	Use locally manufactured fire hose cabinets only for Hose Stations & Fire Department Valve cabinets. All ancillaries such as reels, valves, hoses, nozzles, ...etc. shall be imported materials per specifications.	(117,002)	(12,945)
12	15000	Use locally fabricated pipe supports and hangers (fire protection supports shall comply with all NFPA codes), regarding types, standards, materials, seismic restraint systems, ...etc. Vibration isolation materials shall be in accordance with Specifications.	(14,500)	(1,338)
13	15250	Use calcium cilicate insulation for kitchen black steel ductwork, in lieu of the specified fire rated duct wrap insulation. Submit technical data for approval and confirmation of 2 hour fire rated material	(53,767)	(5,857)
14	15250	Use fiber-glass insulation for chilled water piping in lieu of the specified flexible polyolefin insulation. Use 25mm thick insulation for piping up to 100mm diameter and 38mm thick insulation for piping larger than 100mm diameter.	(91,300)	(7,243)
15	15900	Replace the 144 natural gas meters located at each of the Business & Large Suites with a Global measuring system connected to BMS for measuring the Business Suites and the Large Suites overall consumption.	(105,021)	(13,544)
16	16050	Use XLPE/PVC insulated cables in lieu of the specified mineral insulated cables, except from Fire Pumps to Diesel Generator and Transformers which shall be in hot dipped Galvanized, conduit, armored cables to remain as specified.	(130,704)	(27,948)

ITEM	Spec. Reference	DESCRIPTION	COST SAVING AMOUNT US$	DUTIES & TAXES INCLUDED IN COST SAVING US$
17	02515	Provide precast concrete unit pavers 200mmx200mm in lieu of Type "D" pavers for permiter sidewalk excluding sidewalk paving at driveway. Provide precast Main Entrance concrete curb in lieu of granite stone curb (detail 3, drwg L-116) at perimeter of the site on Houd El Laban Street, Tolombat Street, Gamal El Din Abu El Mahassen Street, and Cornich El-Nil Street. Curb at both sides of driveway up to hotel entry to remain as stone (detail 7, Dwg L-116). This combines previous items attached to Letter of Award numbers II 61, 73 and 74. Technical data to be submitted for approval.	(226,288)	(24,712)
18	08110	In lieu of Hollow metal doors and frames as specified use locally fabricated equivalent hollow metal doors and pressed metal frames. Fire test data to be provided for approval.	(87,630)	(83,202)
19	15440	In lieu of providing Plumbing fixtures as specified in Section 15440 , for Guestrooms and Business Suites use "Ideal Standard" - Top of the line "Heritage" models including one piece for WC and Kohler bathtub in Guestrooms and Business Suites. Specific model number and catalogue data to be submitted for approval.	(504,187)	(87,249)
20	15000	Delete the insulation on domestic cold water piping as specified	(167,124)	(15,419)
21	15000	In lieu of the specified manufacturer for cleanout, floor drains, and roof drains (excluding shower drains) use alternate manufacturer of equivalent materials and systems meeting the specifications. Submit technical data for approval.	(39,367)	(4,879)
22	15000	In lieu of the specified manufacturers for black & galvanized sheet steel for HVAC duct work, use alternate manufactures. Metal gauges shall be according to SMACNA requirements. Technical Data to be submitted for approval.	(83,074)	(6,590)
71	Div. 1	Item 8.0 of "Personnel Facilities for Owner's use" to be 300sq.m. including additional 150sq.m. of office space.	70,400	

SAUDI BINLADIN GROUP
GOLDEN PYRAMIDS PACKAGE No.5
FINISHING & ELECTROMECHANICAL WORKS - VALUE OF ALTERNATIVES

1	2	3	4	5	6	7	8
				COMMERCIAL			
SBG - 101	C	A	E	**ARCHITECTURE/CIVILS**	**EXTERNAL**	ALT. No.1	2,064,853.4
SBG - 102	C	A	E			ALT No.2	3,054,159.7
SBG - 103	C	A	E			ALT No.3	42,995.6
SBG - 104	C	A	I		**INTERNAL**	ALT. No.1	-1,610,342.6
SBG - 105	C	A	I			ALT No.2	-6,210,283.0
SBG - 106	C	A	I			ALT No.3	-90,915.9
SBG - 107	C	H		**H.V.A.C.**		ALT. No.1	38,655,000.0
SBG - 108	C	H				ALT No.2	37,720,000.0
SBG - 109	C	H				ALT No.3	Not Priced**
SBG - 110	C	H				SYSTEM	1,466,354.8
				HOTEL			
SBG - 201	H	A	E	**ARCHITECTURE/CIVILS**	**EXTERNAL**	ALT. No.1	1,547,764.4
SBG - 202	H	A	E			ALT No.2	2,342,573.3
SBG - 203	H	A	E			ALT No.3	117,124.7
SBG - 204	H	A	I		**INTERNAL**	ALT. No.1	-117,427.2
SBG - 205	H	A	I			ALT No.2	-575,103.8
SBG - 206	H	A	I			ALT No.3	-32,193.0
SBG - 207	H	E		**ELECTRICAL**		ALT. No.1	1,700,503.2
SBG - 208	H	H		**H.V.A.C.**		ALT. No.1	42,202,000.0
SBG - 209	H	H				ALT No.2	42,222,200.0
SBG - 210	H	H				ALT No.3	Not Priced**
				BLOCK F1/F2			
SBG - 301	F	A	E	**ARCHITECTURE/CIVILS**	**EXTERNAL**	ALT. No.1	1,532,301.3
SBG - 302	F	A	E			ALT No.2	2,319,169.6
SBG - 303	F	A	E			ALT No.3	12,214.8
SBG - 304	F	A	E			ALT. No.4	9,863.5
SBG - 305	F	A	I		**INTERNAL**	ALT. No.1	-203,662.8
SBG - 306	F	A	I			ALT No.2	-844,808.3
SBG - 307	F	A	I			ALT No.3	-13,043.3
SBG - 308	F1	E		**ELECTRICAL**	**F1**	ALT. No.1	377,332.1
SBG - 309	F1	H		**H.V.A.C.**	**F1**	ALT. No.1	12,242,500.0
SBG - 310	F2	H			**F1**	ALT No.2	10,616,000.0
SBG - 311	F2	H			**F1**	ALT No.3	Not Priced**
SBG - 312	F2	H			**F2**	ALT. No.1	20,479,500.0
SBG - 313	F2	H			**F2**	ALT No.2	20,462,900.0
SBG - 314	F2	H			**F2**	ALT No.3	Not Priced**

KEY
1 SBG INDENTIFICATION REFERENCE
2 CLIENT AREA DESIGNATION
3 TRADE DESIGNATION
A = ARCHITECTURE / CIVIL
E = ELECTRICAL
H = H.V.A.C.
4 LOCATION
E = EXTERNAL
I = INTERNAL
5 TRADE HEADING
6 LOCATION
7 CLIENT'S ALTERNATIVE REFERENCE
8 S.B.G.'s ALTERNATIVE VALUE

** EMPLOYER'S NOMINATED SUPPLIER / MANUFACTURER DID NOT SUPPLY QUOTATION

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PACKAGE No.5

FINISHING & ELECTROMECHANICAL WORKS - VALUE OF ALTERNATIVES

1	2	3	4	5	6	7	8
				BLOCK A1/A2/A3			
401	A	A	E	ARCHITECTURE/CIVILS	EXTERNAL	ALT. No.1	1,735,771.25
402	A	A	E			ALT No.2	2,627,125.50
403	A	A	E			ALT No.3	54,651.66
404	A	A	E			ALT. No.4	11,836.26
405	A	A	I		INTERNAL	ALT. No.1	-265,559.41
406	A	A	I			ALT No.2	-1,112,234.48
407	A	A	I			ALT No.3	-15,335.02
408	A	A	I			ALT. No.4	7,033.86
409	A1	E		ELECTRICAL	A1	ALT. No.1	377,332.19
410	A2	E			A2	ALT. No.1	377,332.19
411	A3	E			A3	ALT. No.1	377,332.19
412	A1	H		H.V.A.C.	A1	ALT. No.1	14,424,000.00
413	A1	H			A1	ALT No.2	14,345,800.00
414	A1	H			A1	ALT No.3	Not Priced**
415	A2	H			A2	ALT. No.1	10,962,900.00
416	A2	H			A2	ALT No.2	11,018,700.00
417	A2	H			A2	ALT No.3	Not Priced**
418	A3	H			A3	ALT. No.1	14,521,500.00
419	A3	H			A3	ALT No.2	14,509,600.00
420	A3	H			A3	ALT No.3	Not Priced**

KEY
1 SBG INDENTIFICATION REFERENCE
2 CLIENT AREA DESIGNATION
3 TRADE DESIGNATION
A = ARCHITECTURE / CIVIL
E = ELECTRICAL
H = H.V.A.C.
4 LOCATION
E = EXTERNAL
I = INTERNAL
5 TRADE HEADING
6 LOCATION
7 CLIENT'S ALTERNATIVE REFERENCE
8 S.B.G.'s ALTERNATIVE VALUE

** EMPLOYER'S NOMINATED SUPPLIER / MANUFACTURER DID NOT SUPPLY QUOTATION

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLOS - CAIRO - EGYPT
ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES
SECTION 2 MECHANICAL SYSTEMS

DATE 3rd September 1997

REFERENCE					DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
					ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
A,F,H,C	GEN			1	Building Management Systems & H.V.A.C. Controls	Simplify Building Management Systems & H.V.A.C. Controls		
A,F,H,C	GEN			2	Domestic Water Piping Copper Pipe Type L , ASTM B88	Replace copper piping by galvanised steel for al domestic hot and cold water.		
A,F,H,C	GEN			3	Sanitary & Storm Water Riser Cast Iron Pipe , ASTM A74	Replace cast iron piping by PVC Class IV piping for all waste drainage and vent riser , and storm water drainage risers		
A,F,H,C	GEN			4	Fire Fighting Pipes	Replace black steel pipe Schedule 40 seamless by ERW to all fire fighting pipes.		
A,F,H,C	GEN			5	Chilled and Hot Water Pipes Black Steel Pipes Schedule 40 , ASTM A53 seamless type	Replace Black Steel Pipes Schedule 40 , ASTM A53 seamless type to ERW to all chilled and hot water piping.		
A,F,H,C	GEN			6	Centrifugal Water Chillers: CH - 1 & 7 Chilled Water Pumps: PP - 1 & 7 Condender Water Pump: CP - 1 & 7	Delete two sets of chillers , chilled water pumps , condenser , water pumps including respective valve packages serving Phase No.2		
A,F,H,C	GEN			7	Centrifugal Water Chillers: CH - 8 Chilled Water Pumps: PP - 8 Condender Water Pump: CP - 8	Delete standby chiller , chilled water pump , condenser , water pump and valve package.		
A,F,H,C	GEN			8	Draw through vertical conter flow cooling tower CT - 5	Delete cooling tower CT - 5		
A,F,H,C	GEN			9	Condenser water pipes , Black Steel Pipes Schedule 40 ASTM A53 , seamless type.	Replace Black Steel Pipes Schedule 40 ASTM A53 seamless type by Schedule 20 ERW.		

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

SECTION 1 ARCHITECTURAL WORKS

DATE 2nd September 1997

REFERENCE				DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
				ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
				BLOCK - A1, A2, A3- APARTMENTS			
				LIFT LOBBY			
A	LL	B6	1	Floor - Polished Granite (Item-B6/3 item G, Dr. A1, AD-31,AD-32, Ad-33)	Option No. 1. High Standard porcelain stoneware tiling . Cleopatra "ISIS" OR "LOTUS" or		
A	LL	B6	1A		Option No. 2. Finishing screed or Terrazo tiles to receive carpet. (Carpet not in SBG scope)		
A	LL	B6	2	Skirting- Granite (Item B6/3-H, Dr. A1-AD- 37 A)	Option No. 1. Ceramic skirting. or		
A	LL	B6	2A		Option No. 2. M.D.F (Medium density fiber board)		
A	LL	B6	3	Ceiling - combination Gypsum & Aluminium tiles. (Item B6/11-D & B6/12-D, Dr. A2-AD 36B, Dr. A1, AD-37A)	Stepped Gypsum board ceiling with access panel & corniches. Remove coffers.		
				ENTRANCE			
A	APT	B6	4	Floor- Polished Granite (Item B6/3-G)	Option No. 1. High Standard porcelain stoneware tiling . Cleopatra "ISIS" OR "LOTUS" or		
A	APT	B6	4A		Option No. 2. Finishing screed or Terrazo tiles to receive carpet. (Carpet not in SBG scope)		
A	APT	B6	5	Skirting - Granite (Item B7/3-C)	Option No. 1. Ceramic skirting. or		
A	APT	B6	5A		Option No. 2. M.D.F (Medium density fiber board)		
A	APT	B6	6	Ceiling - Combination Gypsum & mineral fiber tiles (FCGT & FCMF.1) Item B6/11-D & B6/12-C	G.R.G. tiles- 600x600 mm		

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ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

SECTION 1 ARCHITECTURAL WORKS

DATE 2nd September 1997

REFERENCE				DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
				ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
F	MB	B6	15	Ceiling - Combination of FCGB & FCAT.	Moisture proof G.R.G. tiles 600 x 600 mm.		
				(Gypsum & Aluminium tiles) (Item - B6/7/E & B6/8/A)			
				DOORS			
F	GEN	B5	16	2 hours. fire rating.	1 hour. fire rating.		
F	GEN	B5	17	Solid panelled leaf.	Oak veneered face on flushed door.		
F	GEN	B5	18	Frames	Modify details.		
F	GEN	B5	19	Oak veneered facia.	Flush painted facia to match wall finish.		
F	GEN	B5	20	Overhead decorative panel.	Delete item.		
F	GEN	B5	21	Stainless steel ironmongery for front of House.	Chrome plated or aluminium ironmongery for front of House.		
				VANITY TOP			
F	GEN	B5	22	Methyl methacrylate " Corian " counter tops	Marble or Granite Vanity Top		
				(Pages-B5/16, B5/17)			
				EQUIPMENT'S			
F	E	B11	23	Stainless steel doors to fire box.	Powder coated galvanized steel doors.		
				(Item-B11/1/A, Special item - A)			
F	E	B11	24	Remote controlled sectional overhead door.	Push button or card and electrically operated sectional		
				(Item- B11/G, Special item 28)	over head door.		

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SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

SECTION 1 ARCHITECTURAL WORKS

DATE 2nd September 1997

REFERENCE				DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
				ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
				FINISHES/CEILING			
				Bulk Head			
C	GEN	B6	17	Decorative bulkhead on column. (a.p. Item B6/16/A, B, C, D, Dr. - TP02, 03)	Painted, circular corniche - 150 mm height, placed between stepped ceiling.		
				Wooden Ceiling in Gold Souk.	One step Gypsum board ceiling with corniches and access panel.		
C	GEN	B6	18	(a.p. Item B6/16/F, Dr. - GP02,03)			
				Ceiling in Shopping Corridor			
C	GEN	B6	19	Combination Gypsum board ceiling & mineral fiber (FCGB1 & FCMF) (B.O.Q. item B6/15/E & B6/16/E)	G.R.G. tiles ceiling - 600 x 600 mm		
15							
				MISCELLANEOUS ITEMS			
				Show Case			
C	GEN	B6	20	With Oak veneered medium density fiber board. Polished Brass channels clear mirror over door . (Item- B6/26/A, Dr. MP-31)	Malmine laminated panel with oak wood finish and bidding Golden anodized aluminium channels. Delete mirror.		

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

SECTION 1 ARCHITECTURAL WORKS

DATE **2nd September 1997**

REFERENCE				DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
				ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
				Foyer & Exhibition Hall			
H	FH		38	Decorative solid Oak wood panel (Item-B6/49/B, H1-H2/ID-05/2/AreaRef. 3/Book 1)	Mahogany hard wood decorative panel.		
H	FH		39	Decorative column with solid Oak capital. (Item B6/49/E&F, DWG No. H1-H2/ID-05/M/Area Ref. 3/ Book 1)	Mahogany Hard wood capital.		
				Banquet Hall			
H	BH		40	Veneered Oak wood panel (Item- B6/50/A, DWGNo. H1-H2/ID-05/A/Area Ref. 4/Book 1)	Melamine laminated panel with oak wood finished & wood moulding.		
H	BH		41	Veneered & Solid Oak wood surroundings to folding panel. (Item B6/50/D, DWG No. H1-H2/ID-05/D/Area)	Melamine laminated surrounding with hard wood panels.		
				Cloak Room			
H	BH		42	Counter with Veneered Oak wood worktops solid wood studs. (Item B6/52/D, DWG No. H1-H2/ID-05A/Area Ref.6/Book 1)	Melamine laminated panel with oak wood finish work top with soft wood studs.		
				Japanese Restaurant			
H	JR		43	Solid Oak wood mushrabia. (Item B6/60/C, Dwg No. H1-H2/ID-05/A/Area Ref 23/Book 3)	Red hard wood mahogany mushrabia.		
				Multi purpose Room			
H	MPR		44	Decorative Oak wood panelling to match door D-64. (Item B6/61/D, E, F, DWG No. H1-H2/ID-04/A/Area, DWG No. H1-H2/ID-04/B/Area Ref. 25/Book 3)	Hard wood panelling.		

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

DETAIL OF ALTERNATIVES

DATE 2nd September 1997

REFERENCE					DESCRIPTION OF PROPOSED CHANGES: ORIGINAL SPECIFICATION	DESCRIPTION OF PROPOSED CHANGES: ALTERNATIVE SPECIFICATION	ACCEPTABILITY: YES	ACCEPTABILITY: NO
					COMMERCIAL CENTER			
EXTERNAL FINISHES ALTERNATIVES								
SBG	101	C	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	PRECAST GRC COLOURED PANELS		
SBG	102	C	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	RECONSTITUTED STONE WALL SLAB CLADDING		
SBG	103	C	A	E	REINFORCED CONCRETE ELEMENTS (GRC & PR - PL)	RECONSTITUTED STONE WALL SLAB CLADDING		
INTERNAL FINISHES ALTERNATIVES								
SBG	104	C	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POLYURETHANE FLOOR FINISH		
SBG	105	C	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POWER FLOAT FINISH TO CONCRETE BED		
SBG	106	C	A	I	REINFORCED SCREED IN ALL STAIR CASES	POLYURETHANE PAINT TO DRY FILM THICKNESS		
H. V . A. C.								
SBG	107	C	H		STEAFA CONTROL SYSTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	108	C	H		STEAFA CONTROL SYSTEMS EQUIPMENT	HONEYWELL CONTROL SYSTEMS EQUIPMENT		
SBG	110	C	H			ALTERNATIVE PUMP SYSTEMS		
					HOTEL BUILDING			
EXTERNAL FINISHES ALTERNATIVES								
SBG	201	H	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	PRECAST GRC COLOURED PANELS		
SBG	202	H	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	RECONSTITUTED STONE WALL SLAB CLADDING		
SBG	203	H	A	E	REINFORCED CONCRETE CAPITALS (PR-PL)	RECONSTITUTED STONE WALL SLAB CLADDING		
INTERNAL FINISHES ALTERNATIVES								
SBG	204	H	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POLYURETHANE FLOOR FINISH		
SBG	205	H	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POWER FLOAT FINISH TO CONCRETE BED		
SBG	206	H	A	I	REINFORCED SCREED IN ALL STAIR CASES	POLYURETHANE PAINT TO DRY FILM THICKNESS		
ELECTRICAL								
SBG	207	H	E		COLOUR (FIXED) CAMERAS	(PZT) CAMERAS		

SAUDI BINLADIN .OUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

DETAIL OF ALTERNATIVES

DATE 2nd September 1997

REFERENCE					DESCRIPTION OF PROPOSED CHANGES		ACCEPTABILITY	
					ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	YES	NO
H. V. A. C.								
SBG	208	H	H		STEAFA CONTROL SYSTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	209	H	H		STEAFA CONTROL SYSTEMS EQUIPMENT	HONEYWELL CONTROL SYTEMS EQUIPMENT		
					HOTEL APARTMENTS - F1/F2			
EXTERNAL FINISHES ALTERNATIVES								
SBG	301	F	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	PRECAST GRC COLOURED PANELS		
SBG	302	F	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	RECONSTITUTED STONE WALL SLAB CLADDING		
SBG	303	F	A	E	8 CM INTERLOCKING TILES TO ROADS AND DRIVEWAYS	BITUMINOUS ROAD PAYEMENT		
SBG	304	F	A	E	PRECAST GLASS REINFORCED CAPITAL MOULDING	RECONSTITUTED STONE CAPITAL MOULDING		
INTERNAL FINISHES ALTERNATIVES								
SBG	305	F	A	I	REINFORCED SCREED IN UNDEERGROUND CARPARK	POLYURETHANE FLOOR FINISH		
SBG	306	F	A	I	REINFORCED SCREED IN UNDEERGROUND CARPARK	POWER FLOAT FINISH TO CONCRETE BED		
SBG	307	F	A	I	REINFORCED SCREED IN ALL STAIR CASES	POLYURETHANE PAINT TO DRY FILM THICKNESS		
ELECTRICAL								
SBG	308	F1	E		HIGH VOLTAGE SWITCHGEAR	DIFFERENT BREAKER SYSTEM		
H. V. A. C.								
SBG	309	F1	H		STEAFA CONTROL SYSTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	310	F1	H		STEAFA CONTROL SYSTEMS EQUIPMENT	`HONEYWELL CONTROL SYSTEMS EQUIPMENT		
SBG	312	F2	H		STEAFA CONTROL SYSTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	313	F2	H		STEAFA CONTROL SYSTEMS EQUIPMENT	HONEYWELL CONTROL SYSTEMS EQUIPMENT		

SAUDI BINLADIN GROUP

GOLDEN PYRAMIDS PLAZA -HELIOPOLIS - CAIRO - EGYPT

ASSESSMENT OF AREAS OF POTENTIAL APPLICATION OF VALUE ENGINEERING TECHNIQUES

DETAIL OF ALTERNATIVES

DATE 2nd September 1997

REFERENCE					DESCRIPTION OF PROPOSED CHANGES: ORIGINAL SPECIFICATION	ALTERNATIVE SPECIFICATION	ACCEPTABILITY: YES	NO
					HOTEL SERVICED APARTMENTS - A1/A2/A3			
EXTERNAL FINISHES ALTERNATIVES								
SBG	401	A	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	PRECAST GRC COLOURED PANELS		
SBG	402	A	A	E	EXTERNAL WALL CLADDING BR1 CERAMIC TILES	RECONSTITUED STONE WALL SLAB CLADDING		
SBG	403	A	A	E	8 CM INTERLOCKING TILES TO ROADS AND DRIVEWAYS	BITUMINOUS ROAD PAVEMENT IN BLOCK A2 AND A3		
SBG	404	A	A	E	PRECAST GLASS REINFORCED CAPITAL MOULDING	RECONSTITUTED STONE CAPITAL MOULDING		
INTERNAL FINISHES ALTERNATIVES								
SBG	405	A	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POLYURETHANE FLOOR FINISH		
SBG	406	A	A	I	REINFORCED SCREED IN UNDERGROUND CARPARK	POWER FLOAT FINISH TO CONCRETE BED		
SBG	407	A	A	I	REINFORCED SCREED IN ALL STAIR CASES	POLYURETHANE PAINT TO DRY FILM THICKNESS		
SBG	408	A	A	I	DEMOUNTABLE BACKED ENAMEL PRESS FORMED	FIBROUS GYPSUM TILE DEMOUNTABLE TYPE		
					ALUMINIUM TILE SUSPENDED CEILING	SUSPENDED CEILING		
ELECTRICAL								
SBG	409	A1	E		HIGH VOLTAGE SWITCHGEAR	DIFFERENT BREAKER SYSTEM		
SBG	410	A2	E		HIGH VOLTAGE SWITCHGEAR	DIFFERENT BREAKER SYSTEM		
SBG	411	A3	E		HIGH VOLTAGE SWITCHGEAR	DIFFERENT BREAKER SYSTEM		
H.V.A.C.								
SBG	412	A1	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	413	A1	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	HONEYWELL CONTROL SYSTEMS EQUIPMENT		
SBG	415	A2	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	416	A2	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	HONEYWELL CONTROL SYSTEMS EQUIPMENT		
SBG	418	A3	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	STEAFA CONTROL SYSTEMS EQUIPMENT		
SBG	419	A3	H		STEAFA CONTGROL SYSLTEMS EQUIPMENT	HONEYWELL CONTROL SYSTEMS EQUIPMENT		

Appendix D

(Types of project contracts according to the Egyptian Contractors Federation)

The detailed classification of all types of contracts in the construction industry according to the Egyptian Building and Construction Contractors Federation is composed of five sectors as follow:

A- Buildings Sector:

- Economy housing
- Medium housing
- Upper medium housing
- Administrative buildings including police stations, soldiers and prisoners housing units
- Hospitals and emergency centers and health units
- Hotels, offices and tourists villages
- Clubs, swimming pools, fences, light buildings and playgrounds
- Banks
- Factories, warehouses, concrete storage building, concrete silos, power plants, and wastewater plants
- Maintenance and rehabilitation works

B- Special Buildings Sector:

- Luxury housing
- Skeletons
- Metal silos
- Mechanical foundations
- Pre fabricated housing

C- Electromechanical and building preparation sector:

- Factory and machine equipment
- HVAC work
- Elevators work
- Transformers and generators
- High and medium voltage panels
- Fire, burglary, and extinguishing alarm work
- Sound and antenna work
- Communication and broadcasting equipment
- Water pumps
- Boilers
- Desalination, treatment and filtration equipment
- Medical equipment
- Measuring and control equipment

D- Utility and mine sector & irrigation and land cultivation sector

- Asphalt roads including landfill, trenches, sidewalks, advisory signs, and protection work
- Airport runways
- Covered and uncovered wastewater networks
- Telephone and light pole networks
- Water supply networks and water tanks

- Bridges and platforms
- Well and cleaning and rehabilitation work & waterway and drainage construction

E- Land work and petroleum sector

- Land and marine pipe lines, insulation, casing and pump and gauge instruments
- Platform and water obstruction and dredging work
- Storage pumping containers and what relate to it
- Equipment maintenance, sandblasting and metal surfaces painting