Value Management for Construction Projects Via an Expert System Framework

Maryam Mesbah

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Approval of the Institute of Graduate Studies and Research

_____
Prof. Dr. Elvan Yilmaz
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Interior Architecture.

_____
Prof. Dr. Ozgur Eren
Chair, Department of Civil Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Interior Architecture.

_____
Prof. Dr. Tahir Celik
Supervisor

Examining committee

1. Prof. Dr. Tahir Celik   _____

2. Assoc. Prof. Dr. Ibrahim Yitmen   _____

3. Asst. Prof. Dr. Mehmet Metin Kunt   _____

ABSTRACT

To implement the Value Management (VM), instead of having one organized fixed process, there are different innovative methods. In this study it is aimed to propose a general method for VM practice. To fulfill this aim, a checklist was provided, based on the available experience resources and information, prepared by means of collecting and investigative sufficiently large amount of reviews and available data. Data collection was done through diverse published literatures. However, it was found that the literatures are not adequate sources for the aim of this research. Hence, to get the adequate data, some questionnaires about the VM process and its difficulties in construction projects, were prepared and sent to VM experts of some corporations in different countries.

After the mentioned steps, a VM model was derived from the collected data and an organized system was developed accordingly. To solve the problem and help the companies and specially inexperienced and low-skilled engineers to carry out the process, relevant Expert System software has also been developed by Visual Studio 2012, C# and crystal languages, according to the model. After completing the first version of the program, it was future developed and improved many times, and finally, its performance was successfully assessed in a case study of a water supply project. Moreover, the VM Expert System was evaluated by domain experts that their comment proved that the accuracy of this software.

Keywords: Value Management, Value, Function, Expert System, VM Expert System

ÖZ

Değer yönetiminin uygulanması için standart tek bir yöntem değil, birçok yenilikçi yöntem bulunmaktadır. Bu çalışma, değer yönetiminin uygulanması için genel bir yöntem geliştirmeyi amaçlamaktadır. Amaca ulaşabilmek için, gerekli kaynak ve bilgiler doğrultusunda, verilerin ve değerlendirmelerin toplanması ve araştırılması sonucunda bir kontrol listesi sağlanmıştır, Veri toplanması çeşitli yayınlardan yapılmıştır. Ancak, çalışmanın amacı doğrultusunda yalnızca bir literature taramasının yeterli olmayacağı kanısına varılmıştır. Bu nedenle, gerekli verileri toplayabilmek amacıyla, bazı sorular hazırlanmış ve değer yönetimi süreci ile ilgilenen kurumlara dağıtılmıştır.

doğru bir değer yönetimi süreci için, gerekli giriş verisi, adım ve metotlar, sonuçlar ve raporlar, ve son olarak uyulması gereken standartlar ve talimatlar konularında bilgi sahibi olunması gerekmektedir. Sözü geçen adımlardan sonra, toplanan verilerin sonuçlarıyla bir değer yönetimi modeli oluşturulmuş ve buna bağlı olarka düzenli bir system tasarlanmıştır. Model doğrultusunda, şirketlere ve özellikle deneyimsiz, düşük nitelikli mühendislere ve tasarımcılara yardımcı olmak için bir Uzman Sistem yazılımı geliştirilmiştir. Programın birinci versiyonu tamamlandıktan sonra birçok kez geliştirilmiş ve son olarak performansı bir su kaynağı projesinde başarılı bir şekilde değerlendirilmiştir. Buna ek olarak, VM Uzman Sistemi profesyoneller tarafından değerlendirilmiş ve yazılımın tutarlılığı doğrulanmıştır.

Anahtar Kelimeler: Değer Yönetimi, Değer, İşlev, Uzman Sistem, VM Uzman Sistem

To My Family

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INTRODUCTION

1.1 Introduction

Value Management (VM) is a management service, which is based on analyzing and developing the function of a project or a service. The process can be done by evaluating, reviewing and comparing all the ideas and decisions that are confirmed for that project. Because VM is actually dealing with the assessment of the value of a project, it is more of importance to be performed in the construction sector, as a day-by-day growing of this industry (Kelly,Male,1993).

Nowadays, owing to the intensive competition in marketing and business sector between the construction industries, stakeholders are highly motivated to apply the VM process, throughout their projects, principally in the crucial and strategic stages.

Undoubtedly, VM application will result in lessening the wastes and boosting the efficiencies. Value Management is a practical, innovative and problem solving service, which aims to advance a project's value, by functions analyses. It is also a systematic, function oriented decision making tool, which benefits from structured systems and interdisciplinary assessments (Whyte, Cammarano, 2012).

The beginning of VM concept was first in USA, during World War II. It was initially created by the "General Electric Company", to solve the ongoing issue of raw

materials shortage, which was a mounting problem, caused by the war. At that time, by means of VM process, it was tried to lessen the costs, alongside with growing the products performances. Having this experience, later on, this concept was extended to all the USA industries. This extension was grown consistently to the level that nowadays, from construction industries viewpoint, VM is known as a crucial stage of construction process, especially in many developed countries, including USA, UK, China and etc (Norton, McElligott, 1995).

The process of VM has been known so far as an operational effective method, to reduce the redundant investments and life-cycle costs and boost the value of a project. Although this fundamental theory is well-understood, the correct method of using it is believed to be less known.

When the process of VM is not experienced very well, a certain consequence will be the failure of construction projects' productions. Lack of knowledge and experience is believed to be the main reason of this matter, knowing that professional knowledge is the key element to perform the management tasks (Whyte, Cammarano, 2012).

To overcome these issues, a solution can be using the current available storing technologies. Computers are nowadays available widely and they can be employed easily as storing resources of the experts' knowledge, to benefit both experienced and less experienced individuals. In fact these so-called "Expert Systems" can be used as a precious knowledge resource for the less experienced people, while professionals can also use them to develop their performances' qualities and efficiencies.

To sum up, solving the problem of lacking professional knowledge is a crucial issue, and to solve it, establishing an Expert System, sounds to be beneficial for both stakeholders and engineers, who are dealing with VM application in their construction projects (Yazdanpanah, 2010).

Expert Systems can be in the form of applicable software programs, to be employed in management fields. Their various techniques might also be applied during a Value Management process (VM), for a project appraisal, to perform the best decision making (Yazdanpanah, 2010).

In this study, at first, based on the collected data, an appropriate VM process model has been introduced. Afterwards, based on this model, an Expert System has been developed in the form of a software program by Visual Studio 2012, C# and crystal languages, which is designed to cover all the necessary and common steps of VM process, to be followed by its users. Improvements and corrections of the initial version of the software were also done in subsequent stages, based on reviews and comments of some of this field's professionals. Lastly, practical evaluation of the software was decided to be done. To do so, three references were asked to examine the software and comment about it. Moreover, to find out about the efficiency of the application, the developed Expert System was meant to perform a VM process once again, on a project which was evaluated previously as a case study.

In short, the results of this research indicate that the presented VM process and the developed software are beneficial, especially to guide the less experienced individuals in VM field.

1.2 Statement of the Problem

As it is aforementioned, despite the fact that the idea of VM is clearly known an effective clue to maximize the value and minimize the unnecessary costs of a project, practically, it has been less paid attention comparatively because there is not enough familiarity knowledge about VM in construction industry. To draw the attentions to the practical use of VM and let the construction industry comprehend the effectiveness of this process for the projects, giving a broad review, on the basic ideas and the process of VM, seems to be helpful(Whyte, Cammarano, 2012).

Having the idea, in this research, it is tried to define the actual meaning of Value Management, how this method can be employed optimally and what facilities, tool, strategies and stages are essential during its process.

 Data collection from various resources has been done to fulfill this aim, along with understanding and revealing the correct application method of an integrated Value Management (VM) process, to enhance its benefits. The collected data can also be suitable for those who are less experienced in this field.

Considering these issues, a research gap which can be clearly pronounced, is how to deliver the experiences of the field's professionals to the less experienced ones, in order to follow the VM process correctly. On the other hand, it is known that an Expert System is an advantageous system, in transferring the useful experiences and knowledge from professionals to beginners and less experienced users. Consequently, this research is majorly about developing an advanced Expert System, and understanding how it can be helpful in guiding the users and improve the Value Management employment process.

1.3 Aims and Objectives

The objectives of this study were defined in following:

1- To investigate the application and difficulties of Value Management (VM) in construction industry.

2- To improve the knowledge of construction managers about VM by developing an Expert System

3- To evaluate the capability of the developed Expert System of VM in construction industry by getting the view of domain experts.

4- To evaluate the accuracy of the developed Expert System by applying the developed Expert System in a case study.

1.4 Works Done

To fulfill the aims of this study, a comprehensive data collection method were required. Hence, a checklist firstly was provided, based on the available experience resources and information, prepared by means of collecting and investigative sufficiently large amount of reviews and available data. Data collection was done through diverse published literatures. However, it was found that the literatures are not adequate sources for the aim of this research. Hence, to get the adequate data, some questionnaires were also prepared and gave to the relevant corporations that are involved in VM process. Moreover, the specific standards and guidelines that should be followed were recognized. Afterwards, a proper VM model was derived from the collected data and an organized system was developed accordingly. To help the unskilled people carry out the process, relevant Expert System software has also been developed, according to the model. After completing the first version of the program, the VM Expert System was evaluated by domain experts and their relevant comment were gotten, which they proved that the accuracy of this software. Moreover, it was

future developed and improved many times, and finally, its performance was successfully assessed in a case study of infrastructure project. Totally, In order to achieve four main aims mentioned in last part, following works were done respectively:

1- A Mixed-Method of data collection consists of "literature review", "available resources and experiences investigation" and "questionnaire survey" was applied to explore the application and relevant explanations of VM in construction industry.

2- After reviewing a literature of Expert Systems, an Expert System developed by C# and crystal languages to improve the knowledge of construction managers about VM study.

3- Some human experts were asked to get their view based their experiences about the capability of the developed Expert System of VM in construction industry and evaluate it.

4- The developed Expert System was applied in a case study in water supply (infrastructure) project field to evaluate the accuracy of this software (because of the importance and common difficulties of infrastructure projects, stakeholder need more VM study in these projects that was the main reason to select this type of construction projects as case study).

1.5 Achievements

According all works that was done in this study; the gained achievements are:

1- Determination of the application difficulties of VM study in construction industry and access to a comprehensive explanations and definitions of VM and also a proper view of VM process.

2- Improvement of the knowledge of construction managers about VM study via a developed Expert System.

3- Prove that the capability and benefits of the developed Expert System of VM process in construction industry and get the domain experts opinion in this regard.

4- Prove that the accuracy of the developed Expert System because of its effectiveness in executing a VM study for selected case study.

1.6 Guide to Thesis

This thesis is composed of seven chapters as follows:

- Chapters 2 & 3 present the necessary background and knowledge about Value Management (VM) and Expert Systems and their applications in civil and construction industry.

- Chapter 4 explains the methodology and data collection methods of this study including investigating available experiences and questionnaire survey.

- Chapter 5 presents the procedure of development of this Expert System.

- Chapter 6 presents the ways of evaluation of developed Expert System and results of them.

- Chapter 7 consists of the conclusions and recommendations.

Chapter 2

VALUE MANAGEMENT

2.1 Introduction

This chapter's purpose is to assess value management (VM) concept comprehensively as an organized technique by presenting and discussing the related literature.

First, to attain the stated goal, the concept of value is elucidated. The history of VM is examined and its expressions, definitions, and explanations are reviewed. The advantages of applying VM in construction projects are also discussed. Further, this chapter argues for the participation of certain persons in the VM investigation to facilitate the VM process. In addition, the main steps and phases of a VM study have been identified and, subsequently, the methodologies, common techniques, and methods used in the VM process are presented. More over a list of the standards and guidance used in this field will be illustrated. This chapter also discuss how can improve a VM process and overcome the current barriers against it.

2.2 Value Concept

Value can be described as "the correspondence of an element which is expressed in subjective or objective units of currency, power, exchange, or a qualified scale; it reflects stakeholder's desire to gain or keep that element" (De Marle, 1971). In other words, "the quantities of objective or subjective measures are often interpreted into a financial value as an understandable scale" (Kelly, 2007).

In the field of construction, the cost of a project is often considered for the total life cycle; therefore, value is represented as stockholder's satisfaction over the project life cycle (De Marle, 1971). Kelly (2007) claimed that totally, increasing the satisfaction or decreasing the cost of a project can expand the value.

To analyze the value of the project, there are various criteria including cost, profit return, energy cost, practical performance, operability, reliability, maintenance ability, salability, quality, environment protection and aesthetics, owner requirements and safety.

Having considered the concept of value, the next part argues how this concept began and spread as a new approach around the world. This new approach is called Value Management (VM) and it is a simple and powerful process. The VM aims to maximize the functional value of a product or project against a value system determıned by the owner. As a brief definition, the VM aims to maximize the value of a product or output of the projects by a value system (Abidin, Pasquire,2006).

2.3 The History of Value Management (VM)

Value analysis developed in 1940s, during world war two, when materials and labor shortages enforced the companies and organizations to look for other substitutes. In the United States, Value Management (VM) was presented for the first time by Mr Lawrence Miles. He designed this practice based on value analysis (VA) for General Electric Company (GEC) in the 1940. In those days, all industries of USA were working in their maximum capacity that leads significantly to the raw materials reduction. Therefore, GEC had to focus on using other alternatives which needed less raw material resources.

Miles found new alternatives with less cost, while preserving the quality of results and products. After introducing VM in construction industry, it grows widely in construction projects. In 1954, Navy's Bureau of Ships adopting a formal "VM" process to improve cost in designing phase (Whyte, Cammarano, 2012). Since that time, the VM has been the common practice in all construction and building Industry of North America. In 1959, VM was used at many local government agencies of USA. Later the American Value Engineers Society was established in 1964. Applying VM method by construction industry was extended rapidly, and it became a necessary option in many governmental construction projects of US (Abidin, Pasquire,2006).

In 1960, VE came first to the UK and was accepted by multinational companies. Then in 1966, VM in manufacturing industries became mostly underground practice, but some companies tried to focus on VM teams as organizational practice which can effect on project improvement. In construction industry of the UK, government agencies did not recognize all the benefits of VM, so they were bringing VM by linking their projects with construction companies of North America (Qiping, 2004).

Using VM in UK was started from private organization, such as BNFL, BAA, Rail track, BA and the water companies including Yorkshire Water and Southern Water. Transport industry of UK also actively used VM process in their infrastructure projects (Whyte, Cammarano, 2012).

Moreover in 1960, the VM came to Australia by multinational organizations such as Hawker Siddley and the marketing parts of US and value society of Australia that is

stated – Institute of Value Management Australia (IVMA) was established in those days.

As further effort in 1980, Professor Barton who worked in construction department of University of Canberra started a study tour of VM in the USA to make more familiar Australian experts with VM study (Qiping, Shen, Ann, 2012).

In that time, undertaking VM for Leighton Construction was done by Smith Hinchman and Grylls, in US that led to publish two VM strands (Whyte, Cammarano, 2012).

Another place in employing active VM study for construction projects is Hong Kong. The construction industry of Hong Kong for first time was familiar with the VM concept in 1988. Awareness of the VM study's facts and benefits has been increased recently and it gradually used in governmental construction projects of Hong Kong (Qiping, 2004).

The majority of VM process were started by the Architectural Services Department, main multi-disciplinary professional offices of governmental sector has an important role for supporting and using VM practice in construction projects of Hong Kong. Additionally, the Value Management Institute of Hong Kong was established in 1995. Hence since that time, several International VM Conferences were organized for municipal projects (Abidin, Pasquire,2006). In 2001, using VM was recommended widely for all types of construction projects by Construction Industry Review Committee of Hong Kong through mandatory laws and legal instructions (Qiping, Shen, Ann, 2012).

2.4 Value Management Definition

As Value is the relationship between function and cost, According to Australian Standard (AS 4183, 2007) Value Management (VM) is a regulated, analytical and systematic procedure that pursues to achieve all the essential functions at the lowest cost with required quality's levels and performance. The VM provides an extremely powerful way of discovering the client's needs in depth to improve the quality and value of the projects.

In order to provide owner's requirements, VM is an essential tool that brings together a range of project stakeholders as a VM team in several relevant workshops where different views can be discussed, and problems can be avoided during them (Neasbey, Barton, Knott, 1999).

Always there is several ways based on VM theory to reach the aims of the projects. The most important ones is assessing alternatives which are introduced for a project, it is done by a VM team to create the most acceptable output.

The wide variety of VM team members who attend in VM workshops can help achieve reliable outcomes and ensure that stakeholders' views, purposes and requirements are observed and reproduced in the short-term development decision making (BS EN 12973, 2009).

Commonly, a VM study includes systematic steps and phases based on function analysis, which guarantee that the problem is carefully studied; then innovative alternatives are created and evaluated, and finally best alternatives are carefully

chosen. In addition, checking and controlling the implementation process is done to improve the VM study via gathered information and feedbacks.

There are different times for VM studies to be applied to influence on projects improvement consist of design and pre design, conception formulation, working drawings, construction, and operation phases. Although the VM can be applied in every stage of construction projects, using VM for recognizing stakeholder's requirements at the pre phases of the project can reduce later changes and control them for the benefit of the stakeholder and can be more effective to increase the value of the project (Kelly, Male, Graham, 2004).

2.5 The Terms Used in Value Management

There are some important terms and world which should be understood for implementing an effective VM study including function, cost, worth and value. These terms are described in following.

2.5.1 Function

The normal, characteristic or typical act that can be performed by a product or service is function. It is a typical activity specifically to be utilized or implemented for something. Function always defined and expressed in a verb-noun. If something is designed mainly according to the requirements of use, it is functional.

There are two types of functions including "basic functions" and "secondary functions". The main aim or most important action that is performed by a product or service is the basic function. The secondary function is performance characteristic of the practical solution which is selected other than the required basic function (Spaulding, 2005).

2.5.2 Cost

Cost is the amount of money or the price that is required to pay for something or some services. Cost of a project can be shared and distributed among elements or functions of that project (Ashworth, 2002).

2.5.3 Worth

Worth is not cost because cost is the real amount money paid for something but worth is what owners are prepared to pay for something and service or how the owners value something in their minds or hearts (Ashworth, 2002).

2.5.4 Value

The value results from a balance between cost, time and function or quality of the products or project's outputs (figure 1). The value of a product or project's output will be understood in different ways.

Indeed, it is a high level of performance, emotive demand, capability, style, etc. which is relative to price and cost. This can also be determined as maximizing the function of a project or product relative to its cost Equation 1:

$$\text{Value} = (\text{Performance} + \text{Capability})/\text{Cost} = \text{Function (objective)}/\text{Cost}$$

Above equation reveals value is not a matter of reducing cost. In many cases the value of a project's outputs can be increased by improving its function (capability or performance), so in this case function can increase more than its added cost. Three major ways can improve value by using VM (Value management guidelines-Australia,2005).

1- providing required project functions with lower cost

2- providing additional functions without cost increase

3- providing additional functions in a same time to lower the cost

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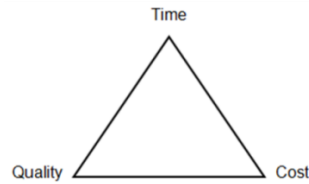
Figure 1: Relationship between Time, Cost & Quality (Norton, McElligott, 1995)

2.6 The Benefits of VM

Table 1 illustrates some benefits and advantages of VM study that are divided in two types consist of "financial benefits" and "unquantifiable benefits" (Norton, McElligott, 1995) and (Locke, 1994).

Table 1: Some Benefits and Advantages of VM Study (Locke, 1994)

Financial benefits of VM
- Obtain maximum efficiency - create a clearer focus on the project objectives - work towards arriving at a more effective design - Identify the alternative methods of construction and favorable adjustments to the construction timeline - Discovery and discussion of project issues, constraints and risks involved - Access clearer project brief and decision making - Identify and remove unnecessary costs associated with the project - Deal with lifecycle costs also, not only initial project cost and provides an authoritative review of the project in its totality and not just a few elements. - Consider all options, alternatives and innovative ideas for a project - Identify possible problems early on in the pre stages of the project - Provide management with authoritative evaluations and supporting information of the project brief or design and their related capital and operation costs
Unquantifiable (secondary) benefits of VM
- VM provides the structure for the project's team to collaborate and gain the benefits of partnering - Improve team and client relationships and boost morale of the team - Give clear definition of roles and responsibilities - Provide higher efficiency via the multidisciplinary and multitask teamwork - Provide joint ownership of solutions and commitment to implementation - Enhance client involvement during the development stages of the project

2.7 Value Management Process (Job Plan)

There are various techniques and phases to obtain an effective VM study implement. Kaufman (1998) stated that these stages are as a job plan which is a well-organized

approach including sequenced stages that help the VM team to answer questions and resolve the project's problems and challenges.

One of the main characteristics of VM is that an approved job plan must be followed. Figure 2 shows the common stages and process that would be followed in a typical VM study. Generally, main seven stages or phases are common in all VM studies which are stated in following.
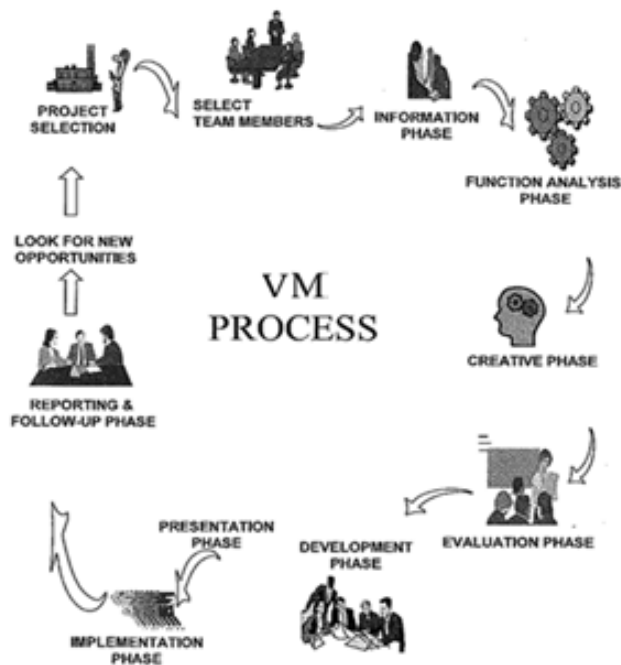
Figure 2: Common Stages and Process of a Typical VM Study (Kaufman, 1998)

2.7.1 Pre-Study (Orientation) Phase

The main aim of Pre-study phase is to make sure that the study is done and is targeted, correctly. Based on Norton (1995), this phase is including some activities such as bellow:

- Coordinating the meeting
- Settling the structure of team
- Determining the study duration

-   Determining location and conditions of the study

-   Gathering Information and data

-   Estimating investment cost and also life cycle cost

2.7.2 Information Phase

Getting a great understanding about all aspects of the project by VM team's members to extend their views of the project's objectives is the main goal of this phase. As Ellis (2004) stated that, a significant part of this phase is answering these questions: 'what does it do?' and 'what else does it do? '. In order to answer above questions, there are several techniques such as FAST diagram. Therefore the information phase can be categorized into two main activities, "Function analysis" and "Presentations" (Armstrong, 1992).

A brief description of the project and its objectives, specifications of the design plan will be presented by design team in this phase. Moreover, Current design is described in the presentation stage of this phase. Designer team should describe and provide a reasoning and background with details for VM team. After the presentations, the reviewing of drawings and other documentation must be done by VM team in this phase (Ellis, Keel, Wood, 2004).

Ranking, identifying and analyzing primary and secondary functions and their associated cost and worth relationship are also done in this phase. The aim of putting the function analysis stage in this phase is to improve the level of understanding about the project objective(s) through function analysis process. To perform this stage, one important tool that commonly used is drawing FAST chart of project's functions.

2.7.3 Creativity Phase

"Providing opportunity for all team members to suggest their idea about beneficial changes is the most important aim of creativity phase" (Thomas, 2005). In this phase team members are encouraged to utilize creative thinking techniques such as brainstorming to find innovative solutions. Brainstorming is the positive method of this phase that it provides a great productivity based on the group and team work.

Moreover, optimistic environment is required in this phase to persuade people for thinking about other ideas; it leads to eliminating the negative thoughts and improve decisions. Suggesting possible new ideas and improving old ideas that it seems they are initially unbelievable but are worthy in depth are occurred in this phase.

VM facilitator is a basic role in this Phase. The role of leader or facilitator of team is to provide a good environment for team to be familiar with analytical thinking modes (Whyte, Cammarano, 2012).

2.7.4 Evaluation Phase

In this phase, VM team will assess all alternatives to select best one in terms of improving the project's value (Stewart, 2010). The team members should evaluate ideas objectively and must consider both advantages and disadvantages of each idea and should not accept an idea very soon. The main parts of evaluation phase are including Procedure, Criteria of Evaluation, and Evaluation techniques (Value management guidelines-Australia,2005).

-**Procedure:** In this part, normally there are many different practices that can be done with flexible rules and methods. In a typically recognized method, the facilitators

assess each idea and then call the idea inventors to clarify the reasons behind the suggested idea.

After that an evaluating technique is used to eliminate unreasonable ideas and hold the other ones that could be valuable for the project. Before the evaluating ideas, criteria evaluation must be applied and chosen.

-**Criteria of Evaluation:** Criteria evaluation depends on each project and its type must be chosen. According to (Norton, McElligott, 1995), the usual, practical and technical criteria that can be chosen are as following:

> **Cost:** for example savings potential such as initial capital cost savings, the cost of maintenance, operating costs etc.
>
> **Function:** for example aesthetics, safety and security, expansion possibilities of future, safety of occupancy and etc.
>
> **Time:** for example the required time to finish design or construction program (Stewart, 2010).
>
> **General:** for example the flexibility, safety matters, political issues and jurisdictional factors.

-**Evaluation Techniques:** There are many evaluation techniques to evaluate alternative ideas in terms of criteria; each technique has some advantages and weaknesses that among them common one is the evaluation metrics that is described at the end of this chapter (Thomas, 2005).

2.7.5 Development Phase

Selecting the accepted ideas for more development to access the technical and economic feasibility is done in this phase of VM process. Proposals descriptions must be detailed and backup data should support them because all decision makers must understand proposals descriptions correctly (Kelly, Male, 1993).

Norton (1995) stated that the normal contents of a proposal are as bellow:

- Original design description

- Design of proposed alternative description

- Proposal advantages and benefits

- Proposal disadvantages and limitations.

- Discussion on proposal topic and content

- Implications of life cycle cost

- Technical backup supports

2.7.6 Presentation Phase

The main purpose of this phase is providing a proposal with a good presentation that is understandable for all VM team members. All drawings, calculations and costs that are offered by the VM team to support proposed ideas are presented at this phase. To raise the quality of presentation phase; The VM members must learn the skills of presentation before starting this phase. Furthermore, Using visual tools such as graphs and picture are helpful to access a clear view of the developed idea (Graham, Gronqvist, Kelly, 2006).

2.7.7 Post-Study (Feedback) Phase

In fact after completing the physical VM workshop, this process is not yet completed. In order to achieve maximum benefits of the VM practice, post-study

activities must be carried out at the end of VM process. The post-study activities guarantee the feasibility and advantages of selected proposals and which can enhance value of project. Generally the post study phase is divided into three stages:

1- Preparing reports and reviewing stage

2- Implementing stage

3- Surveying stage

After finishing the VM study, facilitator make a report about all steps of the process and the results obtained from VM study. This will be the initial report that consists of some information such as executive summary and a brief of the proposals. In addition, a final report of VM is gathered giving the character and specifications of the proposals and lessons that learned during the VM workshops, this report will be made in "preparing reports and reviewing stage" (Value management guidelines-Australia,2005).

In the implementation stage, a program must be planned by the project manager or another representative of other parts of projects to overcome the difficulties and limitations of project against executing accepted alternatives.

Moreover, considering all the proposals and ideas that still left open after the implementation phase and investigating on the ways of VM workshops improvement must be done in surveying phase (Graham, Gronqvist, Kelly, 2006).

2.8 VM Workshops

All phases of VM study should be done during the several workshops. Always the total VM study may take three to six weeks and need to at least 4 or 6 workshops to complete. Arranging the time table of each workshop is the key part of each VM

study. The VM workshops provide the chance to bring together the key stakeholders in a meeting which:

- Increases the contribution all parts of a project

- All decisions and discussions are taken based on brainstorming method

- Considers combined knowledge of people from a variety of field

- Takes advantage of group dynamics, rather than relying on input from individuals in isolation

- Considers to the project as a whole, rather than as a series of independent elements.

- Relies on creativity thinking

Always an appropriate numbers of participants in VM workshops are at least 5 people including one representative of stakeholder, VM and design consultants and sometimes contractor Corporation. In addition, the VM process and related activities must be facilitated and guided by proper facilitator in each workshop (Kelly,2007).

2.9 VM Facilitator

In order to pursue the best value–goal through the VM process, the VM facilitator and also a suitable guidance plays an important role in keeping the whole team and participants on path to specify and discuss the project objectives in the team. An experienced, skilled, and professional VM facilitator is a key part of a VM workshop.

There are two types of VM facilitator including "internal" or "external" person. The facilitator needs an in-depth knowledge of function analysis and skills of group and team building and managing.

They need a lot of skills, knowledge such as excellent communication skills, good listening ability and Strong leadership abilities to arrange stakeholders and experts with often widely different backgrounds, purposes and interests (AS 4183, 2007).

2.10 VM standards and instructions

Regarding the importance of VM field in management area, many relevant standards and instructions have been published to guide designers and engineers how the VM study can be carry out for a project. Some VM standards and guidelines are listed in bellow; they are all typically upon the methodology proposed by SAVE International guidelines (2007).

1- SAVE International, 2007

2- Value management, guidelines, august 2005, Department of Housing and Works Government of Western Australia

3- Australian Standard for Value Management AS 4183 -2007.

4- VM Manual, EPU, 2011

5- BRE Value Management Standard BRE (2000)

6- Management and Planning Organization of the drawer (2000)

7- Guidelines set value engineering studies2006

8- Value Management in Construction: A Client's Guide, CIRIA Special Publication 129.

9- Guidelines of Iranian value society (2001)

10- The Role of the Facilitator in Value Management (2002)

11- British/European VM Value Standard BS/EN 12973:2009

12- UK Department of Trade and Industry Value Management Guide

13- The Value Management Benchmark Male et al (1998a).

14- Value management handbook published by European commission

Directorate-GeneralXIII Telecommunications (1995).

2.11 VM Methods and Tools

Several methods and techniques can be applied during VM process according to the specifications and conditions of the project.

Furthermore, Study team members and organization's skills and knowledge are other criteria to select and then use these tools during VM study. The size, cost and time of the project and also the training background of the VM members, and the potential and facilities of the stakeholders are the important factors to select the proper procedure and tools for a VM process.

Table 2 shows some methods and techniques can be used in the VM study. It must be considered, there are not specific standard or unique tools to be used in VM process.

The various innovative techniques can be created and designed by the VM team based on specifications of the project to evaluate the new ideas and alternatives which among them, "Brainstorming" ,"function analysis(FAST)", "Life cycle cost analysis" and "Evaluation matrix "are most important techniques that are always used in VM process. These techniques are described in following (Directorate-GeneralXIII, 1995), (AS/NZS 4183,1994), (*BS EN 12973*,2009) and (SAVE, 2007).

Table 2: Common Methods of VM Process -(Directorate-GeneralXIII, 1995), (AS/NZS 4183,1994), (BS EN 12973,2009) and (SAVE, 2007)

Methods	Prominent feature
function analysis	Determining the function and objectives of project, each idea or alternative and then discussing about them among team
FAST chart	
life cycle cost analysis	Estimating all costs over life cycle of the project and then evaluating the new alternatives based on this lifecycle cost
Brainstorming	Rely on creativity thinking, Group activity, Group discussion, decision making based on group's idea
Synaptic technique	
Hierarchy diagram	Breaking down a project to sub parts and elements to focus them in detail
Value index	calculating value index based on cost and value of the project
advantages/ disadvantages method	Using advantages disadvantages method to evaluate each idea and also the project.
Risk Analysis	Determining the risks, threats and hazards of each alternative to evaluate them.
Simple multi-attribute rating technique (SMART)	Determining some simple explanation of the project to discuss about it to evaluate the project or each alternative
Time, cost and quality triangle	Evaluating a project's time, cost and quality
Stakeholder analysis	Determining the needs of stakeholder to evaluate project.
Issues Generation & Analysis	Defining main issues related to project to evaluate each alternative.
SWOT analysis	Review of alternative materials 'strengths, weaknesses, opportunities and threats'(SWOT).These specify the objectives of the project and identify all internal and external factors that will either be favorable or unfavorable in a project.
Assessment metrics	using special matrix such as weighted matrix and environment assessment matrix to score each alternative
Lever of value	Evaluating project based on dividing project in several value levels
cost estimation	Estimating the total investment cost each alternative
Spatial adjacency programming	Evaluating project through especial programs and computer algorithm based on knowledge system
Logical Framework	
Cost-Benefit analysis (B/C)	systematic approach in comparing the quantifiable benefits and costs for a particular project or indeed the overall value of the contributory components or sub-components

2.11.1 Function Analysis

Function analysis is a mutual language and method, crossing all skills and technologies used in the VM process. It allows multi-disciplined members of VM team to contribute equally in VM workshops and connect with each other thorough addressing the problem objectively, without bias or fixed conclusions (Celik, 2010).

According to Kelly (1993), defining functions of a project has four steps:

1- **Task:** It is the first stage those stakeholder remarks problems.

2- **Space:** A brief of the project is prepared by brain storming method.

3- **Elements:** Structural form for function building is assumed in this stage.

4- **Point:** An identity is determined for each element based on built form.

Then Functions are classified in to level including basic or secondary; this step is a difficult and subjective work. After defining all functions, the cost of each function must be calculated.

FAST diagram is another technique which is used widely in the VM studies to analysis the functions. This method breaks a problem down into smaller   to find all possible solution ways (Norton, McElligott, 1995).

In order to achieve the FAST chart's purpose, the VM team should ask consequently several questions started with "how", "why" and "when" through brainstorming method, while drawing FAST chart. Finding the proper answers for those questions helps to VM team to find the place of each project's function in the FAST chart. The figure 3 illustrates a sample of FAST chart (Celik, 2010).The common types of all functions such as dependent function, supporting or secondary function and basic or higher function are also illustrated in this figure (Norton, 1995).
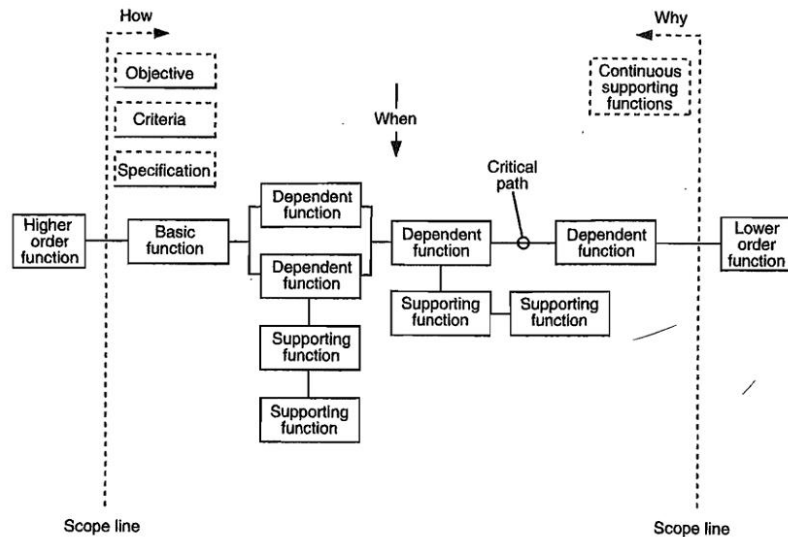
Figure 3: A sample of fast diagram (Celik, 2010)

2.11.2 Brain Storming

Brainstorming is the most popular method that is used in all stages and phases of VM studies, especially to create new ideas in the creativity phase. Brainstorming is a group or individual creativity method by which tries to find a conclusion and answer for a problem or question by gathering a series of ideas naturally contributed by the members of the VM team (Value Management Guidelines, 2005).

This technique of VM study is based on group work. The VM team as a group assesses a project's function and then gives its suggestions and comments. Every suggestion in simple or complicated format is recorded; in fact, any idea that comes to mind is recorded. Brainstorming method is including several rules which the important ones are (Kelly, 2007):

Rule 1: Postponing and withholding the judgment of ideas.

Rule 2: Encouraging the group to suggest wild and exaggerated ideas.

Rule 3: Quantity counts not quality

Rule 4: Shape of the ideas put forward by others

Rule 5: Every member of the group and every idea have equal worth

Using rules involved the brainstorming eliminates inhibitions and helps people to be able to think more generously and freely. So finally it leads to the creation of new ideas and solutions. According brain storming method, the participants define ideas as they occur to them and then the shape of the ideas improved and rose by others. All ideas firstly are recorded and are not assessed; only after brainstorming session is done, the ideas are evaluated. Totally the brainstorming technique has several benefits and applications for VM process, the most ones are (Department of Housing and Works, 2005):

- Solve the problem types

- Solve problems on a purely linguistic level

- Formulate objectives and

- Set out as an introduction to a topic, the field of possible solutions

2.11.3 Life Cycle Cost Analysis (LCCA)

Life Cycle Cost Analyzing (LCCA) is an exact method in evaluating the design alternatives economically with different investment, operating costs, maintenance costs and different life spans.

Particularly, LCCA method is applied when a project needs high initial investment costs to identify if the project is economically feasible. There are two reasons to apply LCCA process in construction projects that one reason is to compare different systems or alternatives and the second reason is to determine the most cost-effective plan, system and equipment (Cloete, 2008).

Life Cycle Costs (LCC) are all costs related directly with construction and operation, maintenance and disposal phase (whole cost from starting construction to demolishing a project).

Typically, two main cost categories of projects should be evaluated in a LCC method including initial expenses and future expenses. All costs incurred prior to occupation of the facility are initial expenses and all those that gained or paid over the project are called future costs (Cloete, 2008).

The quantity of LCC is equal the sum of the present values (PV) of the total costs over project's life cycle including investment and capital costs, indirect costs of insurance and taxes, installation and construction costs, energy costs, salvage costs, maintenance costs, operation costs and demolition costs, as expressed in equation 2. By present worth method, all present and future costs are converted to a single point in the equal time that is typically at around the time of investment, so time value of money must be considered by discounting the outflows and future inflows to their present values. The relationship between interest rate and time is called the time value of money (Celik, 2010).

Equation 2:

LCC=PV [Investment Cost s+ Energy Costs+ Operation and Maintenance costs+ Replacement costs + Salvage and demolition costs+ Associated costs (Taxes, Transportation Costs and etc.)]

2.11.3.1 Important Economic Factors in LCCA

In order to analysis the LCC of the project various factors should be considered which the most important ones are described in following.

- Life Cycle period: The analysis period is the longest time which the life cycle cost should be evaluated over it. In other words, the analysis period is the number of years that the total cost of ownership will be determined for the various design alternatives. This time usually starts with the beginning of the implementation phase of the project (pre study phase) and lasts until the end of demolition phase (Fuller, 2005).

- Initial investment Costs: The first step in the LCCA process is to define all the initial investment costs of each alternative. Initial or capital investment costs are costs that will be incurred before to the occupation of the facility.

- Cash flows: Cash flow is a prediction of current financial situation of a project for wanted dates. In other words, cash flow consists of gained money from sale and money that is paid monthly during the life cycle of a project. Cash flow includes inflows and outflows. A cash inflow means that cash is going into a corporation, and a cash outflow is the costs that are going out of that corporation (Cloete, 2008).

- Interest rate: The interest rate is the percent paid for the use of money. In fact interest rate is the time value of money. For making time-equivalent of cash flows, the Life cycle cost method used interest rate factor. Interest rate represents the saver's minimum satisfactory rate of return (Fuller, 2005).

-Present value: Present value (PV) or Present worth (PW) is the value of the sum of money at the present time that, with compound interest, will have a specified value at a certain time in the future. PV analysis provides factors to determine the equivalent, or present value of a single payment to be expended or received at some point in the future considering the time value of money through especial calculations as shown in

equation 3. The advantage of PV calculation is that the effects of inflation that are considered through these calculations (Fuller, 2005).

Equation 3:

$$PV = \frac{FV}{(1 + d)^n}$$

Where:

PV is the present value;

FV is the value in the future;

d is discount rate or interest rate; and

n is the number of years.

2.11.4 Evaluation matrix

Evaluation Matrix is the other common and popular technique which is widely used in the VM studies. This method consists of non-monetary benefits can be important to the decision makers. Alternatives can be evaluated by the weighting evaluation method.

This method consists of four steps including determining criteria, weighting the criteria, evaluating the design alternatives according to criteria, rankıng and selecting the alternatives. This technique is a creativity method so it should be done in brain storming process.

All criteria to evaluate new ideas are chosen based on the objectives and specifications of the project, for example the most popular criteria for construction projects are aesthetics, color rendition, environmental sustainability, obsolescence avoidance, operational effectiveness, durability and future extendibility.

In this method, each pair of criteria is compared together, and the stronger of them is scored to infer that how important each of them. Then each alternative is rated based on a defined scale (e.g. in figure 4, the scale is 1 to 5) to be identified to what extend it provides each benefit (Celik, 2010).
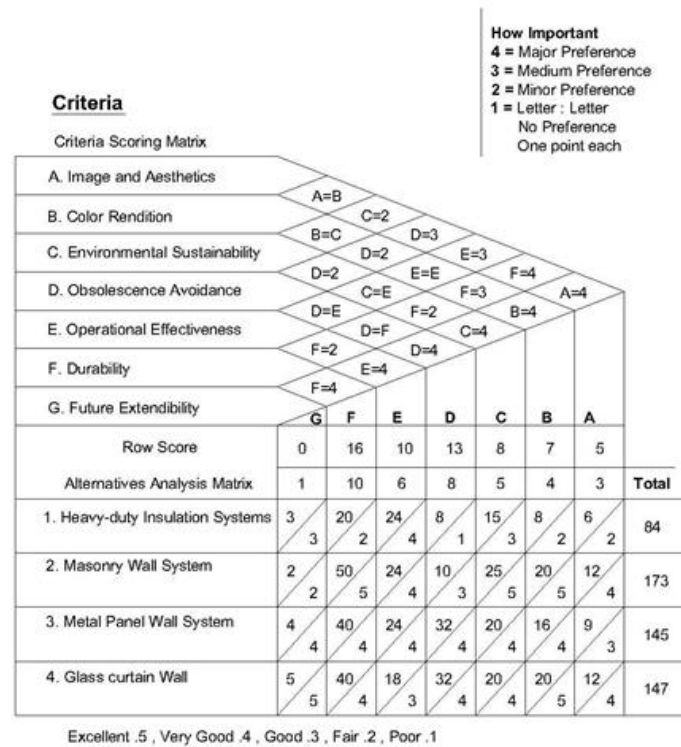
Figure 4: A Sample of Evaluation Matrix

2.12 VM Process Improvement

In construction projects, the poor quality of information and lack of enough familiarity with VM process always are main barriers against VM study and that influence the decisions that are made negatively.

There are innovative problem solving tools can be used to enhance the efficiency of the VM study. Regarding the application and benefits of some particular software worked based on Knowledge Management systems such as Expert Systems, it seems

they would be a worthy and applicable way to eliminate some problem with VM study such as managing knowledge and providing required information and guidance and also specific trainings for unskilled person.

Hence, next chapter discusses on Expert Systems to reveal that developing an Expert System for a VM process to what extent can be effective and beneficially to improve VM study particularly for unskilled and inexperienced people in this field (Yazdanpanah, 2010).

Chapter 3

EXPERT SYSTEM

3.1 Introduction

Expert System as a subset of artificial intelligence has been more considered recently. In artificial intelligence area, a computer system that simulates the decision-making capability of people who are expert is called an Expert System (Hayes-Roth, 1983). In fact the first truly successful forms of the artificial intelligence software were Expert Systems. In the 1970s, the Expert Systems for first time were generated and then developed since 1980s. The purpose of Expert Systems is to solve difficult and complex problems by available knowledge. Indeed, Expert Systems seek to solve those real problems which generally require the human expertise.

Some Expert Systems are planned to take the human experts' place, while others are created to aid unskilled people (Yazdanpanah,2010).

Regarding to the main aims of this study is developing value management by an Expert System, in this chapter the back ground of the Expert Systems, related definitions, explanations, types, advantages and applications of the Expert Systems will be described. Furthermore, the Expert Systems' effectiveness on Construction Industry will be discussed in this chapter.

3.2 Back Ground of Expert System

Hayes-Roth stated that the main aim of first Expert Systems to be that intelligent systems are based on knowledge they have rather than from the particular inference schemes. Until then, researcher had focused on developing problem solvers such as pre software (Hayes-Roth, 1983).

Edward Feigenbaum who is referred to as the "Expert Systems' father "for first time introduced the Expert Systems through Stanford Heuristic Programming Project. In that program, the Stanford researchers identified domains where expertise was extremely valued and complex. Expert Systems were the first successful types of Artificial intelligence software. For first time the studies of the US focused on rule-based systems, systems hard coded and Expert System shells development (which were easier for non-programmers to use).

Since 1980s when the first Personal Computer was introduced with the MS-DOS operating system, the Expert Systems increasingly developed and many companies applied the Expert Systems in daily business activities. The figure 5 indicates the development trend of Expert Systems during 1940 to 1990, schematically (Motameni, 2010).

Since 1990s, after identifying the many applications of Expert Systems in solving complex problems and managing the knowledge in all parts of industries, Expert Systems has been developed and considered more by all industries and businesses (Arockiasamy, 1993).
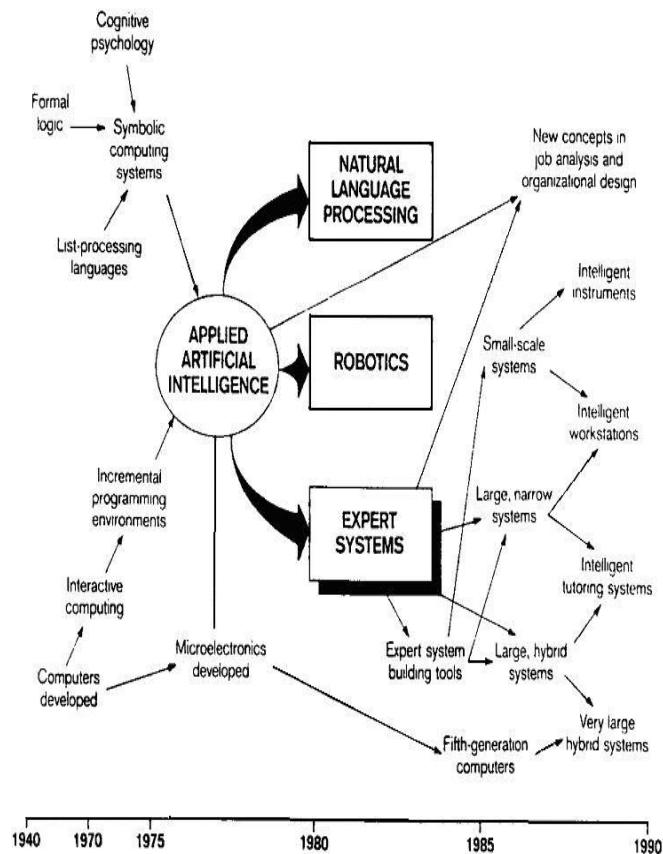
Figure 5: Development Trend of Expert Systems, 1940 - 1990 (Motameni, 2010)

3.3 Expert System Definition

Expert Systems are part of a common category of computer applications that are known as artificial intelligence. Indeed, they are a computer application with specific objective that can be designed by human experts to transfer their knowledge to other humans who need to those skills. This means, the Expert Systems are a sample of the knowledge-based system for instant the Expert Systems are appropriate for the range of architectural design and construction method; it can solve architectural problems which require specific experiences and knowledge (Motameni, 2010).

In order to design an Expert System, knowledge engineers are required; they study how a human expert make decisions and translates the rules into terms that

a computer can understand. Common developed Expert Systems have been made up

tree portions, figure 6 and table 3 shows these parts (Arockiasamy, 1993).

Table 3: Tree Maine Parts of an Expert system (Motameni, 2010)

Main parts of Expert Systems	Specification
User interface	This is the system that allows a non-expert user to query (question) the Expert System, and to receive advice. The user-interface is designed to be a simple to use as possible.
Knowledge base	This is a collection of facts and rules. The knowledge base is created from information provided by human experts
Inference engine	This acts rather like a search engine, examining the knowledge base for information that matches the user's query. Inference engines can also include explanation and debugging capabilities.
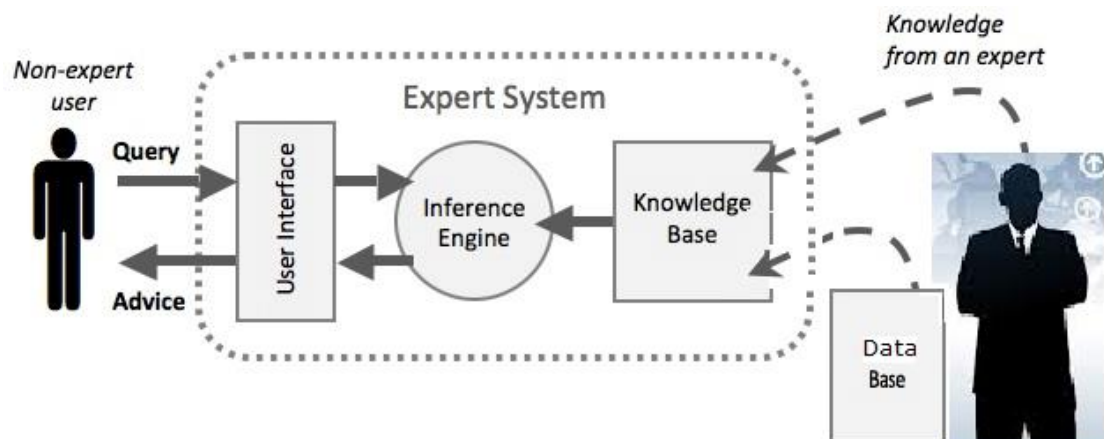
Figure 6: Tree Portions of an Expert system (Arockiasamy, 1993)

3.3.1 The User Interface

User interface is an important section of an Expert system. The system will not be

very effective and useful, if Expert Systems don't have an effective user interface.

Indeed, the user interface looks as a connection bridge between user and Expert

Systems problem-solving process. User interface has specific questions to ask from

users and accepts their proper answers. Then the answers are translated to the known

and clear answers to machine language. After that, next questions will be asked based

on pervious answers. Moreover the user interface must be able to translate the generated answers to an understandable format for the unskilled users (Motameni, 2010).

3.3.2 The Knowledge Base

The knowledge base is a place for storing the facts, knowledge and rules connected with the specific problems; the inference engine refers to this base sources to find best suggestion and recommendations (Arockiasamy , 1993). These facts can be generated in the system. Usual rules and relevant standards are recommended by domain expert to solve a type of problems. (Motameni, 2010).

3.3.3 The Inference Engine or Shell

The inference engine is an automated mental system that assesses the current situation of the knowledge-base, applies relevant rules, and then supports new knowledge into the knowledge base. The inference engine can explain to a user the series or chain of the reasoning utilized to reach a particular conclusion based on several related rules (Hayes-Roth, 1983). An inference engine has primarily two modes including "forward chaining" and "backward chaining". The different methods are dictated that are depends on that the inference engine is driven by the antecedent (left side) or the consequent (right side) of the rule. For example, following rule is a simple example of forward chaining:

R1: Man(x) => Mortal(x)

In this case, R1 is matched and supports Mortal into the knowledge base. The system looks at possible conclusions in backward chaining; in this case the system works backward to understand if they might be true. So for above example if the system wanted determine Mortal is true; it would discover R1 and request the knowledge base to see if Man is true.

One of the early applications of Expert Systems shells was to incorporate inference engines with the user interface; this could be particularly influential with backward chaining. If the system wants to know a specific fact, it can simply create an input screen and ask the user when the information is recognized. The Expert Systems developed many new techniques were combined with several types of inference engines as it can be seen in table 4 (Berners-Lee, Hendler, Lassila, 2001).

Table 4: Types of Inference Engines of Expert Systems
(Berners-Lee, Hendler, Lassila, 2001).

types of inference engines	Specification
Truth Maintenance systems	The dependencies are recorded in a knowledge base so that when facts are altered dependent knowledge can be altered accordingly
Hypothetical Reasoning systems	The knowledge base can be divided up into many possible views, aka worlds. This allows the inference engine to explore multiple possibilities in parallel
Ontology Classification	These types of special purpose inference engines are known as classifiers. Although they were not highly used in Expert Systems classifiers are very powerful for unstructured volatile domains and are a key technology for the Internet and the emerging semantic web

3.4 Forward and Backward Chaining

Backward and forward chaining attitudes are two reasoning attitudes to be used for analyzed rules. Forward chaining attitude begins with the available documents and uses the analyzed rules to create more and valid data till an anticipated goal is gained. An inference engine which works with forward chaining, explores the analyzed rules until it finds right one. Then it concludes and adds this gathered information to its data. It should follow this way until a goal is gained. Because the data defines which analyzed rules are used, this method is known as "data driven".

Backward chaining begins with a list of objectives and works backwards to find out if there is any information that will allow concluding any of these objectives. An inference engine using backward chaining would explore the analyzed rules until it finds one that matches a desired objective (Hayes-Roth, 1983).

3.5 Individuals Involved in Expert Systems

Four individuals associate with the Expert Systems development process (Momeni, 2010):

- End-user

- Problem domain expert

- System engineer

- Knowledge engineer

The relation between this part and their role are illustrated in figure 7.
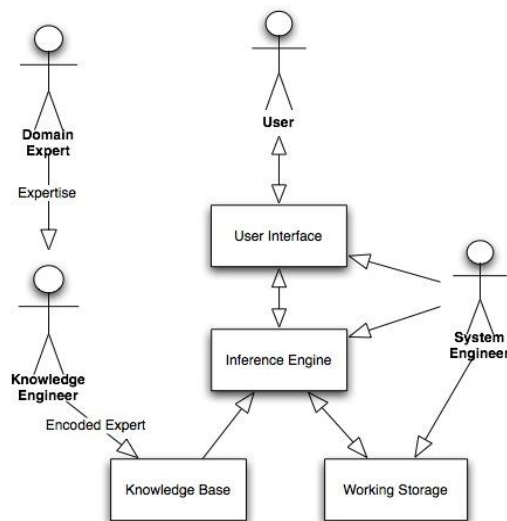
Figure 7: Individuals Involved in Expert Systems (Momeni, 2010)

3.6 Knowledge in the Expert System

The knowledge engineer must encode the collected data to a common language that is readable by Expert System. Then this basic data will be accessible to software to make decision and solve problems.

The knowledge representation method is based on the problems' characteristics and nature. Different ways exist to implement and present knowledge for the software such as rules creation. These rules include action parts. By production rules usage, the knowledge is able to be used in the manageable sections. Managing and arranging a complicated knowledge base including more than hundreds of rules seems to be too difficult. Dependent links usage in this condition might make an easy organization accomplishing and rules visualization (Berners-Lee , Hendler, Lassila, 2001).

While the user stores the software parts by the facts, the inference engine explores in the rule base to find the circumstances which can be satisfied. The rules will be performed after all of them are matched, then the result can be illustrated. Inference engine shows which question must be answered and how the facts can be entered.

Rules with various values are combined in knowledge base, and then the results are presented based on these rules. So it is not necessary to prepare a comprehensive set of data for decision making process (Hayes-Roth, 1983).

3.7 Decision Making Process in Expert System

Reviewing ability is a main feature of Expert Systems. They are able to clarify conclusion and demonstrate how it was gained. The reconsideration of the result

route is printable and it can be analyzed as a record of the cerebral process which is used by the domain expert (Momeni, 2010).

3.8 Developing an Expert System

The Expert System's power is resulted from the expert's knowledge. There are available procedures that are able to be followed to develop Expert Systems, although firm adherence to these procedures is not essentially a requirement for a successful development struggle (Berners-Lee, Hendler, Lassila, 2001).

Development method must be adopted according to thinking and problem part. The process of an Expert System program development is divided into three parts which are (Momeni, 2010):

- Picking a problem
- Gathering knowledge and representation
- Assessment and adoption.

3.9 Picking the Problem

Recognizing the problem is a serious step in an Expert System development (Durkin, 1993).The subject is verified before beginning to improve Expert System. If the subject needs knowledge and human expertise, this subject is proper for developing an Expert System (Momeni, 2010).

3.10 Gathering Knowledge and Representation

In this part the knowledge which is used to solve the problem must be learnt and presented in a reasonable format; this data is added to the knowledge base of system. Representing and gathering knowledge is done by domain experts (Momeni, 2010).

There are many negotiations in the literature on the withdrawal of knowledge from domain experts. Most developers of the Expert System advise a knowledge engineer (a person who is qualified in the extraction of data from experts) who extracts the knowledge and designs the Expert System. Sometimes, a knowledge engineer is desirable to 'tease apart' extremely compiled expert knowledge since the expert is so familiar with that part to break it into its reasonable components. There is also available software to support the self-knowledge engineering (Berners-Lee, Hendler, Lassila, 2001).

3.11 Expert System Applications

According to Hayes-Roth, the applications of Expert Systems are divided into ten categories that are shown in the table 5. It should be noticed that some cases might have specifications of more than one category.

Table 5: Ten Categories of the Applications of Expert Systems (Hayes-Roth, 1983)

row	Category	Problem Addressed	Examples
1	Interpretation	Inferring situation descriptions from sensor data	Hearsay (Speech Recognition), PROSPECTOR
2	Prediction	Inferring likely consequences of given situations	Pretirm Birth Risk Assessment
3	Diagnosis	Inferring system malfunctions from observables	CADUCEUS, MYCIN, PUFF
4	Design	Configuring objects under constraints	Dendral, Mortgage Loan Advisor, R1 (Dec Vax Configuration)
5	Planning	Designing actions	Mission Planning for Autonomous Underwater Vehicle
6	Monitoring	Comparing observations to plan vulnerabilities	REACTOR
7	Debugging	Providing incremental solutions for complex problems	SAINT, MATHLAB, MACSYMA
8	Repair	Executing a plan to administer a prescribed remedy	Toxic Spill Crisis Management
9	Instruction	Diagnosing, assessing, and repairing student behavior	SMH.PAL, Intelligent Clinical Training, STEAMER
10	Control	Interpreting, predicting, repairing, and monitoring system behaviors	Real Time Process Control, Space Shuttle Mission Control

3.12 Advantages and Disadvantages of Expert Systems

The main advantages and disadvantages of Expert Systems are as following (Momeni, 2010) and (Berners-Lee, Hendler, Lassila, 2001).

Advantages:

- Encouraging organizations to explain the reasons of their decision-making
- Not forgetting the information
- Asking the questions, that a human may forget to ask
- Having the ability to work continuously
- Having the ability to be used frequently by the user
- More than one user at a time can serve multi-user Expert System.
- Providing answers for repetitive decisions, tasks and processes.
- Reducing the costs of employee training
- Centralizing the decision making procedure.
- Reducing the required time.
- Combining multiple experts
- Reducing human errors.

Disadvantages:

- Not having some ability to give the creative answers, as human experts can generate in uncommon conditions.
- There are some challenges in automating complex processes.
- The lack of enough ability and flexibility to be adapt against the changes of environment.
- Not having the ability to generate a creative answer when there is not available answer.

3.13 Expert Systems in Construction projects

In several energy situation, human experts my not be readily or easily accessible, so using expert systems to make expertise and knowledge available as a domain expert can be appropriate solution. Construction projects provide a suitable opportunity to use the applications of expert systems to solve common problems because (Momeni, 2010)

1- Due to the internal factors including methods and external effects such as economic conditions, construction industry has an uncertain and unforeseeable environment that makes the construction and project process to be forecasted hardly.

2- Sometimes the construction and project management methods are different in each project, and each construction project might have unique specifications. Many factors related to construction methods consist of design, time, cost and management can be changed in construction projects.

3- The project managers have to make quick and correct decisions about all aspects of the projects. Always managers do not have enough time to think about the project's problems and find the best solutions but they have to make immediately appropriate decisions, so in this situation, Expert Systems can find quick and reliable solution.

4- In construction industry, transferring the skills of experienced managers to those one who are not professional in those skills is an essential need. Expert System programs collect the knowledge and expertise to make them available for persons

who are not familiar with that knowledge as much as required. Totally, by using and developing Expert Systems in construction (Berners-Lee, Hendler, Lassila, 2001):

1- Always planning and design time is reduced

2- The communication between the participants and engineers is improved on a project.

3- Manual Errors during the project would be eliminated.

4- Rework can be reduced.

5- The feasibility of project can be evaluated and also cost and time would be assessed

6- Enhancing the automation in construction projects

7- Knowledge definition in all parts including management, planning, design, and construction would be improved.

8- Coordination among all aspects and phases of the projects would be improved.

3.14 Expert Systems in Management Field

Nowadays, in spite of modern tools and methods that have been applied in management field, still many developing countries are not familiar with basic parts of management, and face with lots of problems to understand or use them. Researcher's studies expose that the main problem in managing the projects results from lack of pay attention to executive process, documentations and knowledge management (Yazdanpanah, 2010).

Regarding the extensive competition among the construction industry, knowledge within an organization is an important issue. Managers of big construction projects

are completely aware of the above mentioned fact, so they try to consider the management systems that are based on knowledge and their powerful tools such as Expert Systems.

Hence, the Expert Systems have high potential in management area especially in construction project management.

In project management field, the Expert Systems always have been developed for decision-making, planning, project controlling, scheduling, risk modeling, monitoring, and technical advising and cost analyzing, however based on the literature review that was done in this research, an Expert System has not been developed to cover all common phases of VM study yet. Different methods and techniques are used in VM study that would be why there is not integrated VM software.

Some of famous Expert Systems models of construction management and their details are mentioned in table 6 (Yazdanpanah,2010).

Table 6:Expert Systems Models Samples of Construction Management
(Yazdanpanah,2010)

Expert System	Year	Presenter team	Concluding method	System purposes	Characteristics of System
MASON	1987	Hendrickson & Martinelli	Based on Back ward chain	Estimation of constructing activities	Knowledge accomplishment through experienced experts Knowledge engineering using foremen as source Using backward chain method
RETAIN	1994	Adams, Hendrickson, & Chrisiano	Based on backward chain	Recognizing retaining wall construction methods	Combining construction knowledge and tubular database(table in formation of price)
(Planex)	1987	ChrisHendrickson,arlos Zozaya – Gorostiza,Daniel Rehak,EduardoBaracco-Mille,Peter Lim	Based on rule	Defining activities and relations between them and estimations	- Prototype model (Hasn't been operated)- Combining usage of rule based Expert System and Planning Process- Utilizing heredity in knowledge modeling- Using Expert System as Interpreter Post Processor
CONSAS	1988	M. L. Gilmore ,Illinois University &American Army	Based on frame	Scheduling program analysis	Combining Expert System, databases and PMIS
ESSCAD	2002	WANG ShouQing	Based on rule	Exploring WBS from construction plan file	Using Expert System for analyzing another system output-in this case CAD output files-
CONBPS	2003	Joanna Poon, Keith Pottsand Peter Musgrove	Based on rule	Construction process improvements based on RIBA standard	Modeling Architectural Standards Using Production Rule

Chapter 4

DATA COLLECTION METHODS

4.1. Introduction

In order to achieve the research objectives, proper research method should be selected and performed. Research method selection of this study is based on previous studies review, available information resources and also common delimitations and limitations over this type of study.

Regarding the importance of research method, in this chapter after introduction, data collection methods used in this study are explained. The Research and data collection methods of this study are:

- Reviewing previous researches and studies

- Investigating available information resources

- Doing questionnaire survey among experts in this subject.

In this chapter, the particulars of previous VM studies of different projects and the related research literature are listed and utilised to revise the available information and data resources for this subject.Therefore the details of data collection methods including the details of available information checklist and designed questionnaire also explained. Furthermore, analysis the results gained from each method and a summary of whole gathered information are given in following. At the end of this chapter, based on all collected data, a proper VM process is suggested as a final

conclusion to be applied for construction projects that will be improved by developing its relevant Expert System in next chapter.

4.2 Selecting Data Collection Methods

The methods of collecting data allow researcher to gather systematically and beneficially the data which related to the research's objects. Generally, various research methods in terms of data collection are common, such as (Temple, Young, 2004):

   -Reviewing literatures that are related to the study's subject

   - Using available information of other experiences that are related to the study

   -Observing situations related with current study

   -Interviewing   with people who deal with study's subject

   -Carrying out the question survey

   - Group discussion   about study's subject with experts in relevant field

   -Studying a sample case.

In many cases, researchers prefer to use combined method in their study because each of common research methods have limitations and advantages in some aspects, so their combination may lead to improve the research's results.

According to (Sixsmith , Murray, 2001), in theoretical subjects and nor numerical ones such as management area, literature and available resources review and questionnaire survey are most appropriate and popular methods among researchers.

As all mentioned above, in this study, "literature review'' was done to achieve a clear familiarity with the VM study and Expert Systems characteristics and applications, then a combination of "available information resources investigation'' and

"questionnaire survey" methods were applied to collect useful data about VM process because these methods always are available and experimental.

The results obtained from the literature review are briefly explained in earlier chapters. In addition, in this chapter the "available information resources" and "question surveying" methods used in this study and relevant results will be described and discussed.

4.3 Using Available Information Resources

In general, in order to gathered data from available resources, the researcher must prepare a checklist about all required data to complete the research (Patton, 1990).

Hence in this study according to literature review that was done, the check list was made in four parts to collect required data about VM studies which were applied before for previous construction and infrastructure projects. The categorized parts of this checklist are illustrated in following table.

In this part, twenty eight construction projects all around the world were selected which have applied VM study. The available specifications and results of these studies were categorized according the check list mentioned in above to discuss them. The table 8 shows all selected projects with the specification and the details of their VM study.

Table 7: The Checklist Designed to Collect Available Information Resources

row	parts	The details
1	basic information	Name of project
		Country
		Project type
		Cost
		Project's time
2	VM process	Phase of the project that VM used
		Team Leader-management
		Workshop number
		Who are the team members and how many people are
		Methods and tools that used in VM process
		VM standards that were used
3	value management results	Cost saving (%)(after doing VM study)
		Time saving (%)(after doing VM study)
		Increasing quality (%)
		VM report types
4		References

Table 8:The specification and details of the VM study of selected projects

Row	1	2	3	4
Name of project	Administrative Center for Agricultural Research	2Malaysian public projects	Kansas City District Lewis and Clark Center Command & college, Ft. Leavenworth, KS	Louisville District Human Performance Wing Patterson AFB
Country	India	Malaysia	United state	United state
Project type	building	- Water system - road	building	Building
Cost ($)	152,000	50,000,000	150,000,000	208,000,000
Project's time	18 month	3 to 5 years	3years	2years
Phase that VM used	Design	- pre design - Design - construction	-pre study -design - construction	-pre study -design -construction
Facilitator	VM Consultant	VM Consultant	VM Consultant	VM Consultant
Numbers of workshop	15	20	15-20	20-30
Workshop's Participants	-Stakeholder -Consultant -10people	-Stakeholder -Consultant -6people	-Stakeholder -Consultant -Contractor -5t015people	-Stakeholder -Consultant -Contractor -5t015people
Methods and tools that used during VM process	-FAST chart analysis -life cycle cost analysis -weighted metrics	-Logical Framework -Analysis (LFA) -Cost-Benefit Analysis -VM Template -Cost estimation -Preliminary Detailed -Life cycle cost analysis	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics
VM standard	-SAVE International -Value Standard	-SAVE International Value Standard -VM Manual, EPU, 2011 -Australian Standard, Value Management AS 4183.	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard
Cost saving	5 %	23.53%	12%	26%
Time saving	0	20%	15%	32%
Increasing quality	10 %	–	–	–
VM report contents	-idea analyzing and assessing report -idea creation report	-decision making report -alternative analyzing	–	–
References	(Aini, J., 2012)	(Aini, J., 2012)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)

5	6	7	8	9
Savannah / Mobile Battalion / Brigade Headquarters	Sacramento District Groundwater Treatment Plant Hawthorne Army Depot, Nevada	Sacramento District General Instructional Building VI Presidio of Monterey, California	Walla Walla District Little Goose Temporary Spillway Weir (TSW)	Portland District The Dalles Spillway Extension The Dalles, Oregon
United state	United state	United state	United state	United state
road	building	Building	water structure	water structure
290,000,000	11,000,000	28,000,000	6,000,000	38,000,000
3 years	4 years	3 years	3 years	5years
-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-pre study -design -construction
VM Consultant	VM Consultant	VM Consultant	VM Consultant	VM Consultant
20-30	20-30	20-30	20-30	20-30
- stakeholder - consultant -contractor -5t015people	- stakeholder - consultant -contractor -5t015people	- stakeholder - consultant -contractor -5t015people	- stakeholder - consultant -contractor -5t015people	- stakeholder - consultant -contractor -5t015people
-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics
-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard
33%	24%	33%	24%	9%
13%	15%	13%	15%	10%
–	–	–	–	–
–	–	–	–	–
(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)

10	11	12	13	14
Portland District Elk Creek Lake Fish Passage Corridor Oregon	Los Angeles District City District Los Angeles County Drainage Area (LACDA) Los Angeles, CA	Albuquerque District Santa Ana Pueblo Riparian / Wetland Restoration Project Bernalillo, New Mexico	Jacksonville District Portuguese Dam / Portuguese & Bucana Rivers Project Ponce, Puerto Rico	New Orleans District Southeast Louisiana Flood Control (SELA) Pump to the River Harahan, LA
United state	United state	United state	United state	United state
Water structure	road	road	Water structure	Water structure
15,000,000	216,000,000	35,000,000	181,000,000	68,000,000
1 year	1.5 years	4 years	3.5 years	5 years
-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-pre study -design -construction
VM Consultant	VM Consultant	VM Consultant	VM Consultant	VM Consultant
20-30	20-30	20-30	20-30	20-30
- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people
-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics
-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard
20%	28%	25%	22%	15%
11%	32%	29%	12%	26%
—	—	—	—	—
—	—	—	—	—
(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)

15	16	17	18	19
Kansas City District Tuttle Creek Dam Manhattan, Kansas	District USDA Forest Products Laboratory Madison, WisconsinLouisville	Nashville District Riverbank Stabilization at Moccasin Bend Chattanooga, Tennessee	Jacksonville District Rio de Grande Arecibo Flood Damage Reduction Project Puerto Rico	omidiye post development
United state	United state	United state	United state	Iran
road	Building	Water structure	Water structure	Building
245,000,000	35,800,000	36,900,000	12,800,000	23,000
4 years	2 years	2years	2 years	7 month
-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-pre study -design -construction	-design
VM Consultant	VM Consultant	VM Consultant	VM Consultant	stakeholder
20-30	20-30	20-30	20-30	5
- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people	- stakeholder - consultant -contractor -5to15people
-FAST chart- analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics	-FAST chart-analysis -brain storming -life cycle cost analyzing -evaluation metrics
-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	-BRE Value Management Standard BRE (2000) -SAVE International Value Standard
20%	9%	59%	12%	7%
28%	6%	35%	15%	5%
—	—	—	—	—
—	—	—	—	—
(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(U.S. ArmyD.C.,2009)	(Raeispoor, a., 2006)

20	21	22	23	24
Northern Ireland's construction industry-residential buildings area	Pizza Hut UK	Gas Power plant Bandar Abbas	Power line 400 of 40 column	Power line 400 of Sabzevar- 30 %
Northern Ireland's	UK	Iran	Iran	Iran
Building	Building	building & structure	building & structure	building & structure
390,000	400,000	563,000,000	75,482	96,200
1 year	1 year	5years	1 year	1.5 years
construction	Design	-pre study -design -construction	Design	-design
VM Consultant	value management facilitator from outside the project team	VM Consultant	design consultant	stakeholder
20-30	10	23	4	20
- stakeholder - consultant -contractor	Design consultant	- stakeholder - consultant -contractor - VM consultant	Design consultant 5to15people	VM consultant
—	- Traditional format information exchange, -functional analysis -brainstorming of -alternatives evaluation.	-function analyzing (FAST) - metrics method - brain storming - Simple multi-attribute rating technique (SMART)	-brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis	-metrics method -brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis
-BRE Value Management Standard BRE (2000) -SAVE International Value Standard	SAVE International Value Standard - Value Management in Construction: A Client's Guide, CIRIA Special Publication 129.	SAVE International Value Standard - Iranian guidance	SAVE International Value Standard -Iranian guidance	SAVE International Value Standard -Iranian guidance
11%	10%	30%	5%	13%
12%	15%	25%	18%	20%
-idea creation and assessment report	15%	30%	10%	10%
—	—	all steps report	reports of VM results	-cost analyzing report -function report(FAST chart) - time and cost saving report
(Srinath, P, 2011)	(Constructing Excellence, 2004)	(Rahmanian, D, 2011)	(raeispoor, a., 2006)	(Rahmanian, D, 2011)

25	26	27	28
power post of Rezaei-Khorasan -40% cost	Power line of Ward Abad	power post of part of Tehran -12% cost	water transfer line form Ardak dome to Mashhad
Iran	Iran	Iran	Iran
Building	Building	building & structure	Water structure
245,000	456,000	400,369	635,000
1 year	1 year	2years	5 years
Design	Design	Design	Design
VM Consultant	VM Consultant	VM Consultant	VM Consultant
12	12	15	25
- stakeholder - consultant -contractor - VM consultant	- stakeholder - consultant -contractor - VM consultant	- stakeholder - consultant -contractor - VM consultant	- stakeholder - consultant -contractor - VM consultant
-brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis	-brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis	-brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis	-brain storming -triangle evaluation (based cost, quality and time) - fast chart - functional analysis - life cycle analysis
SAVE International Value Standard -Iranian guidance	SAVE International Value Standard -Iranian guidance	SAVE International Value Standard -Iranian guidance	SAVE International Value Standard -Iranian guidance
10%	15%	20%	20%
20%	20%	15%	15%
105	10%	10%	20%
reports of VM results	reports of VM results	reports of VM results	reports of VM results
(Rahmanian, D, 2011)	(Rahmanian, D, 2011)	(Rahmanian, D, 2011)	(Rahmanian, D, 2011)

4.3.1 Basic Information

Among 28 projects, 11 construction projects were executed in Asian countries including India, Malaysia and Iran. Furthermore, the VM specification of 16 water structures, building and road projects of the United States are considered in this part, the stakeholder of these projects was "U.S. Army Corps of Engineers of Washington". The brief detail of VM study of building industry of Ireland and a building project's VM study in the United Kingdom also were described as data collection in this section. Totally, these projects all in terms of their cost and time are divided as following:

- Required cost to implement project:

- Less than 50,000($):1 project

- Between 50,000 to 200,000 ($):3projects

- Between 200,000 to 400,000 ($):5 projects

- More than 400,000($):19 projects

- Required time to implement project:

- 1 year or less: 11 projects

- 3 years or less: 8 projects

- 4 years or less: 5 projects

- 5 years or more: 4 projects

4.3.2 Value Management Process

-The phase of project that VM used: According to data collection, the majority of selected projects added the VM study just in their design phase, although many projects with high cost and longtime such as U.S. Army's projects and Gas Power

plant of Bandar Abbas in Iran that applied VM study during predesign, design and construction phases.

-Facilitator: The VM consultant corporations as external facilitator controlled the VM process in all construction projects except 2 projects with low-cost and short time including "Power line 400 of 40 columns, Iran" and "Omidiye post development, Iran"; for these projects, the VM study was facilitated by design consultant and stakeholder as internal facilitator.

-Workshop number: About 24 projects held more than 12 workshops over the VM study and the remained projects had the workshops less than 12 numbers. It should be mentioned the projects with less than 12 workshops had low cost and short time in compare with other selected projects with more than 12 workshops.`

-The VM team members: In all projects, the stakeholder, VM consultant and design consultants' representatives attended in the VM workshops as VM team members except in tow projects that the VM consultant did not presented in the workshops; this could be due to the internal facilitators leaded these studies. Moreover in those VM processes that applied in construction phase of projects, the contractor also attended in VM workshops (e.g. 16 projects of US army).

- The methods and tools that used during VM process: Based on data collection table, all projects used "FAST chart "method in their VM study. Only "two Malaysian public projects" utilized another tools and methods instead of FAST chart to analysis the functions; these projects used especial and unpopular tools such as Logical Framework Analysis (LFA).

Moreover, another popular methods used in VM studies are "Brain storming" and "Lifecycle cost analyzing" which were used in about 24 projects. As mentioned in data collection, all projects' VM study relied on evaluating the projects by evaluation or weighted matrix.

-**The standards used in VM studies:** According to the selected data, the VM study of selected projects were according to the following standard list that among them the "SAVE International Value Standard, 2007" more popular than others. Furthermore, all the selected projects of Iran used "Guidelines of Iranian value society (2001)" to apply the VM study. The standards used on these 28 projects listed on following:

-SAVE International Value Standard (2007)

-VM Manual, EPU, 2011

-Australian Standard, Value Management AS 4183

-BRE Value Management Standard BRE (2000)

-Management and Planning Organization of the drawer (2000)

-Guidelines set value engineering studies2006

-Value Management in Construction: A Client's Guide, CIRIA Special Publication.

-Iranian value guidance (2001)

4.3.3 Value Management Results

Cost saving: according to data collection, after using VM study in the selected projects, the percentage of saving cost was as below. It must be considered that the small projects (with low cost and short time) had the minimum of cost saving.

  -5 % or less: 2 projects

  -10 % or less: 8 projects

  -15% or less: 6 projects

  -20% or less: 4 projects

  -More than20%: 8 projects

Time saving: the percentage of saving time among selected projects was about 5 to 32 % except one of them that did not have any time saving. The selected projects can be divided in terms of time saving as following.

  - 5 % or less: 2 projects

  -10 % or less: 2 projects

  -15% or less: 9 projects

  - 20% or less: 5 projects

  - More than20%: 8 projects

Increasing quality: Although, there is not any information about the quality of 17 collected projects, the percentage of increasing the project's quality after using VM practice was about 10 to 30 % for other ones. The classification of data collection in terms of projects' quality improvement is as bellow.

  - 5 % or less: 2 projects

  -10 % or less: 2 projects

  -15% or less: 9 projects

  - 20% or less: 5 projects

- More than20%: 8 projects

VM reports: According to the data collection, the results of function analysis, FAST chart, idea creation, decision making and also total outcomes of VM study were prepared as the final VM report by the VM team. It should be mentioned that; although there are not any information about content of 17 selected projects' VM report, according to the standards used in these projects, it seems the results of each phase of VM study might be sent to the head of organization as final report.

4.4 Question Survey

Based on the definition stated by (Sixsmith, Murray, 2001), "questionnaires are a series of questions or statements to get the idea and opinion of those people who are related to the subject of study, then respondents react either by writing out their answers or selecting the best choice among existing answers. " Always in a question survey, respondents who their fields or experiences are in common with research's subject should answer some questions.

What point which should be carefully considered in this method is designing the proper question to provide the best situation for respondents to share their opinion and experiments as well as possible.

4.4.1 Questionnaire Design

Generally, there are two types of questions to design a questionnaire "close questions" and "open questions". In this study the designed questionnaire is including some close questions that was designed based on the literature review and selected information of available resources to answer the research questions. "A closed-ended survey question provides respondents a series of fixed number of responses to choose an answer by marking it." this kind of question is useful to

access the results with better categories and arrangements (Sixsmith, Murray, 2001). So in this questionnaire survey, In order to answer the questions; the respondents just mark proper answer that is according to their experience and idea.

4.4.2 Questionnaire Content

According to available information and literature review, the questionnaire of this study was designed in six parts to cover all aspects of value management subject as it can be seen in following table. A sample questionnaire with details also is attached in Appendix A.

Table 9: The Parts of Questionnaire Designed

row	Part	Questions
1	Respondents	Personal information
2	organization	Organization name
		For how many years your organization has used VM for their project (years)?
3	Project	What is the project type that your organization has used VM process for them?
		How much is the estimated cost of this project?
		How many years is the estimated time of this project?
4	VM process	Which phase of the project was the VM study applied in?
		Who was the facilitator of this VM study?
		Who did participate at the VM workshop and how many people were as the team members?
		How long has been VM team members trained?
		How many was the workshops number of VM study?
		Which tools and methods were used during VM process?
		Which VM benchmarks and standards were used?
5	VM Results	What percent of the project cost was saved after doing VM study?
		What percent of the project time was saved after doing VM study?
		What percent increase was the project quality after doing VM study?
		What was the report content that your organization made at the end of VM process as final output to give the head?
6	VM benefits and barriers	What issues are affecting on VM study?
		What are the benefits of VM study?
		Totally do you agree with applying value management process in your future projects as before?

Having considered to appendix A, it can be clearly seen, respondent's part is including some personal information which is about name, surname, educational level, responsibility, experience and country.

In the second part the specifications of the organization which the respondents have worked there, are asked such as name and the number of years that organization has applied the VM process for its projects.

In third part, the project's type (road, water system and building structure), total estimated cost and time of that project which applied VM study were asked.

In forth part, the information about the trend of VM process which was applied by organization is asked. This information is including the member and facilitator's type of VM team, methods, tools and standards used applied in VM process.

In fifth part, the respondents are asked about the results and out puts gained through VM process such as the percentage of saving cost and time, the amount of increasing quality and the content of VM reports.

In last part, two questions are designed to respondents give their idea about benefits and barriers of value management based on their experiences.

It should be noticed that as mentioned above, respondents for answering the questionnaire must mark the best choices that are in accordance with their experiences; in all questions they can mark one or more choices. In addition, for each question, one blank line was placed for other comments and shortages which respondents think must be in this section to fill it.

Finally, last questions are about respondents' tendency to participate in using value management process (VM) in other projects in future "Totally do you agree with applying value management (VM) process in your future projects as before?"

4.4.3 Testing and Validating

In order to test the quality of questionnaire according to Saris (2007), tree works can be done" Checking on face validity", "Controlling questions through questionnaire routing" and finally "Using a pilot study to test the questionnaire"

After checking the face and routing in the questionnaire, three experts of a well-known corporation in VM services consultant, Mahab Gh of Iran, who works as VM team in big projects which applied VM process, were asked to fill out the first draft of questionnaire as a pilot study, and then they were asked to discusses all questions, one after another; after that, all questions were corrected and changed based on their comment and advice. In order to cover and improve the data that gained from available resources by questionnaire survey, the corrected questionnaire was checked based on the results of data collection; afterward, final questionnaire was distributed among respondents.

4.4.4 Respondents and Their Organizations

According to advice of Iran Value associate (http://www.iranvalue.ir), questionnaires were distributed among 10 Iranian and some international corporations and organizations which are professional in VM process. The majority of questionnaires were sent by the email; among them just about 5 of them were deliverd to 5 Iranian corporations by hand directly.

Finally, 6 corporations and organizations (respondents) filled out the questionnaires for 39 projects which they have applied VM process. Based on the questionnaire's

results, the experience years of using VM for each corporation who attended in this survey are as bellow:

Between 6 to10 years: 2 corporations

Between 6 to 10 years: 1 corporation

Between 11 to 20 years: 1corporation

More than 21 years: 2 corporations

Organizations which the Respondents work there divided to 3 categories in terms of their field including road, water systems and building-structure. The figure 8 illustrates the percentage of respondents of each field.
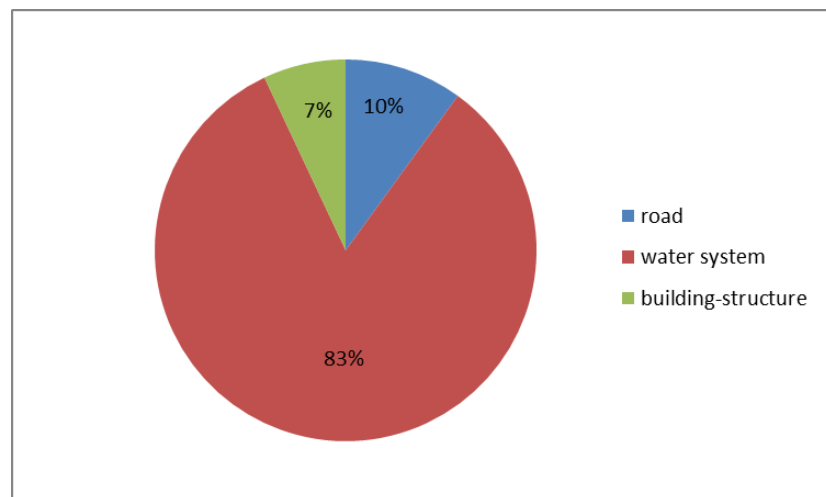
Figure 8: The Percentage of Respondents of Each Field

4.4.5 Projects

According to the results of questionnaire survey, the projects that were asked about them, in terms of the cost and time divided to some groups as is visible in the figures 9 And 10 respectively.
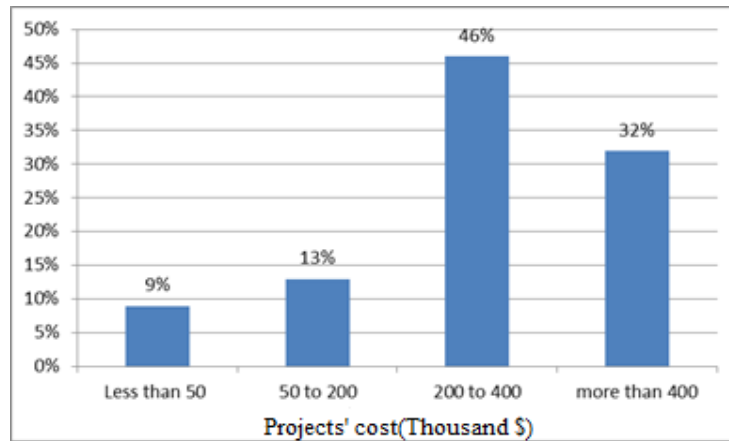
Figure 9: Estimated cost of the Projects
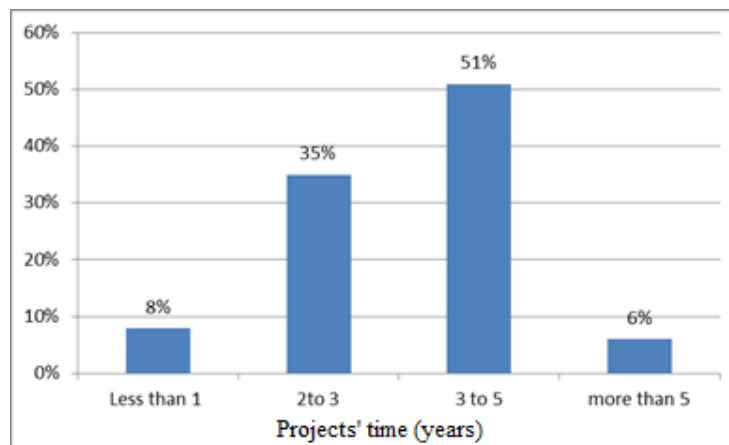
Figure 10: Estimated Time of the Projects

4.4.6 VM Process

4.4.6.1 The Time of Using VM in this Project

Assessing questionnaire revealed that the majority of projects applied the VM study over the design phase, the figure 11 shows the percentages of VM studies that were adopted in pre design, design, construction and operation phase of the projects.
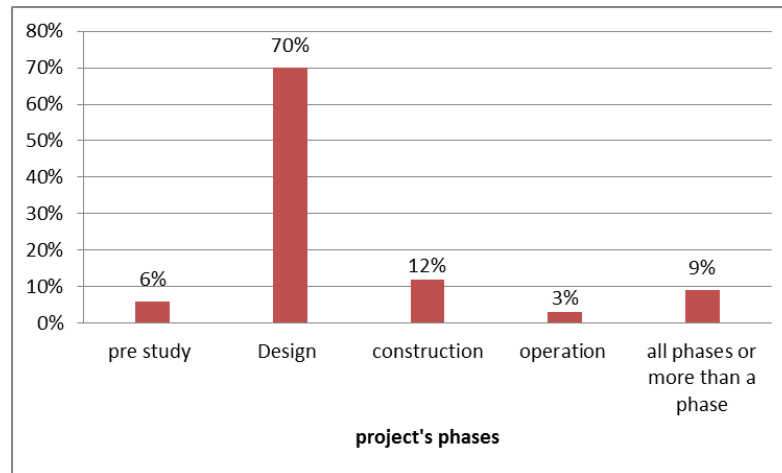
Figure 11: The Percentages of VM Studies that Were Adopted in Each Phases of the Construction Projects

4.4.6.2 Facilitator

According to respondent's answers, about 67 % of the projects used VM consultants service as external facilitator, other ones used design consultant, stakeholder or other parts of project to facilitate and control the VM study (figure 12).
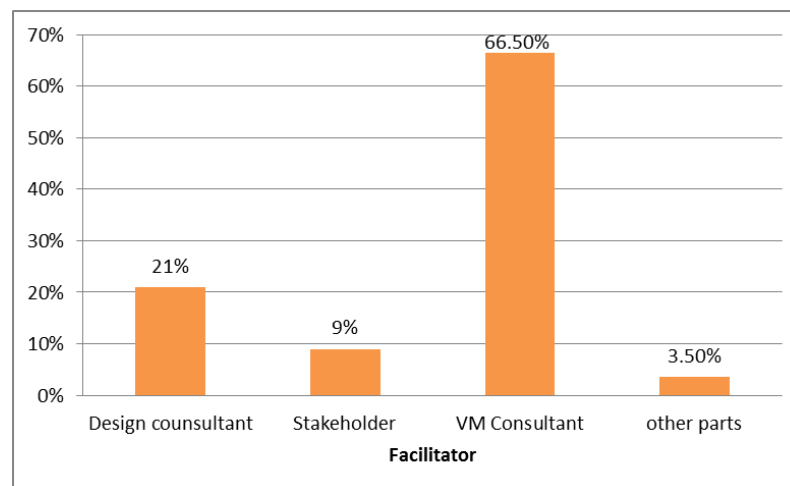
Figure 12: the facilitator type of the VM studies

4.4.6.3 VM Team Members

According to questionnaire survey, all projects (100%) held their VM workshops with participating facilitator and stakeholder as the main members of VM team. Moreover design consultant and contractor attended in VM workshops in about 85%

and 35 % of projects, respectively. Totally in those projects that applied in design phase, both design consultant and stakeholder attend in VM workshops, while in those ones that applied VM study in construction phase, contractor instead of design consultant participated in VM process.

Furthermore, all parts of the project including design consultant, stakeholder and contractor participate beside facilitator in VM workshops as VM team members. More over the number of members who attend in VM workshops of projects as following:

VM member number:
- Less than 5 person: 40% of projects
- Between 6 to 10 person: 46% of projects
- More than 10 person: 12% of projects

4.4.6.4 Training

According to questionnaires, about 5 % of projects had no any training program for VM members. On the other hand, the organizations of remained projects had about 8 to 30 hours of training program to learning participants that how VM study should be done. Moreover for 2 projects, the VM members had to pass the training course for 30to 50 hours. Finally in just a project, the VM members were educated for more than 50 hours.

4.4.6.5 Tools and Methods

Based on what that the respondents answered, the common tools and methods of VM process used in the projects are according to table10. It must be considered that, in many cases the combination of several tools and methods were adopted in projects

together. The figure 13 also shows the percentage of using above methods and tools in the projects attended in questionnaire survey.

Table 10: The Common Tools and Methods of VM Process Used in 39 Projects

Tools and method	The number of projects that used this method
Function analysis	39
Cost-Benefit analysis (B/C)	4
FAST chart-analysis	35
Hierarchy diagram	9
Brain storming	39
calculating value index	21
using pass/ fail method to evaluate	1
using advantages/ disadvantages method to evaluate	11
weighted matrix	35
life cycle cost analysis	35
labels rating	10
SWOT analysis	3
Stakeholder Analysis	2
Simple multi-attribute rating technique (SMART)	5
Value index	19
Time, cost and quality triangle	23
assessment metrics	38
Lever of value	1
cost estimation	37
Spatial adjacency programming	1
Logical Framework Analysis (LFA)	4
Risk Analysis	14
Issues Generation & Analysis	5

	100.0%	97.0%	97.0%	94.90%	89.70%	89.70%	89.70%	59%	53.80%	48.70%	35.90%		28.20%	25.60%	23.10%		12.80%	12.80%	10.30%	10.30%	7.70%	5.10%	2.60%	2.60%	2.60%
	Function analysis	Brain storming	assessment metrics	cost estimation	FAST chart-analysis	weighted metrics	life cycle cost analysis	Time, cost and quality triangle	calculating value index	Value index	Risk Analysis	using advantages/ disadvantages method to evaluate	labels rating	Hierarchy diagram	Simple multi-attribute rating technique (SMART)	Issues Generation & Analysis	Logical Framework Analysis (LFA)	Cost-Benefit analysis (B/C)	SWOT analysis	Stakeholder Analysis	using pass/ fail method to evaluate	Lever of value	Spatial adjacency programming

Figure 13: The Percentage of Using Common Methods in the VM Studies

4.4.6.6 VM Standard and Guidance

The respondents said that about 89 percent of their VM studies were based on "SAVE International Value Standard" other common VM standard were "Australian Value Standard AS 4183:2007" and "British/European VM Value Standard BS/EN 12973:2000" which were used in 65% and 16 % of VM studies, respectively. Moreover, based on answers just in one case "UK Department of Trade and Industry Value Management Guide" and "The Value Management Benchmark Male et al. (1998a)" were considered in VM process. Since the majority of projects were done in Iran, the main reference is "Value Management national guidance of Iran" that it is own based on "SAVE International Value Standard", "Australian Value Standard AS 4183:2007"and "The Value Management Benchmark Male et al. (1998a)"

4.4.6.7 VM Results

According to questionnaire survey, after the VM practice done, the projects faced the amount of cost and time saving as it can be seen in figure 14 and 15.
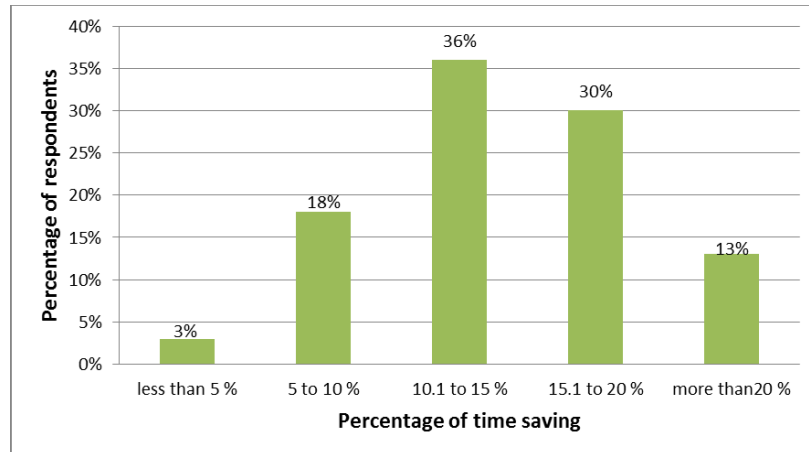
Figure 14: The Percentage of Time Saving after Applying VM Studies
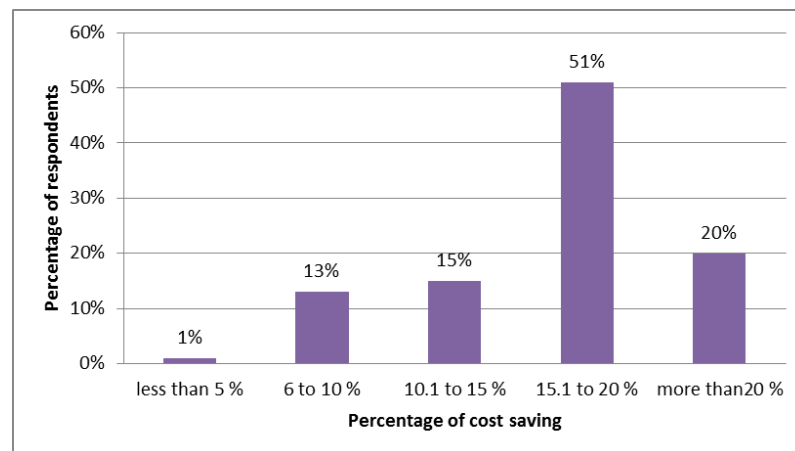
Figure 15: The Percentage of Cost Saving after Applying VM Studies

Moreover, the respondents said applying VM study helped them to increase the quality of projects' results. They estimated the percentage of increasing quality of their projects and then marked one of the levels determined in questionnaire. Figure 16 shows the amount of increasing quality of projects based respondents'' opinion .
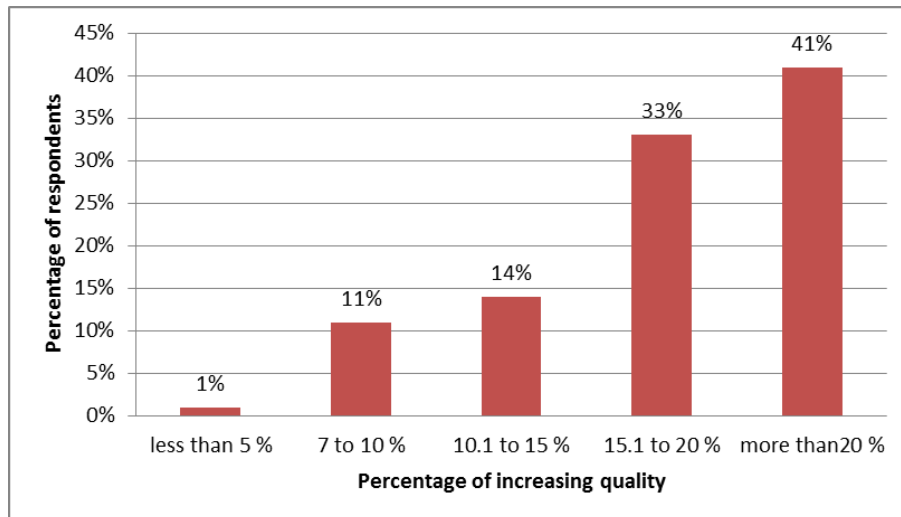
Figure 16: The Percentage of Increasing Quality in the Projects after Applying

VM Studies

4.4.6.8 VM Report Content

According to questionnaire survey the content of the reports that sent to the head of

organization or achieved document of the projects are as following table. In this table

the number of using each content and subject of VM reports are available

Table 11: The Reports that Were Sent to the Head of Organization

Report's content	The number of projects with Report's content
basic information of project such as name cost and time or other specification	39
the information of VM team (members and meetings time)	35
function analyzing reports	39
idea creation reports	38
idea analyzing, scoring and assessing report	39
the information of cost and time saving percentage after VM process and percentage of increasing of quality	35
extra attachments such as drawings ,study deportment or other instrument	18

4.4.6.9 Issues Affecting VM

According to respondent's answers, the issues that effect on VM studies are arranged in order of their negative influence degree as below (figure 17).
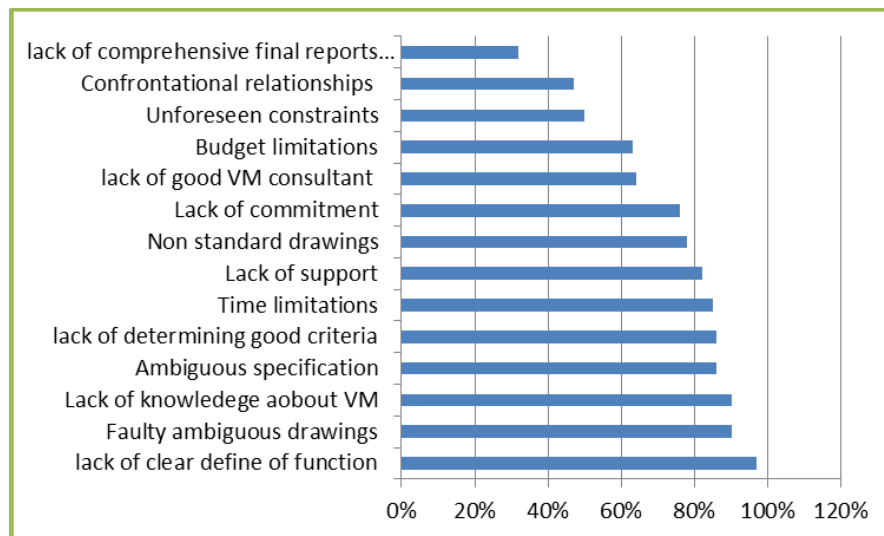
Figure 17: The Effective Issues in the VM Studies

Having considered the graph, we can infer that the respondents think "lack of knowledge about VM", "faulty ambiguous drawings" and "lack of clear defined function" are the most harmful issues against a VM study that effect negatively on the accuracy of the VM study's results.

4.4.6.10 VM Benefits

Based on the respondent's comments, the VM benefits are sor ted in terms of importance level in following picture (figure 18).
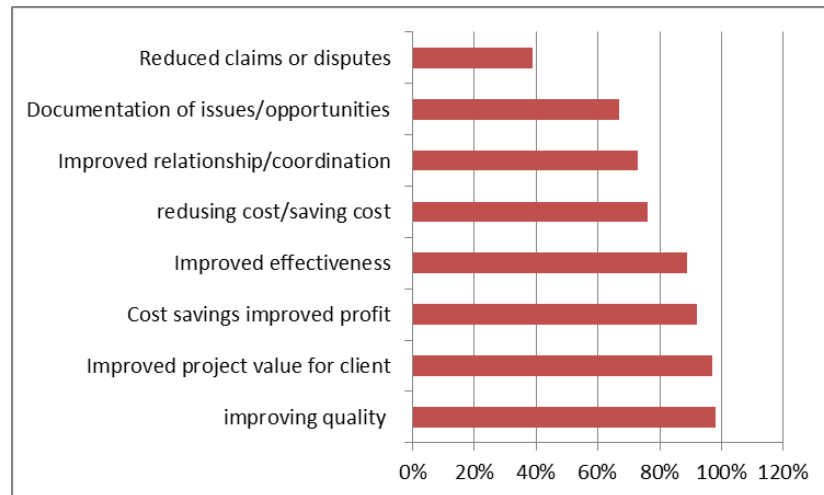
Figure 18: The VM Benefits in Terms of Importance Level

Finally, as last question, about 94% of respondents supposed that they participate in using value management process (VM) in other projects in future. Totally regarding the benefits of VM study, they agree with applying value management (VM) process in their future projects as before.

4.4.7 Results of Data Collection

To sum up based on both available information of other experience and questionnaire survey that was done about VM study, following items are resulted:

1- The VM studies were carried out more for Infrastructure projects such as Water systems and road Construction.

2- Always the VM study was applied for large projects with a cost more than 200 thousand dollars.

3- Many projects applied VM study in design phase.

4- The majority of VM studies used external facilitator.

5- Depending on phase and needs of the project, the representatives of stakeholder, facilitator, design consultant or contractor or the corporation of them attended in VM workshops as VM team members.

6- The number of VM team members often was about 5 to 10 person

7- In all VM studies, the VM team members were trained about relevant skills and tools.

8- Brain storming, life cycle cost analyses (LCCA), FAST chart, function analyses and evaluation matrix were used in VM studies as common tools and techniques.

9- "SAVE International Value Standard" was considered in all VM studies as the main reference. Moreover, because of the majority of projects were done in Iran, the main reference was "A series of instructions of Value Management before construction published by Programing and management office of Iran, 2007" that it is own based on "SAVE International Value Standard", in addition another references are "Australian Value Standard AS 4183:2007" and "British/European VM Value Standard BS/EN 12973:2009".

10- After the VM practice done, the amount of cost and time saving were average 10 to 30 %

11- In majority projects, applying VM study was effective to increase the quality of projects' results more than 20 %.

12- Totally, the content of the reports that which sent to the head of organization as VM study report included both basic information of project and the results of each phase of VM study.

13- According the respondent's opinion lack of knowledge about VM is one of the important issues which affect the quality of VM study

14- Based questionnaire survey, the value and quality improvement and also enhancing cost saving are more important benefits of VM study.

4.5 Designed VM process

A proper VM process must be include some main parts and activities to cover all common 7 phases of VM study that mentioned in chapter2.

To achieve this aim, based on the results of data collection and also reviewing literature review and VM standards including "SAVE International Value Standard" and "Australian Value Standard AS 4183:2007", a useful, beneficial and efficient VM process can include 32 steps and parts as they are shown in table12.

 In order to remove all misunderstandings that maybe happened for users and also manage all data, information and knowledge which are created and imported during VM process, an Expert System as VM software was developed. This software helps and guides unskilled users to follow the VM process to properly carry out a VM study.

Table 12: The Steps of Suggested VM Process According to Data Collection

Row	Phases	Steps and activities
1	Pre study phases	1-Requesting for VM study
		2-Importing basic information and data of projects
		3-Assessing the request
		4-Approving the request
		5-Choosing the VM team members
		6-Selecting facilitator
		7-Determining the number of workshops
		8-Workshops Schedule arrangement
		9-Importing developed information of project
		10-Analyzing documents and attachments
		11-Analyzing collected data and information
		12-Holding related workshops
2	Information phases	13-determining functions of project
		14-Drawing FAST chart of project
		15-Estimating the cost of each function
		16-Estimating the time of each function
		17-Selecting functions with the best possibility of improvement
		18-Drawing FAST chart of selected functions (improvement)
		19-Estimating the life cycle costs
		20-Estimating the time in details
3	Creative phase	21-Suggesting new idea for each selected functions
		22-Drawing FAST chart of each new ideas
		23-Estimating the life cycle costs of each new idea
		24-Estimating the time of each new idea
4	Evaluation	25-Evaluating new idea based on time-cost-quality
		26-Value creation and label
		27-Determining criteria
		28-Evaluating each idea based on all criteria (evaluating matrix)
		29-Final scoring each idea
5	Development	30-Determining the limitations, advantages of selected idea
6	Presentation	31-Making final reports and results
7	Post study	32-Assessing the improvement situation (in construction phase)
		32-Making document the results of reviewing

start

1. Provide data and information of project

In construction phase

16. Assessing the Improvement Situation

3. Workgroup formation in Stakeholder' organization to assess proposed plan

2. Prepare proposal plane or VM study request

4. Proposed plan assessment

Approved

5. Select VM team & facilitator

Approved

Feedback

15. Documentation

6. Start VM study

End

7. Workshop arrangement: select the practice should be done during VM process

14. Best alternative suggestion

Unapproved

Unapproved

☆ Common and necessary practices of VM proccess

8.
1. Analyzing attachments
2. Analyzing collected data and information
3. Determining project
9.
4. Determining function of project
5. Drawing FAST chart
6. Estimating life cycle cost of each function
7. Estimating time of each function
8. Select the best functions for improvement
9. Determining selected function's elements
10. Drawing FAST chart of selected function
11. Estimating life cycle cost of each element
12. Estimating time of each element

10.
11.
12.
13.

13. Creating new ideas
14. Drawing FAST chart of new ideas
15. Estimating life cycle cost of new ideas
16. Estimating time of new ideas
17. New Idea Evaluation in terms of cost-time –quality
18. Value Creation and label
19. Determining Criteria
20. Weighting criteria
21. Evaluation Matrix
22. Final Reports and Results

☆ Common and necessary practices of VM proccess

Phases of VM study

1. Information Phase 1,2,3,4,5,6,7
2. Function Analysis Phase 8,9
3. Creative Phase 10,11

4. Evaluation Phase 12
5. Development Phase 13,14
6. Presentation Phase 15
7. Post study 16

Figure 19: Integrated flowchart chart of the developed VM Expert Systems

Chapter 5

METHOD OF EXPERT SYSTEM DEVELOPMENT

5.1 Introduction

This chapter defines the development of an Expert System shell for a VM process. In general, various method and environment exist to develop an Expert System shell. Furthermore, there are many Software tools available to help designers to develop a particular purpose Expert System. The earliest and most convenient Expert System shell is selected for this study. In this chapter, the problem and the specifications of the Expert System shell that is used to determine a VM process have been defined.

This software is prepared in several steps and parts with mandatory practices. Each part's specifications and all information and data that should be imported as the inputs and all out puts will be described in this chapter.

5.2 Scope

In this study the problem is to develop a knowledge based on Expert System for the VM study implementation in design and construction phase of the construction projects.

5.3 Development Method

This Expert System is developed to clarify different steps in the VM process and lets the users run the process, in the best possible way. Indeed, this developed Expert System guides users apply a VM study and follow all steps of VM process which designed according to collected information and created knowledge.

After creating knowledge base according to gathered data and available guidance, it is essential to produce a user interface for the system. In order to create the user interface for VM Expert System, a word editor database was used.

To develop this Expert System, "Visual Studio 2012" and "C#" are employed as an integrated development environment, and the language of the program, respectively. Crystal Report application is also utilized to take the print of information, received in the software, by the user. The database, which is used in our program, is SQL server Express 2012.

In the drawing section of the program, Visual Basic Power Packs is used, to facilitate creating different shapes, for drawing Fast Chart.

Furthermore, to run the software, Net Framework 4.5, Crystal Report runtime and SQL local DB must be preinstalled on the system.

Totally two series code used to develop the Expert System:

1- The bellow Code gets the data from user and saves them inside the database (figures 19, 20):

Figure 20 :The View of Programming Environment with Code were Used to Get the Data from User

```
using (SqlConnection connection = new SqlConnection(@"Data Source=(LocalDB)\v11.0;Atta
{
    connection.Open();
    SqlCommand command = new SqlCommand(" INSERT INTO Application(App#,Sub,Place,Advis
    command.Parameters.AddWithValue("@App#", textBox1.Text);
    command.Parameters.AddWithValue("@Sub", textBox2.Text);
    command.Parameters.AddWithValue("@Place", textBox3.Text);
    command.Parameters.AddWithValue("@Advisor", textBox4.Text);
    command.Parameters.AddWithValue("@Goals", textBox5.Text);
    command.Parameters.AddWithValue("@Phas", comboBox1.Text);
    command.Parameters.AddWithValue("@AppExp", textBox6.Text);
    command.Parameters.AddWithValue("@InvExp", textBox7.Text);
    command.Parameters.AddWithValue("@UtiExp", textBox8.Text);
    command.Parameters.AddWithValue("@KepExp", textBox9.Text);
```

Figure 21: Code were Used to Get the Data from User

2- The bellow procedure sends the information received by user, to crystal

report, for printing (figures 21 and 22).

```
private void Form52_Load(object sender, EventArgs e)
{
    try
    {
        SqlConnection connection = new SqlConnection(@"Data Source=(LocalDB)\v11.0;AttachDbFilename=|DataDirectory|\ValueManagementDB.
        SqlDataAdapter data = new SqlDataAdapter("SELECT * FROM [Cost] WHERE App#=@app order by Row", connection);
        data.SelectCommand.Parameters.AddWithValue("@app", textBox1.Text);
        DataSet set2 = new DataSet();
        data.Fill(set2);
        CrystalReport24 report = new CrystalReport24();
        report.Database.Tables[0].SetDataSource(set2.Tables[0]);
        crystalReportViewer1.ReportSource = report;
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message, "ERROR", MessageBoxButtons.OK, MessageBoxIcon.Error);
    }
}
```

Figure 22: Procedure that Sends the Information Received by User for Printing
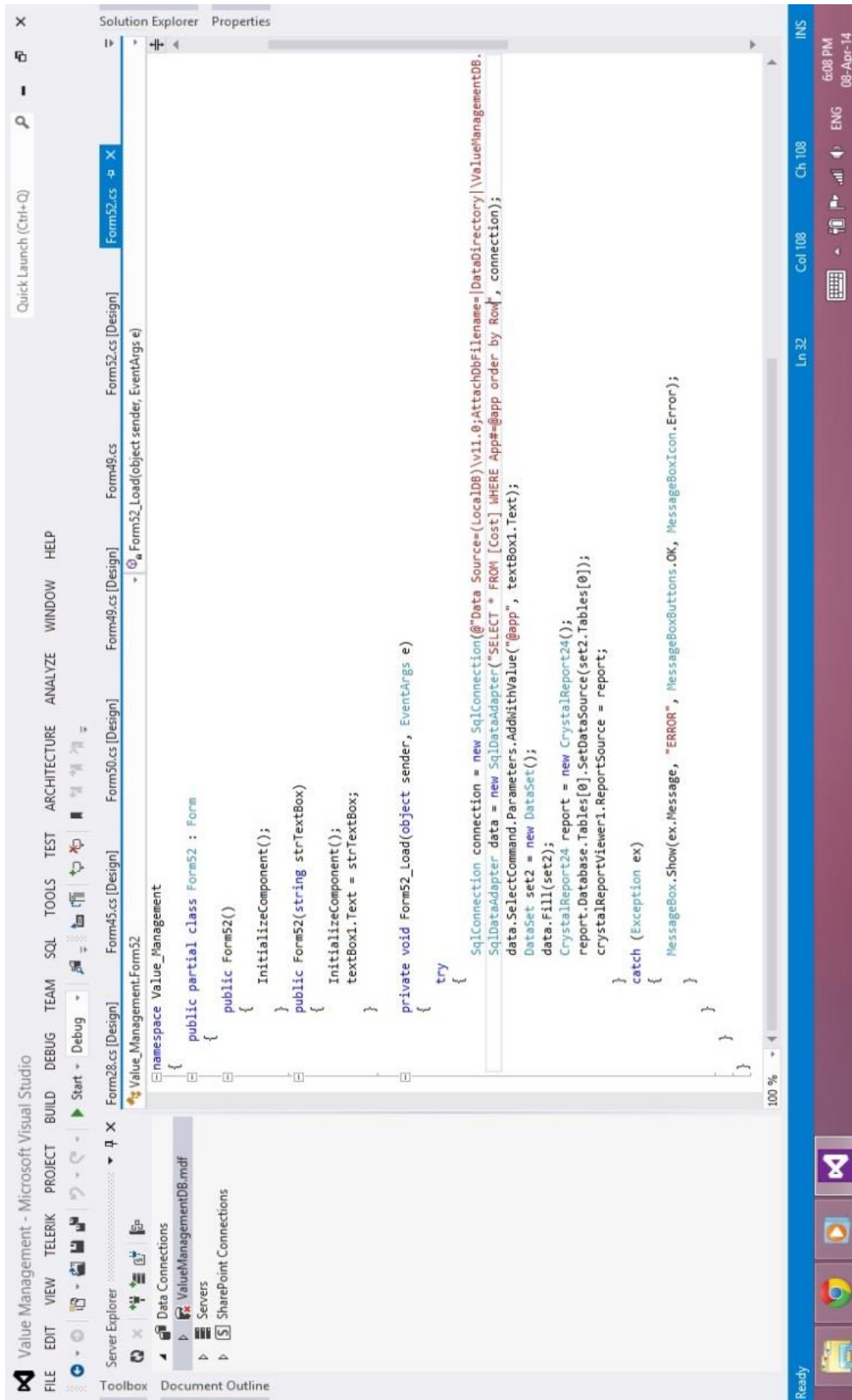
Figure 23: The View of Programming Environment with Procedure that Sends the Information Received by User for Printing

5.4 The Parts of VM Expert System

The knowledge base written for the system is in 29 sections (it involves 6 main parts and about 21 necessary practices). In this section, the instruction of using Value Management software (developed Expert System) is explained. It helps operator to use the software in a proper mode and get the right result. Therefore all inputs, outputs and operation connected with each part will be defined. Before describing each part of this Expert System, following items should be considered:

1- Each part has a help as guidance which users must read it before starting that.

2- If during importing data, users made something wrong, error awareness will be appeared to warn users about their mistakes, in this case operators can continue the process after correcting the error.

3- The print page of all inputs, outputs and results of each part is available after completing that part.

5.4.1 How to Install Value Management Software

In continues a brief guide on how to install Value Management software is mentioned which helps users to install and run the software properly.

Firstly, some software must be preinstalled in the computer system to run the VM software correctly, which are consist of .Net Framework 4.5, Crystal Report runtime and SQL local DB. In the next step the user needs to run setup.exe and then a wizard will be appeared for installing the application. Figure 23 shows the first page of installation wizard. After some proration process, "welcome" page will be appeared. Click "Next" to continue the installation process (figure 24).Then Click on "Install" button, as it is shown in the figure 25.
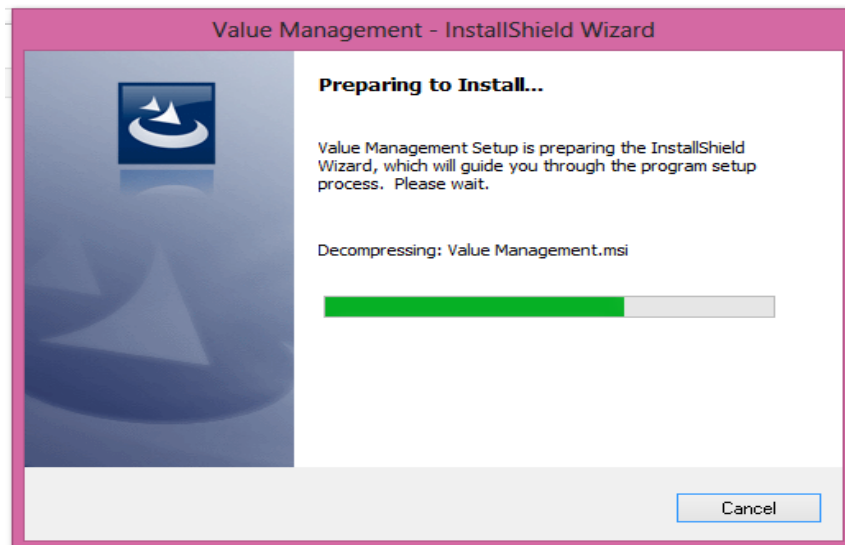
Figure 24: First Page of Installation Wizard

Figure 25: Second Page of Installation Wizard
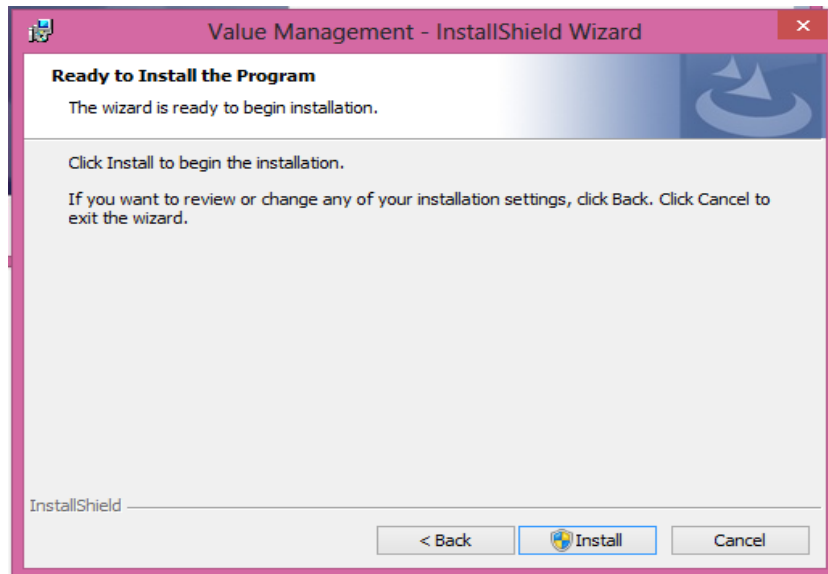
Figure 26: Second Page of Installation Wizard

Picture 26 shows the last step of installation process. Click on "Finish" and run the software by clicking on "Start" and then "Value Management".
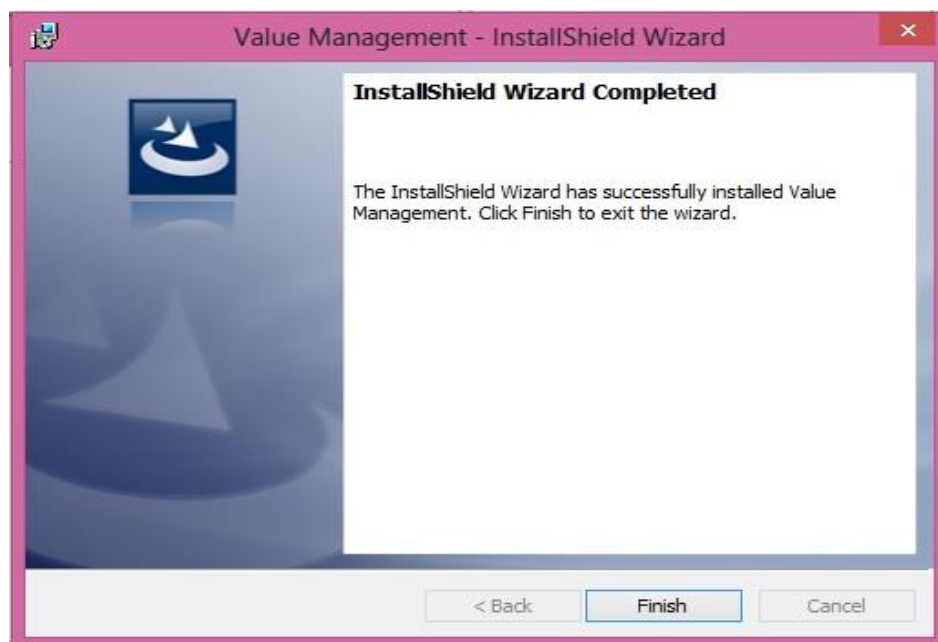
Figure 27: The Last Step of Installation Process

5.4.2 Part 1- Welcome

Welcome page is the first part of the program which consists of four tabs including Welcome, Project Information, Print and Help. These tabs gives services for starting the process, brief information of previous projects, printing out the results and the name of steps followed by user in the value management process.

- Welcome tab: In this tab there are two options for starting the process. In the case of using the software for new project, the user needs to click on New Project button otherwise project number of the project is asked to enter to process. Picture 27 shows the welcome tab.
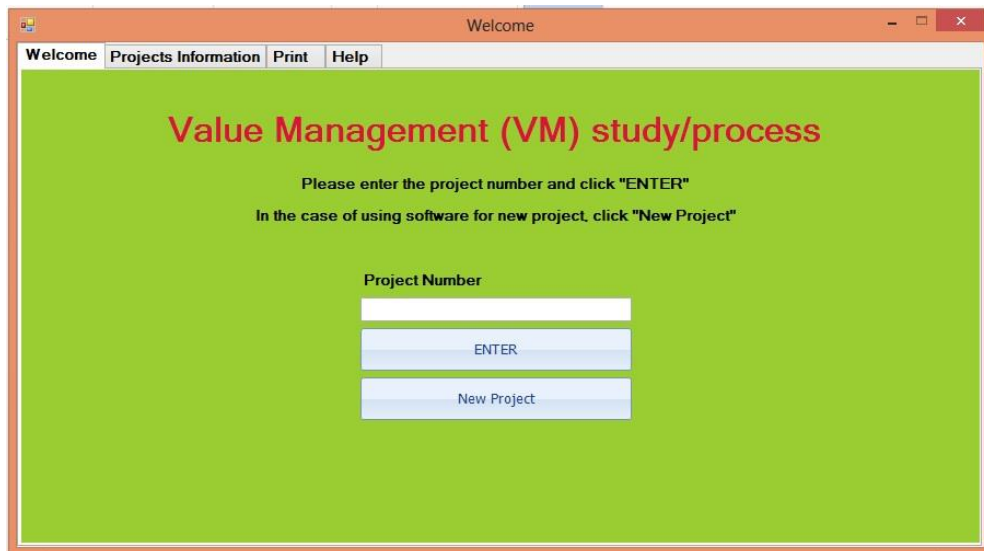
Figure 28: The View of Welcome Tab

- Project information tab: This tab provides some information about the pervious projects. Moreover, this tab offers the ability of deleting a project from software's database. To do so, the operator must enter the project number and press the "Delete" button. "Refresh the above list" button revives the table and gives the latest information saved in database. Picture 28 displays the project information tab.

Figure 29: The View of Project Information tab

- Print tab: Print tab provides the ability of printing out the result of each step of the process separately. For doing so, the operator should enter the project number and click on the button of the intended step. Picture 29 demonstrates the Print tab.
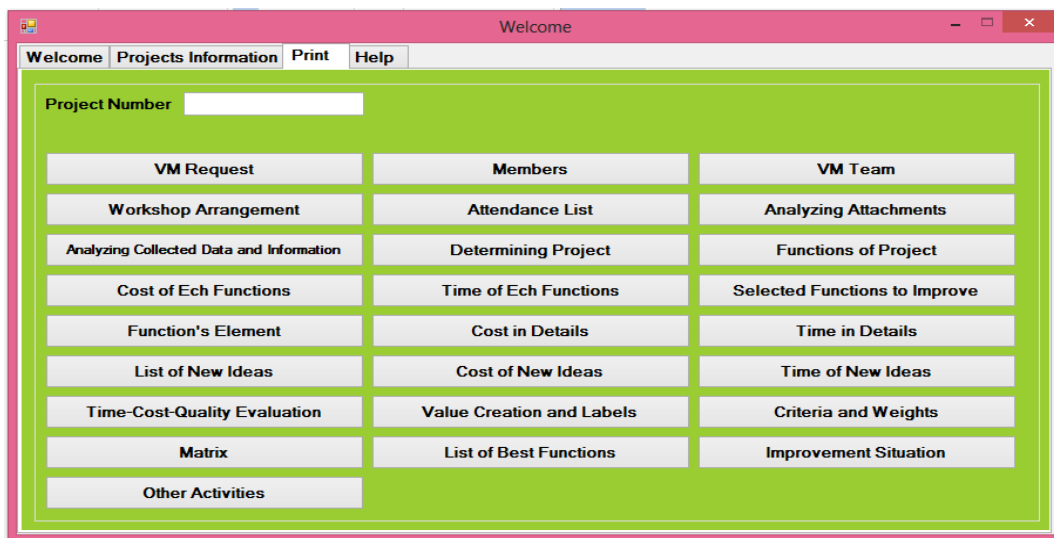
Figure 30: The View of the Print Tab

- Help tab: A Help tab is provided in each part of the software and includes information of that part. In this part, Help tab gives steps of value management process which must be followed by the user. Picture 30 shows help tab of welcome page.
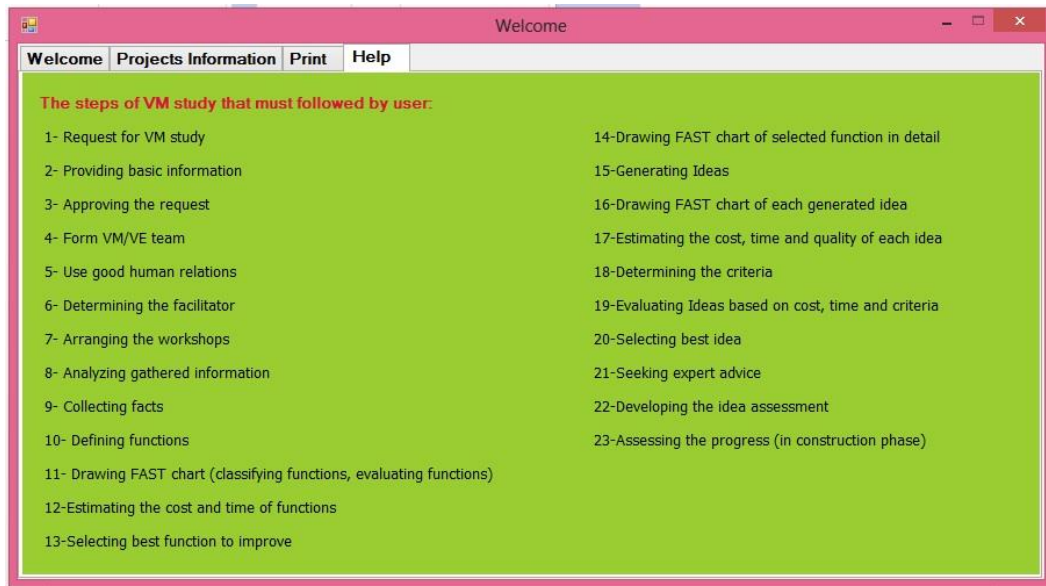
Figure 31: The View of Help Tab of Welcome Page

5.4.3 Part 2- Request for VM

In this part user suggest a project to VM department of relevant organization to be evaluated in terms of the potential of improvement by VM study. In order to assess the improvement potential of suggested project by that organization (as stakeholder of the project), operator must follow the steps in bellow:

Step 1: Import basic information of the project such as project's number and subject, design consultant's name, the phase and pre cost estimation of the project.

Step 2: Determine available attached documents of suggested project such as feasibility reports, drawings and etc.

Step 3: Load the logo of organization that is a stakeholder.

Step4: Describe the summary of project.

This part ends by entering the name and surname of the applicant and the request date. Figure 31 shows the view of this part

Figure 32: The View of VM-Request Page

5.4.4 Part 3- Decision Making

The members of VM central department of stakeholder organization are introduced in this part. These members must decide that if the proposed project needs to VM study or not.

To do so, at least 5 members should be introduced as the members of VM central department of organization in two types of full time or part members. These members decide whether the VM study for suggested project should be done or not.VM process for suggested project should be done, if at least two full members approved it. At the end of this part, the date of approving the project must be recorded. Figure32 demonstrates the view of this part.
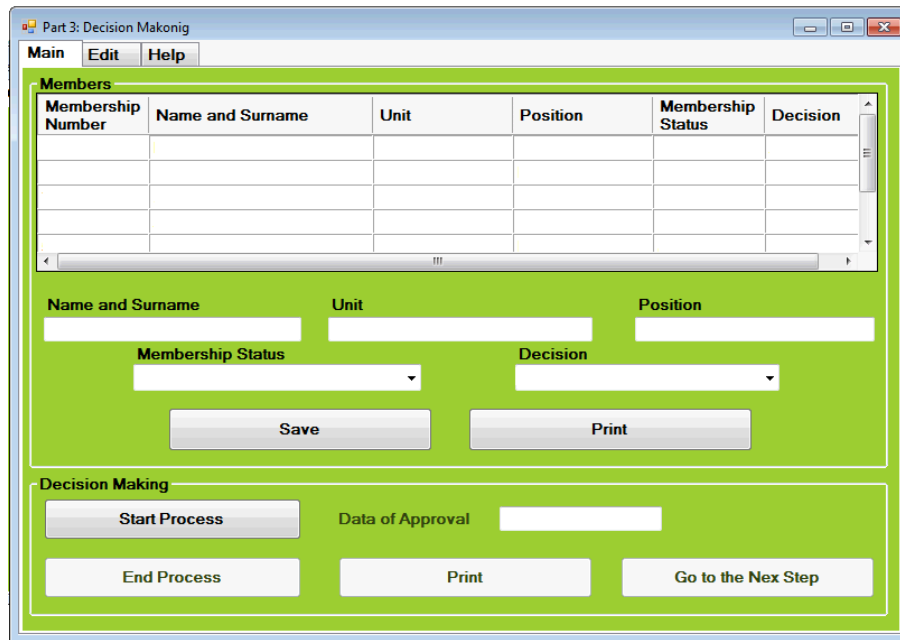
Figure 33: The View of Decision Making Page

5.4.5 Part 4-VM Team

In this part, the type (external or internal) and name of facilitator must be determined by operator, although the type of the facilitator is suggested by software according to following table.

Moreover in this part, the members of VM are determined. The VM team must have at least five members including at least one representative of stakeholder, VM consultant and designing consultants. It should be considered if the VM study was applied in construction phase of project, the representative of contractor must be attend in team too. Other items which should be determined in this step are organization's type and name and professional responsibility and also decision situation of each VM member. The view of part 4 can be seen in figure 33.

Table 13: The Types of the Facilitator in Terms of Cost

Facilitator type	project cost $
Internal	Less than 50,000
Internal or External	50,000 to 400,000
External	More than 400,000
1-Internal: the organization(stakeholder –VM department of organization- or designing consultant facilitate the VM study 2- External: A consultant corporation which is expert in VM field facilitate the VM study	Description

Figure 34: The View of VM Team Page

5.4.6 Part 5-Work Shop Arrangement

This part includes 2 steps:

Step1: In this step the number of workshop that can be held, will be suggested by software based on the size of projects according to table 14.It must be noticed the

number of workshops cannot be less than suggestion, while it can be more than suggestion.

Table 14: The relation between project's cost and the number of workshops
(Programing and management office of Iran , 2007)

After 25 % of progress	After 12.5 % of progress	The first stage of construction	Design	Pre study	Project's cost ($)
4 to 6days (mandatory)	4 to 6days (mandatory)	4 to 6days (mandatory)	4 to 6days (mandatory)	4 to 6 days (optional)	Less thn 50,000
4 to 6days (mandatory)	4 to 6days (mandatory)	4 days (mandatory)	4 days (mandatory)	4 days (mandatory)	50,000 to 400,000
4 to 6days (mandatory)	4 to 6days (mandatory)	4 to 6days (mandatory)	6 days (mandatory)	6 days (mandatory)	More than 400,000

Step 2: This step is workshop schedule arrangement. In order to organize the workshops, user determines work shop number (according to suggestion-step1), the major steps and activities that should be done in each workshop. It must be considered, the software has 21 practices as default that VM team should perform all of them respectively during all workshops, although if it is needed, extra activities would be done during these workshops.

So in this step users must determine the date, starting and finishing time and also all activities (mandatory and extra activities) of each workshop. The view of this part is illustrated in figure 34.
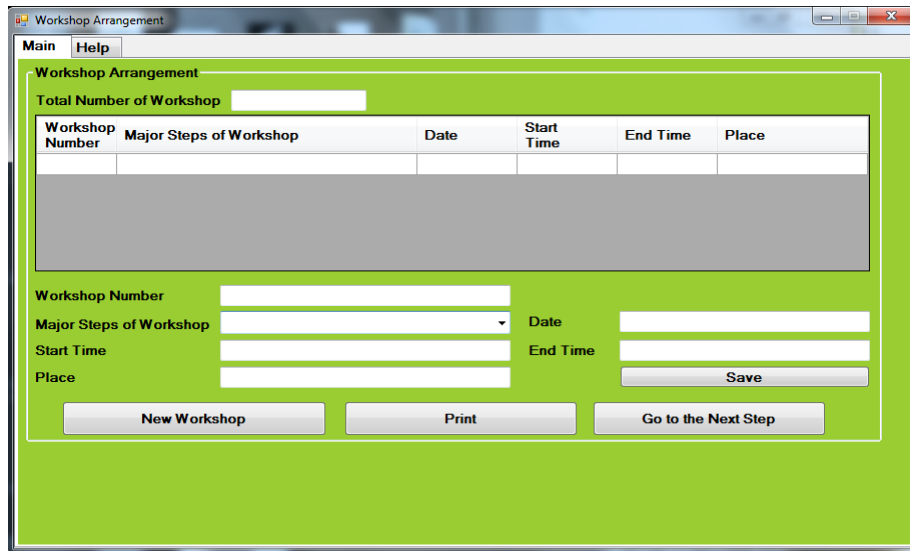
Figure 35: The View of Workshop Arrangement

5.4.7 Part 6- Attendance and Step Selection

At the first of this part, operator choses the workshop's number, and then the relevant practices based on workshop schedule are illustrated by the software to be selected and done by VM team.

In addition, user must check the attendance situation of all VM team members. The workshops should not be held without at least five members of VM team. The figure 35 shows the view of the attendance and step selection.
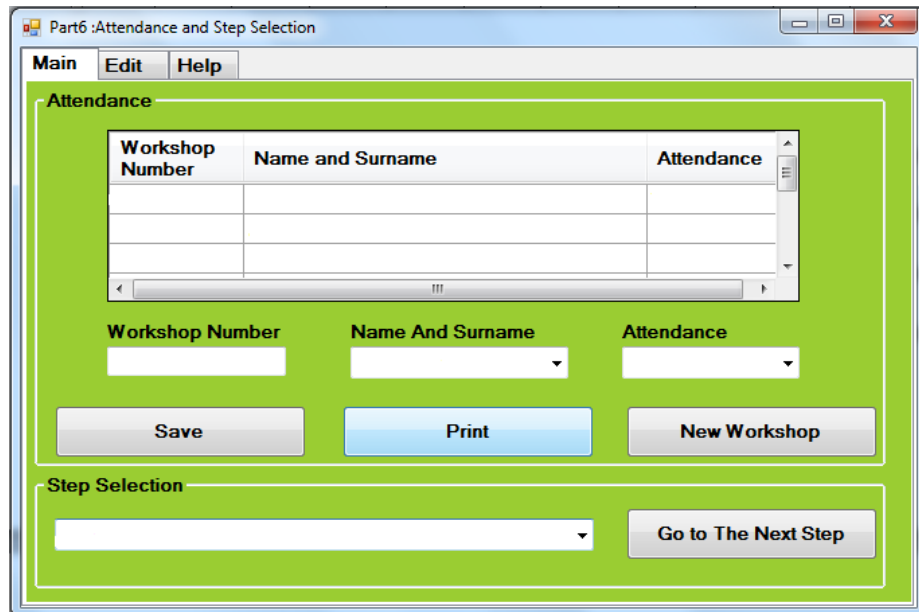
Figure 36: The View of Attendance and step Selection Page

5.4.8 Common and Necessary Practices

As mentioned in last part, 21 practices are required necessary to carry out during all the workshops respectively, in following all of them will be explained briefly.

5.4.8.1 Analyzing Attachments

During this practice VM team members tend to analys all the project's attachments in a workshop and then their comments gained thorough brain storming should be recorded as it can be visible in figure 36. As it can be clearly seen, the shortages of each attachment also should be written in this step.
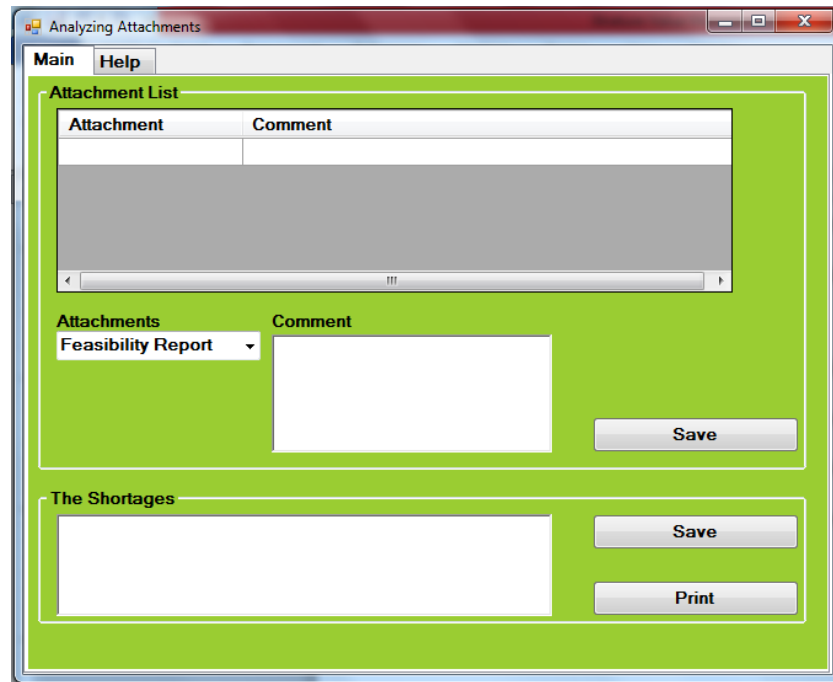
Figure 37: The View of Analyzing Attachments Page

5.4.8.2 Analyzing Collected Data and Information

To carry out this practice, all selected data and information of project must be assessed by VM team in a workshop and the results are recorded too (figure 37). According to VM team's discussion, other required information will be mentioned in this step too.
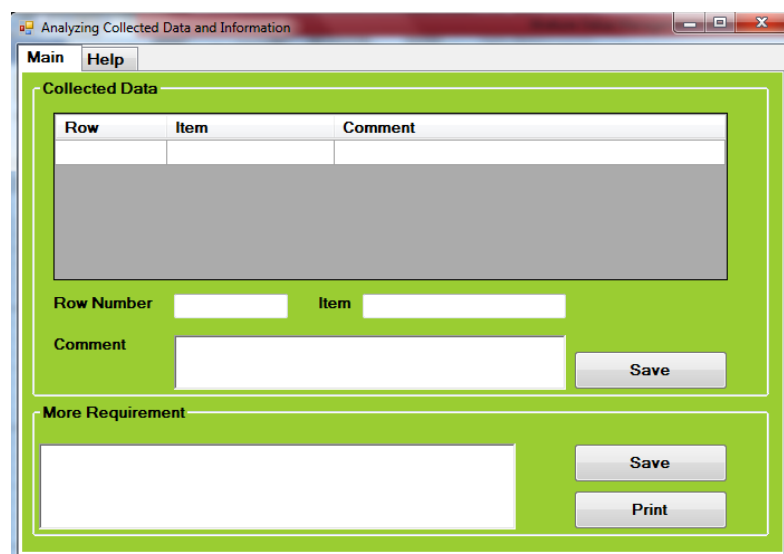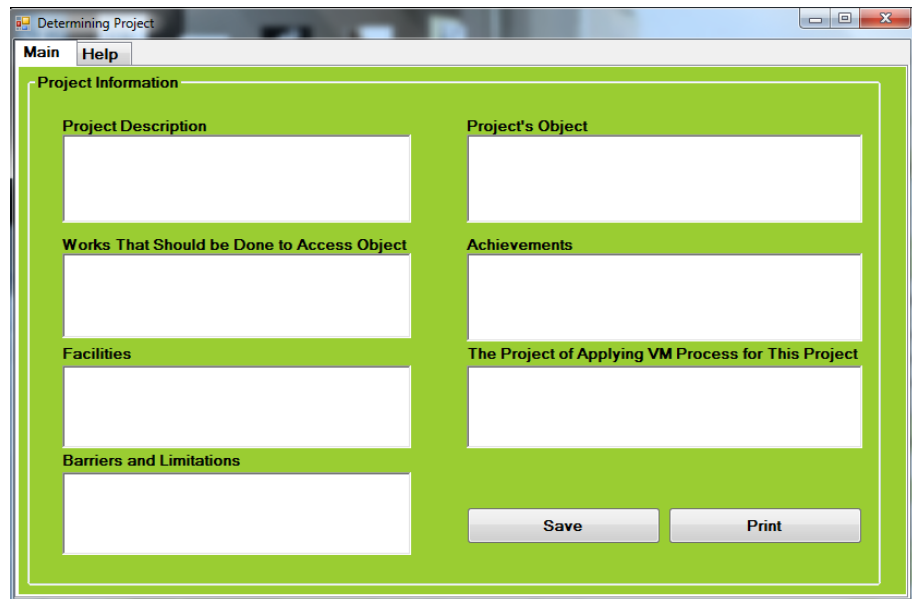
Figure 38: The View of Analyzing Collected Data and Information

5.4.8.3 Determining Project

The summary of project including project's description, objects, achievements, facilities, barriers and limitations must be provided and then recorded based on VM team discussion in this practice (figure 38).

Figure 39: The View of Determining Project Page

5.4.8.4 Determining Function of Project

All functions of project must be revealed and determined via brain storming and group discussions as mentioned in chapter 2; then the results are recorded in a related blanket places. Figure 39 Shows these places whiten the software. It should be considered that this step is one of the most important steps of VM process which has the big influence on whole process.
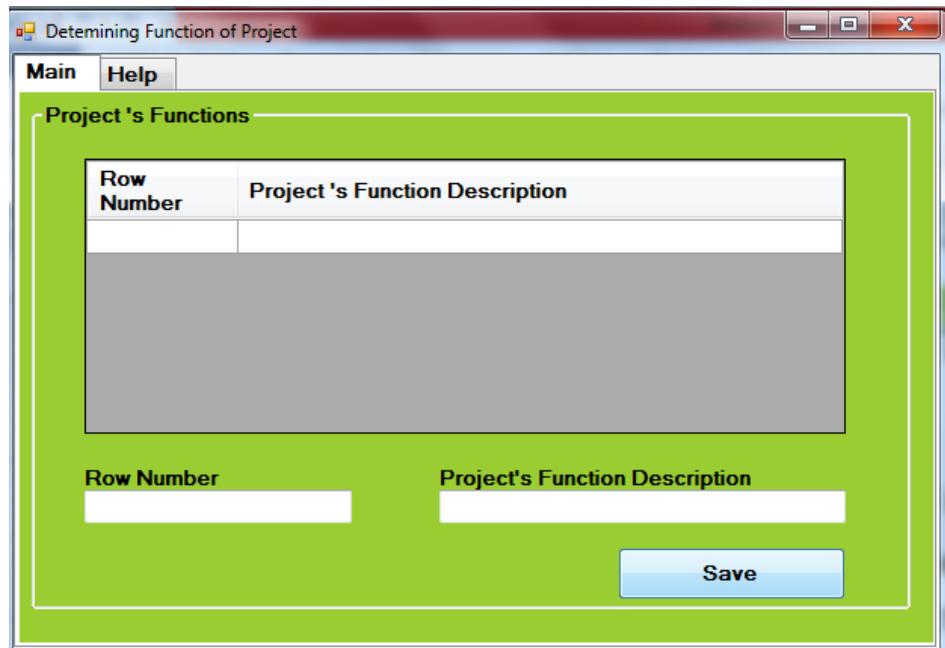
Figure 40: The View of Determining Function of Project

5.4.8.5 FAST Chart

According to brain storming and VM team members' opinion, the FAST chart including all defined functions are drown. In order to draw FAST chart, users must select a function (for example function A) and then determine the functions that are happened before and after this function. Moreover, users specify those functions can be done with or instead of function A. The figure 40 shows the view of Drawing FAST chart step. For more guidance, a brief explanation about the FAST chart technique is presented in "Help" tabs; those relevant questions that would be asked during a group discussion as mentioned in chapter 2 are mentioned in these helps too (figure 41 and 42).
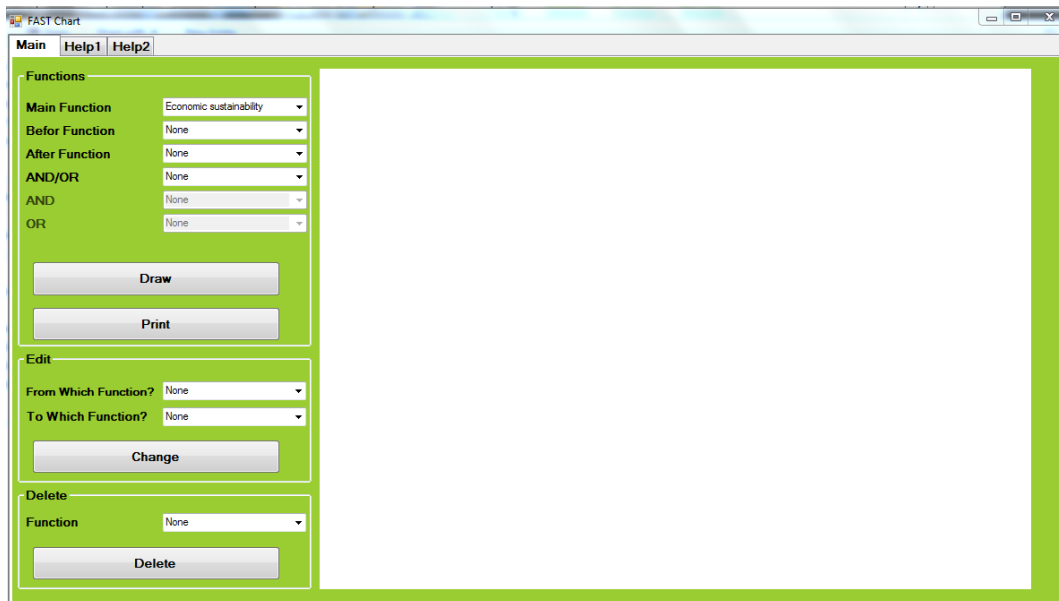
Figure 41: The View of FAST Chart Page
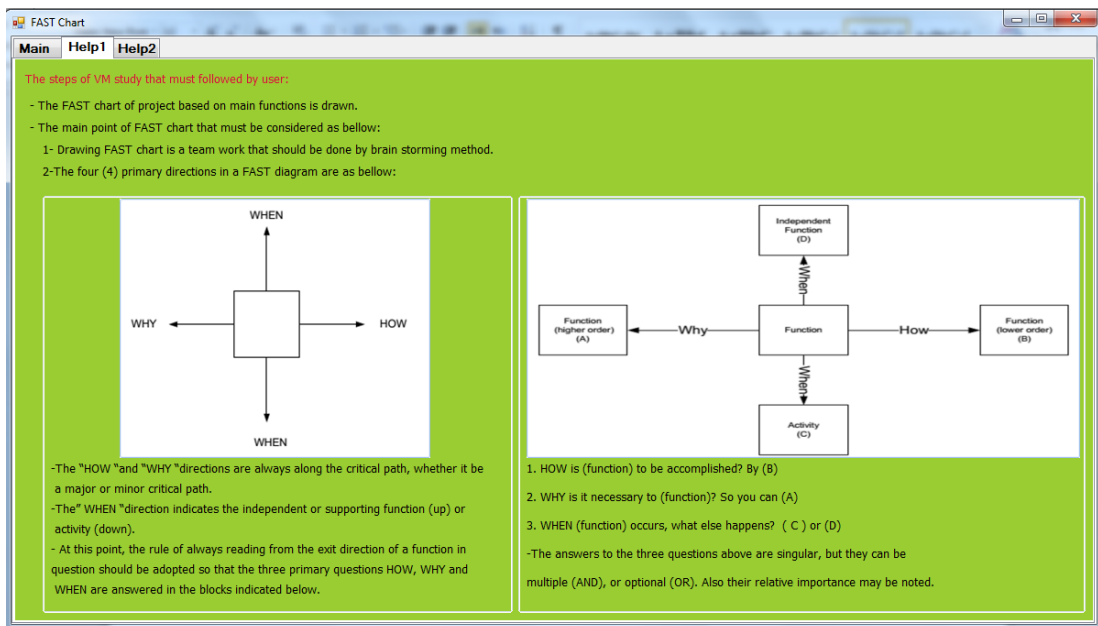
Figure 42: The Help-1 of FAST Chart Page
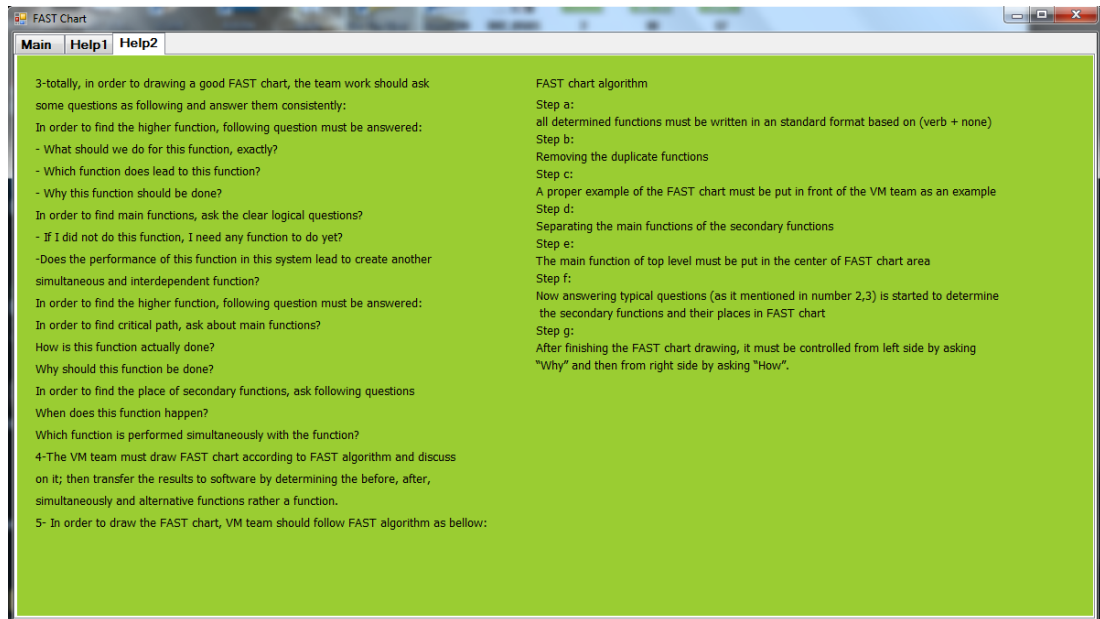
Figure 43: The Help 2 of FAST Chart Page

5.4.8.6 Cost of Each Function

In this practice, the life cycle cost of each function must be estimated by VM team as described in chapter 2. To calculate the life cycle cost, developed Expert System asks the present worth of each function in 6 parts separately:

1- Investment/construction cost

2- Energy cost

3- Operation and Maintenance cost

4- Replacement cost

5- Associated costs

6- Demolition cost

The life cycle cost of each function   is resulted from the sum of these items that is done by the software. Figure 43 shows the view of this practice's window.
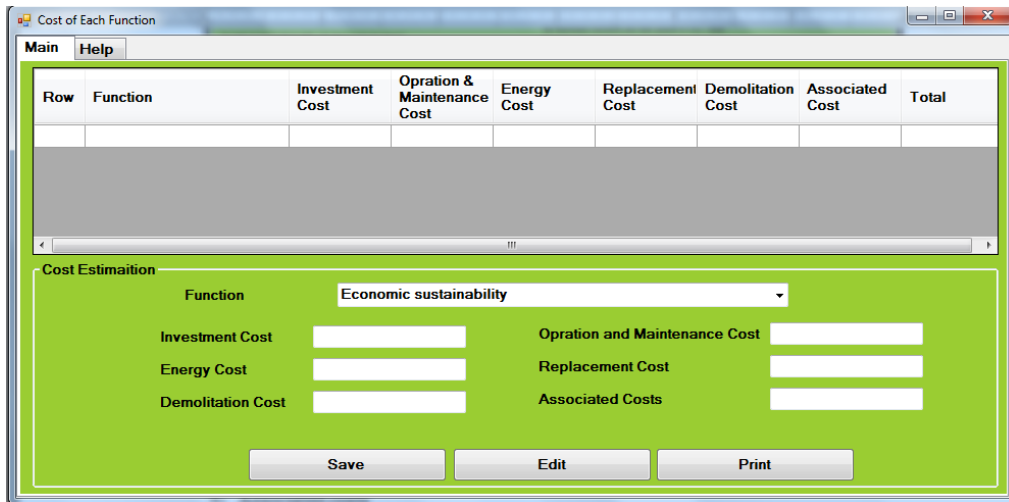
Figure 44: The View of Cost of each Function Page

5.4.8.7 Time of Each Function

To carry out this practice, the whole required time to finish each function and also the

total time of project must be estimated and recorded by the VM team (figure 44).
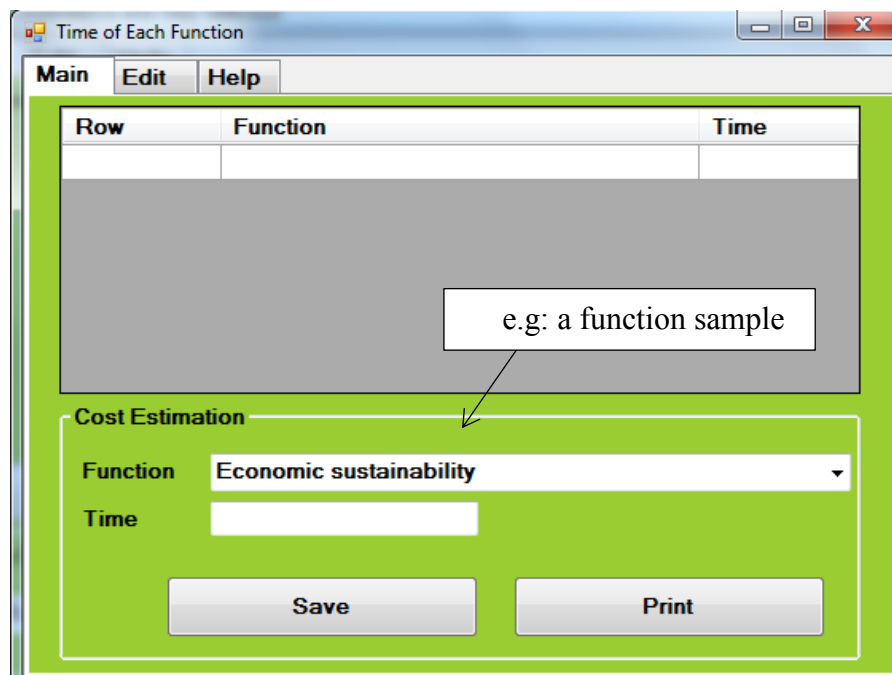
Figure 45: The View of Time of each Function Page

5.4.8.8 Improvement

After functions analysis, the VM team must select one function or more with best possibility of improving. The main aim of this study is improving these functions to increase the project's value. As it is illustrated in figure 45, the results of estimating times and life cycle costs help users to choose the functions for improvement process. They are enhanced by changing some their elements or new suggestions that completely will be explained in next practices.
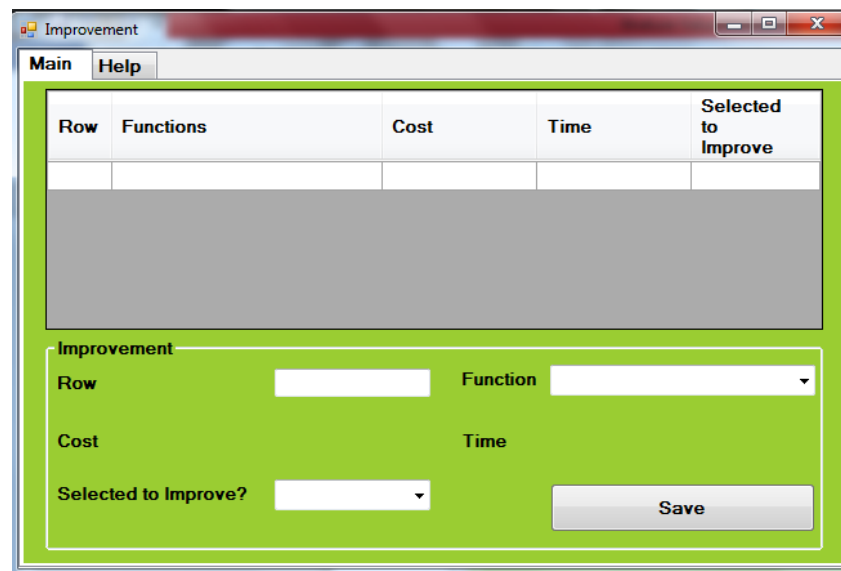
Figure 46: The View of Improvement Page

5.4.8.9 Determining Function's Elements

VM team determine the elements of selected functions that form those functions by using the brain storming method and active participation of all VM team's members. Figure 46 shows the view of this practice in the program.
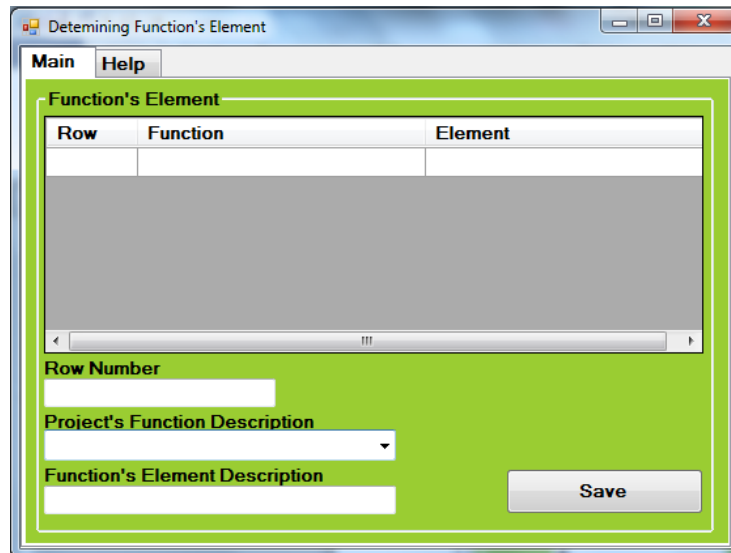
Figure 47: The View of Determining Function's Element

Having considered the above picture, it can be inferred that all selected project's functions are accessible as default in relevant places and user just click them, while function's elements description must be written by user in this page.

5.4.8.10 FAST Chart of Selected Function

For this practice the VM team draws the FAST chart of each selected function and its elements through brain storming according to those mentioned in 4.4.6.5 part. It is shown in figure 47.
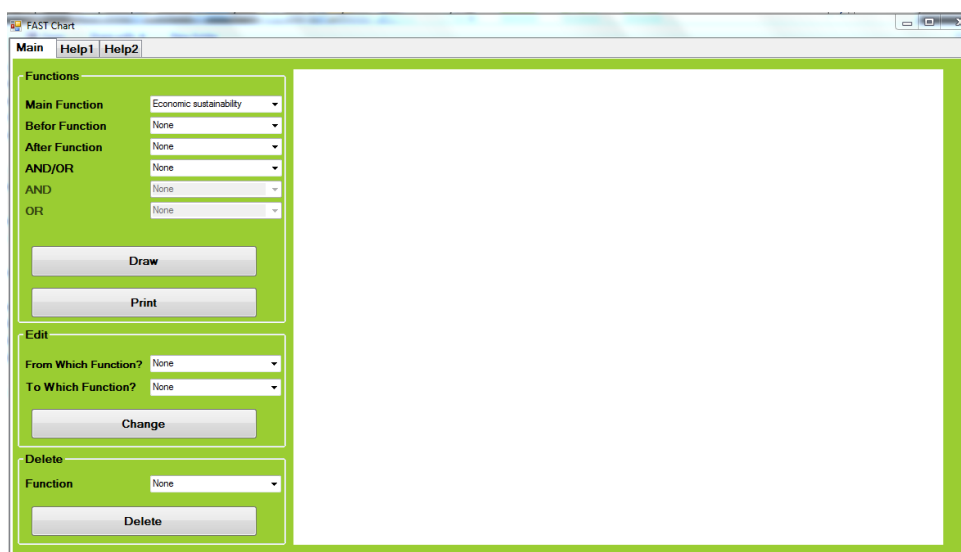
Figure 48: The View of FAST Chart Page

5.4.8.11 Cost Details

The life cycle cost of each element of selected functions should be estimated in six parts by the VM team members during related workshop. Figure 48 shows the view the six blank spaces for recording the costs.

Figure 49: The View of Cost Details Page

5.4.8.12 Time Details

In this part, the whole required time to finish each selected function's element and total time of each function must be estimated and then recorded by VM team through adopting brain storming (figure49).

Figure 50: The View of Time Details Page

5.4.8.13 New Idea

VM team suggests one or more alternative as new idea to be done instead of each selected function based on their discussion. Applying and using brain storming to do this practice is so import and helps to suggest better idea. All elements of each new idea also should be determined by user for this practice (figure 50).
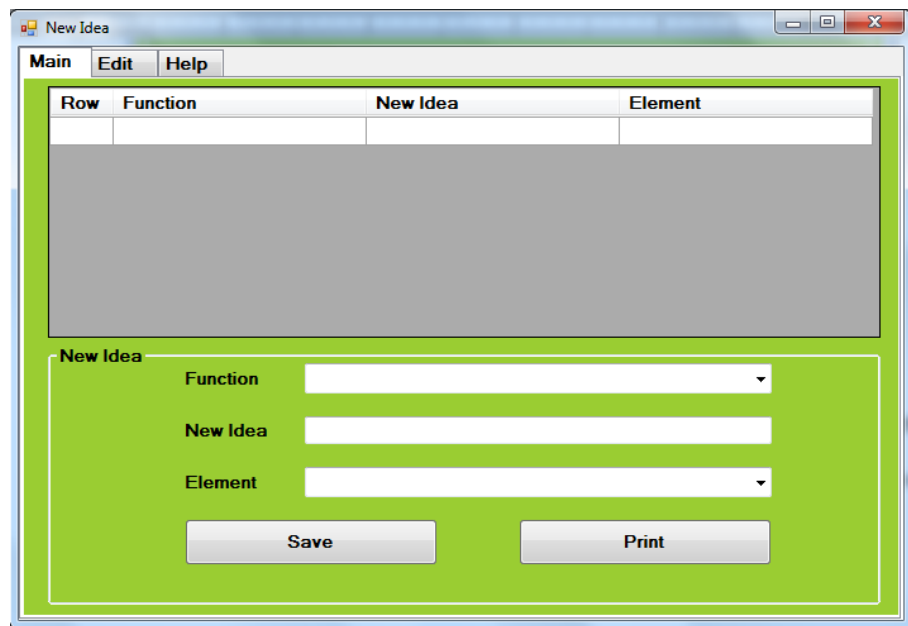
Figure 51: The View of New Idea page

5.4.8.14 FAST Chart of New Idea

For this practice the VM team draws the FAST chart of all new ideas and their elements through brain storming according to those mentioned in 5.4.8.5 and 5.4.8.10 parts (Figure 51). After drawing the FAST chart of a new idea, "New FAST drawing" button must be clicked to appear new page for drawing another new idea's FAST chart.
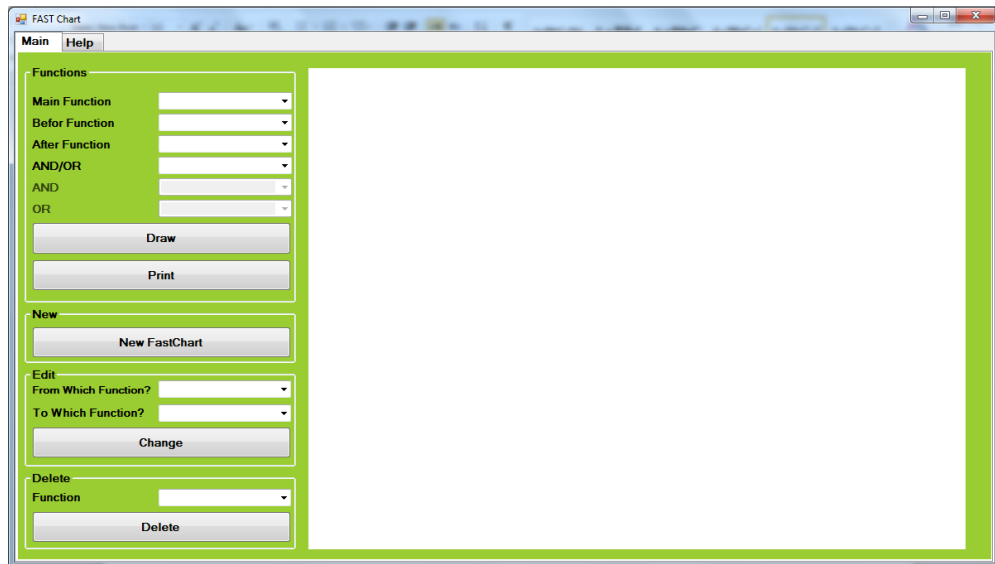
Figure 52: The View of FAST Chart Page

4.4.6.15 Cost of New Idea

VM team should estimate life cycle cost of all elements of each new idea. The results of cost assessing   must be recorded in 6 places including "investment/construction cost, energy cost, operation and maintenance cost, replacement cost, associated costs and Demolition cost". The figure 52 illustrates the view of this practice.
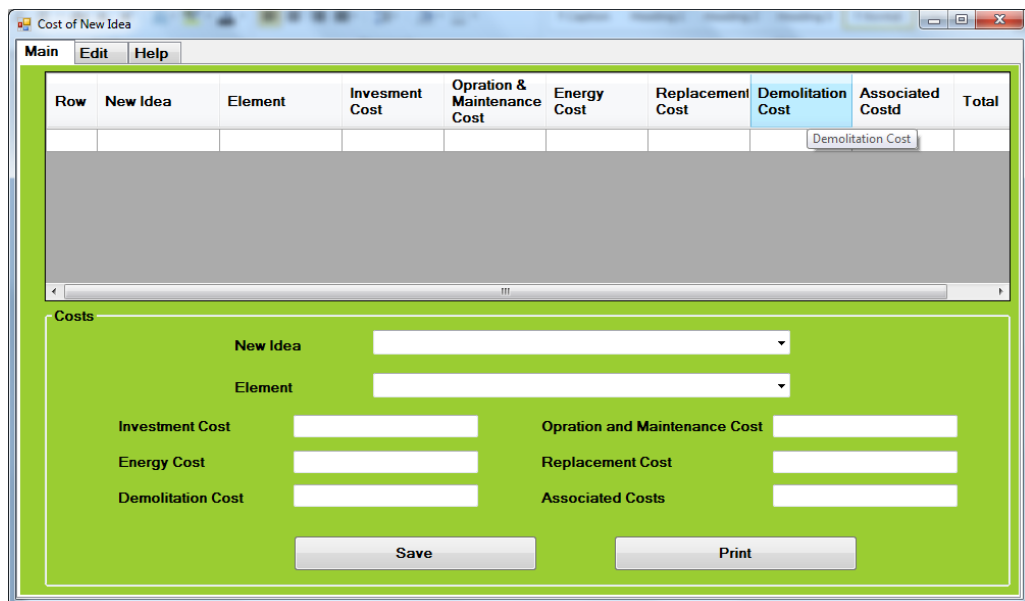
Figure 53: The View of Cost of New Idea Page

4.4.6.16 Time of Each New Idea

In order to follow this practice, VM team must estimate the whole required time to finish each elements of each new idea and then record them based "day" in relevant place. The total time of each new idea also should be determined in this practice (figure53).
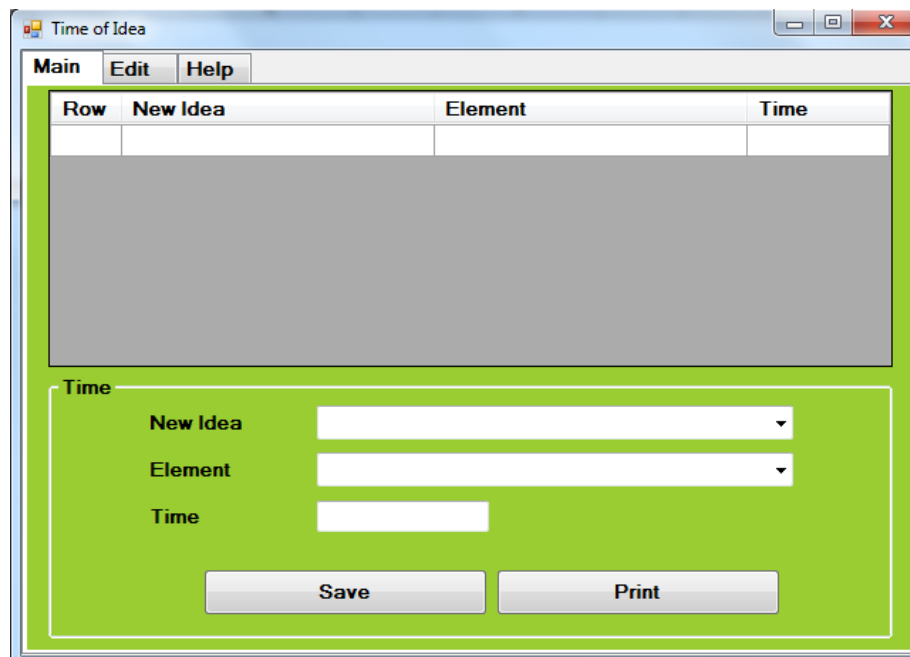
Figure 54: The View of Time of Idea Page

5.4.8.17 Evaluation-New Idea

After new ideas suggestion, the amount of improving the quality of each function via relevant new idea must be determined in this practice. Hence, the quality levels have been divided in 7 types including Excellent, High, Average, and Low, weak, Not effective and Negative that one of them must be chosen for each new idea through group discussion among VM team and VM members' opinion assessment(table 15).

Then to finish this practice, the software calculated the percentage of saving cost and time and final score based on before parts' input and bellow table. In this case the

percentage of saving cost and the percentage of saving time are calculated according to equation 4 and 5 respectively. Figure 54 sows the view of the of this practice window within the software.
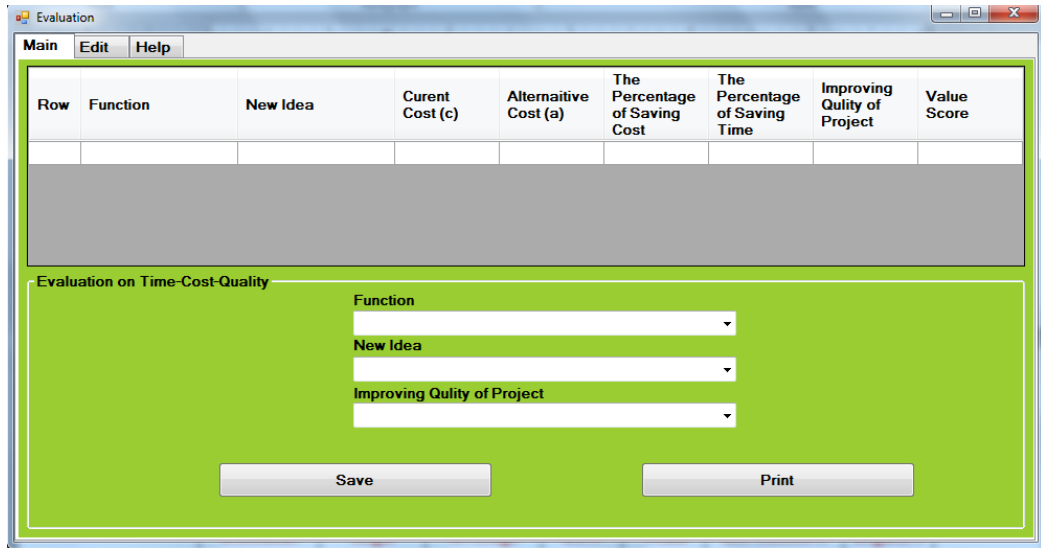
Figure 55: The View of Evaluation Page

Table 15: The Scores in Terms of Cost-Time-Quality

Point 5	Point 4	Point 3	Point 2	Point 1	Point 0	Point -1
The percentage of saving cost						
>25.1	20.1-25	15.1-20	10.1-15	5-10	0-5	>0
The percentage of saving time						
>25.1	20.1-25	15.1-20	10.1-15	5-10	0-5	>0
The percentage of improving quality						
Excellent	High	Average	Low	weak	Not effective	negative

Equation 4:

The percentage of saving cost =100-((C2/C1)*100)

C1= the total cost of function A (resulted from 5.4.8.11 section)

C2= the total cost of successor idea instead of function A (from 5.4.8.15 section)

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Equation 5:

The percentage of saving time =100-((T2/T1)*100)

T1= the total time of function A (resulted from 4.4.6.12 section)

T2= the total time of successor idea instead of function A (from 4.4.6.16 section)

5.4.8.18 Value Creation and label

This practice tends to define the Value label for each idea based on following table. The software according to value scores resulted from last section (5.4.8.17) identifies the label of the suggested ideas based on table 16. After that, the VM team's member should analyze these labels and then give their comment. The relevant window of this practice is sown in figure 55.

Table 16: Value Label in Terms of Cost-Time-Quality

Value score based on time-cost –quality	Value label	Value Creation amount
15	A+	100-90%
14	A	90-80%
13	A-	80-70%
12	B+	70-60%
11	B	60-50%
10	B-	50-40%
9	C+	40-30%
8-7	C	30-20%
6.9-5	C-	20-10%
Less than 5	D	Less than 10%
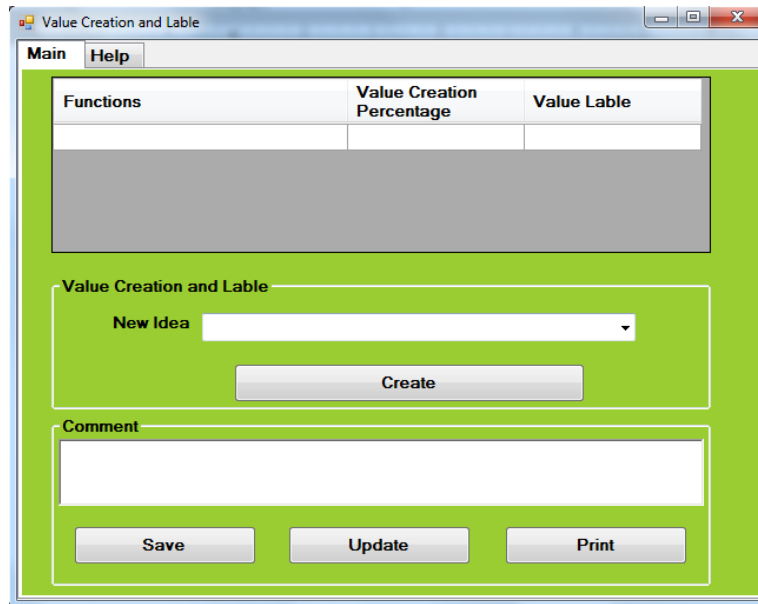
Figure 56: The View of Value Creation and Label Page

5.4.8.19 Determining Criteria

In this part at the first VM team defines the main criteria of evaluation process by using creativity techniques such as brainstorming. Afterwards, VM team compares each pair of criteria together and score the stronger of the two to rate how important each criteria (score range is 1 to 5) (figure56).
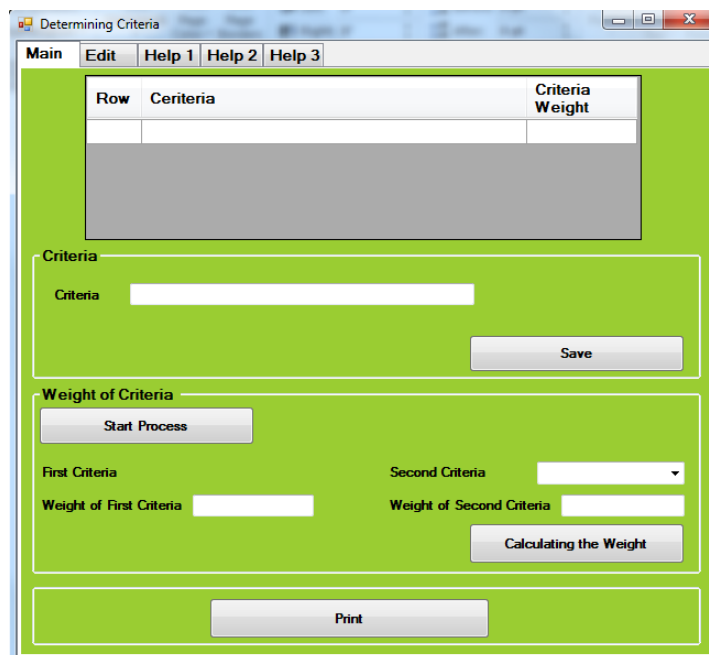
Figure 57: The View of Determining Criteria Page

5.4.8.20 Matrix Evaluation

For this practice, the suggested ideas and original functions must be appraised in terms of these clarified criteria through an evaluation matrix. First user scores the alternatives to the criteria and then software calculates the total scores of each alternative utilizing the evaluation matrix method. The range of score to assess the alternatives is 1 to 5. The figure 57 shows a view of this practice in software.

A sample of idea evaluation process of this software to evaluate four exterior wall systems is shown in table 17, for detailed instructions (Celik,2010).
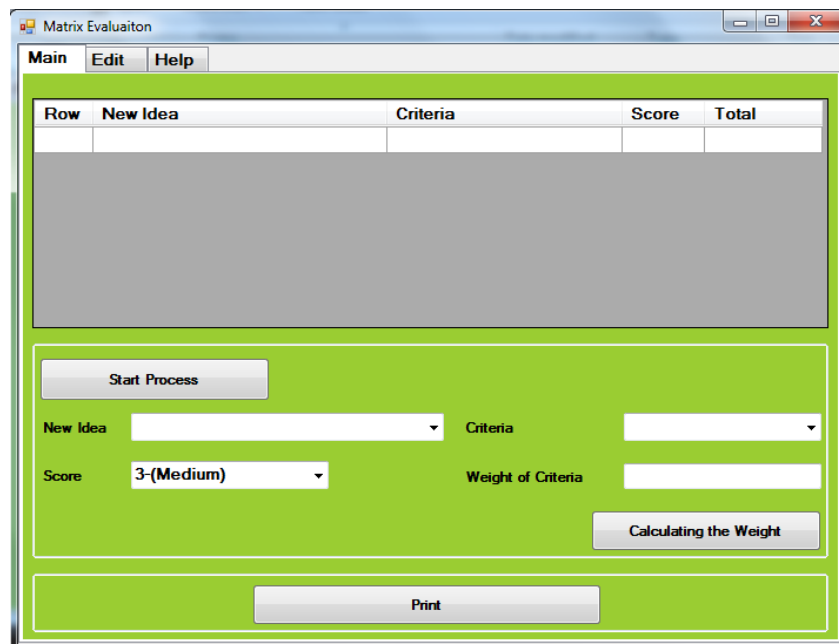
Figure 58: The View of Matrix Evaluation Page

Row	Step	Explanation
1	Identifying the main criteria	For instant in this case, criteria for the evaluation are chosen to be: • image/aesthetics • color rendition • environmental sustainability • obsolescence avoidance • operational effectiveness • durability • future extendibility
2	weighting criteria	• Each pair of criteria is compared and the stronger of the two is scored to how important scale. • For example, durability is more important than operational effectiveness, and there is a score of f=2 between two benefits. • Similarly, between operational effectiveness and future extendibility, there is a score of e=4 in favor of operational effectiveness. • Raw score as illustrated at the bottom of criteria scoring matrix, gives the addition of all the scores for each criteria. • For example, raw score of 13 for obsolescence avoidance is the sum of the numerical of d-3, d-2, d-2, d-l, d-l, and d-4. • Note that if the two criteria of a pair have • The same importance level in comparison, then they both have one score each. • Next line in the table shows the weighted importance of the criteria between1 to 10, based on the raw scores. • Note that if the criteria have zero raw score then a minimum score of 1 can be assigned for calculatıons (Celik,2010).
3	Scoring the alternatives(all ideas) in terms of criteria	• The analysis matrix lists the alternatives and each alternative is then rated on the degree to which it provides each benefit, according to the scale (1 to 5) as shown at the bottom of the figure. • A benefit score is then found for each alternative-benefit pair by multiplying the alternative rating by the benefit weight. • For example, for alternative one and color rendition this sore is 3x2=6. The total benefit score for each alternative is the sum of its individual scores. • Alternative with the highest total benefit score is the best recommended alternative(Celik,2010).

5.4.8.21 Final Reports and Results

The software finds the best idea based on the total score that gained from preceding parts (Value label and Matrix evaluation), continuity VM team's members must discuss on the result and decide to approve or disapprove it. In this way, all VM members make their final decision based on their opinion. In order to reveal their view, they should choose one of the following Items:

- I agree with this idea

- I assess this idea and it needs to be improved

- I disagree with this idea

If at least half of the VM members or more agree with the final results, it will be considered as the best idea to be done, unless the results are not be accepted and VM team must choose another idea as the final result via group discussion or VM study must be reviewed again to access new results. The date of approving of the new idea and all required comments must be recorded at the end of this practice for reporting to head of organization (figure 59).

Figure 59: The View of Final Reports and Results Page

5.4.8.22 Assessing the Improvement Situation

In this part during implementing the project in construction phase, VM team must estimate the percentage of progress of accepted idea by regularity project observation. They might periodically visit the site or assess the worksite reports made and sent by contractor to analysis the progress statement of the project. This part just is done when the VM study is applied in construction phase of project. The view of this part can be seen in figure 59.

Figure 60: The View of Assessing the Improvement Situation Page

5.4.8.23 Other Activities

If during workshops arrangement part the specific activity was added in a workshop which is not in mandatory practice list, VM team must explain and note these activities. In this case, activities are mentioned in first space of relevant page (figure 60) and then a summary of each activity and any extra explanation or VM team's opinion will be verified in "description" and "comment" places, respectively.

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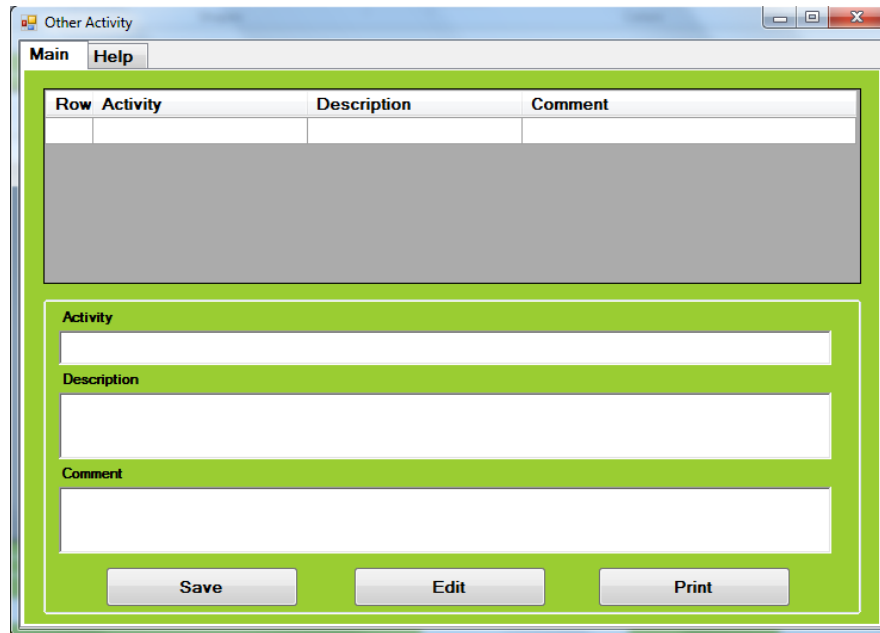
Figure 61: The View of Other Activity Page

5.4.8.24 End of the VM Process

Indeed, the VM process is finished when the best alternative and suggestion is chosen and approved. After finishing VM process, the workshops would be reviewed by VM team to be corrected and updated.

It should be noticed; a backup of every VM study with a specific number will be saved in "project information data base" as a document of VM projects of the organization (figure 28). A complete report should be made by printing the outcomes of each section. The print tab provides an access to the results for preparing the final report. User can access to each project's VM study by inputting the number of that project in the related place to print the results of each part (figure 29).

Chapter 6

EXPERT SYSTEM EVALUATION

6.1 Introduction

While Expert System is being developed to increase the quality of their design and the performance, they are usually tested.

The test consists of the performance evaluating and prototype program utilizing that is termed informal assessment. Through the informal assessment, the builder of system advances the system by getting the domain experts' feedback to create a proper type of the system. In checking process, the designed knowledge base content is changed, deleted, added, or refined, or its facilities are improved. Therefore, an Expert System development process contains an internal loop of evaluation (ISO/IEC 9126-1, 2001).

This chapter reports the informal evaluation of the Expert System. During evaluating the knowledge representation of the system, the validity of reasoning, the constancy of the expert's internal knowledge, and the system interaction ease with the users are tested. Afterwards, the system's ability to implement the essential task is examined. If the program completes the task satisfactorily, it is recognized as suitable. So, evaluation is a way to measure the success degree of an Expert System in doing a required task.

Because of the importance of Expert System evaluation before utilizing that, this chapter defines the technique used in this study to assess the accuracy of the developed Expert Systems. Moreover, this chapter discusses on the results of Expert Systems evaluation procedure.

6.2 Evaluation Methods of Expert System

Although, various common programs include solving problems that would be evaluated by clear and direct answers such as "wrong" and "right", Expert Systems do not comprise such this ability.

Hence, assessment of this study is not straight forward. The evaluation methods defined are to show that, optimal problem's solutions are found. The evaluation methods used in study are (Motameni, 2010):

1- Comparison with the experts' experiences

2- Novice users Opinion

6.2.1 Evaluation by Experts

This software was advanced with collaboration of some VM experts. During the stage of system development, several discussions about the gathered knowledge were done with these experts. This Expert System was improved by editing the program according to experts' views after discussion.

Finally the system was assessed by some other experts. These "Human Experts" were from two different construction corporations working in VM study field including "Omran Sara Karestan" and "MA-GH". More over as another "Human Expert", one faculty member of the computer engineering of Eastern Mediterranean University was asked to evaluate this software in terms of technical aspects.

The software was installed on a computer to be assessed by these human experts to be received the experts' views and relevant discussion that are mentioned in below.

The experts examined the designed VM process within the software by following related sections and parts then they compared the findings of software with their own experience and evaluate the software.

6.2.1.1 Software Functionality Checking

 In order to evaluate technical and functional features of the developed software, it has been tested by a software expert. The examination was according to ISO/IEC-9126 model which was used for software evaluation. The software was evaluated in two levels comprising some features which listed in figure 61.

Table 18 illustrates the result of examination of software by the software expert. The evaluation was taken place in six major aspects which are functionality, reliability, usability, efficiency, maintainability and portability. After evaluating each aspect the result indicates that the software has a high percentage of validity which is 85 percent. Regarding to the result of examination, the software is powerful in functionality, maintainability and portability. On the other hand, reliability of the software can be mentioned as a weakness.
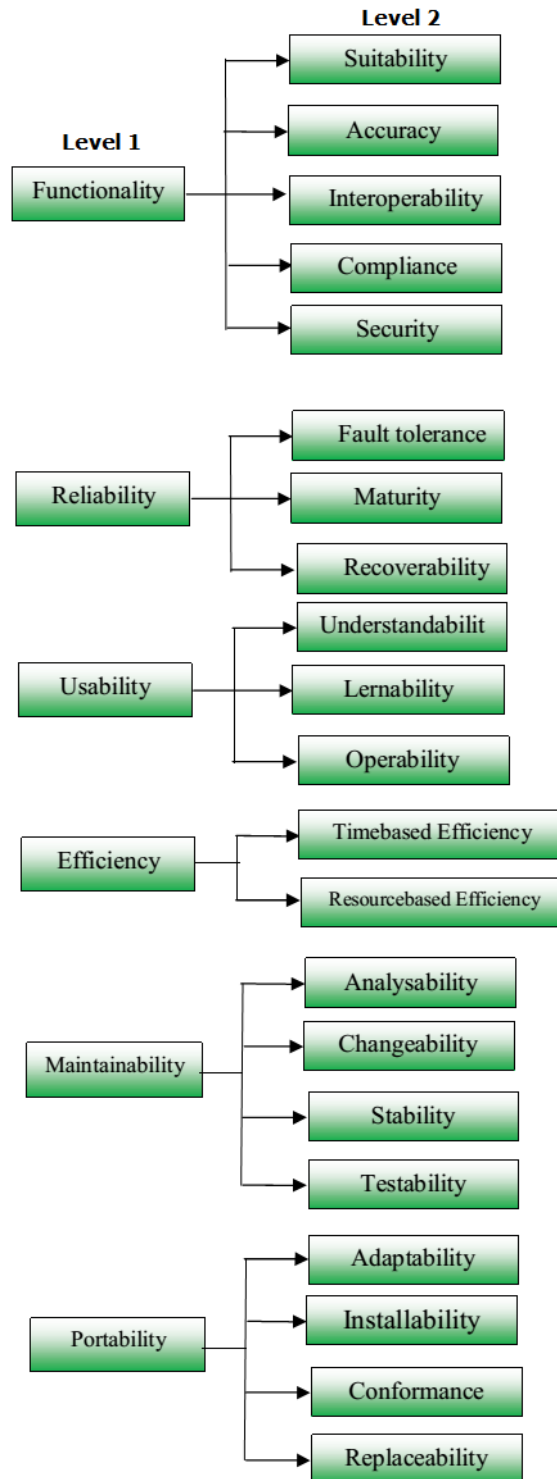
Figure 62: The Important Features to Evaluate a Software-ISO/IEC-9126

Totally, in technical aspect, the value management software is powerful and it has been developed by simple C# code which helps the application run faster and

efficient. But graphically, the software can be improved to make the software more users friendly.

Table 18: The Result of Examination of Software by the Software Expert

| Assessor | Functionality | | | | | Reliability | | | Usability | | | Efficiency | | Maintainability | | | | Portability | | | | Total score | The percentage of validity |
	Suitability	Accuracy	Interoperability	Compliance	Security	Fault tolerance	Maturity	Recoverability	Understandability	Learnability	Operability	Time-based Efficiency	Resource-based Efficiency	Analyzability	Changeability	Stability	Testability	Adaptability	Install ability	Conformance	Replace ability		
Human Expert	5	5	5	4	3	4	3	3	4	5	4	4	4	5	5	5	4	5	5	4	4	90	85%
Base point	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	105	

6.2.1.2 Experts Comment

Finally, the experts mentioned their views about the program through a letter which the summary of this letter can be visible in table19. Overall, having considered the comments; the value management software is efficient enough to use in value management projects.

Table 19: The View of Expert Systems

Assessor	View and comment	Recommendation for future study
OmranSara Karestan	It is a unique and innovative program. It seems it can be very executive and helpful program. This Expert System is like an appropriate guide and manual for those ones who are not familiar with VM study and unskilled in this field. It is a new program which is used in management field. This idea can solve probable problems in Value Management study and also decision making process and would be utilized as recommendations of the experienced VM experts.	The output of this expert can be enhanced by integrating the value management and risk management , so four future study another step particular about risk analysis can be add to this program
MaGH	This software would be helpful for pre-design phase of the projects to improve the value of construction projects. This program guides user to follow all its parts and steps by making challenging practices. It aims to raise the creativity in a decision making team. This Expert System was designed to help engineers and designers of the construction projects in group and team activities by encouraging them to utilize the methods such as Brainstorming. One of the advantages of this software is that the outputs of the program is printable and in the text form. Generally, according to our experiences, this Expert System can provide necessary information and recommendations about VM study.	For future study, the Expert System can be developed and improved by adding advanced part about time management and project planning and scheduling. Furthermore, a topic about Risk management can be useful to improve this Expert System.
Computer department's faculty of EMU	Regarding to the result of examination, the software is powerful in functionality, maintainability and portability. The value management software is powerful and it has been developed by simple C# code which helps the application run faster and efficient.	Graphically, the software can be improved to make the software more users friendly.

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6.2.2 Novice Users View

This developed Expert System was tested by some novice users who were inexperienced in VM study. We ask them to give their view about this software after utilizing it.

According their comment, these users understood the offered knowledge, and found the recommendations of this Expert System are "understandable". They supposed that the facility of explanation within the system is useful and it reveals the information and material that they were previously unfamiliar and unaware about that. Thus this software guided them on correct ways of applying the VM study for construction projects as a proper and helpful instruction. Based on their comments, all explanations or descriptions are very effective and clear, for instant the part of drawing FAST chart is very helpful and intelligible. In overall, Novice Users could follow the VM process within this software easily.

6.2.3 Examination by Case Study

In order to examine the details of this software exactly, a corporation experienced in VM study was asked to apply this software for re-studding a project' VM. This project has been done once and its pervious results are available. Next, the experts of that corporation gave their opinion about this VM Expert System comparing new outputs and old results.

6.2.3.1 Case Study Specifications

In this case, "Omran Sara Karestan" applied this software to follow the VM process for an infrastructure project that aims to provide the water for a plain.

Geographically, this plain with 16096 km^2 is located in 55 ° longitude, 29 ° latitude. Due to the limitations of surface water resources of this plain, the ground water

sources provide all water requirements of agriculture, drinking, health and industry parts. Hence, about 212 million m^3 of well water uses is more than the optimal capacity of the plain.

On the other hand, around 97 %(73000 Hectare) of total area of the plain is dedicated to farm lands such as pistachio orchards that need the ground water resources for irrigation. Recently, the rate of ground water resources reduction and the water salinity has been increased because the water withdrawal has been increased. The water salinity is about 20000 to 25000 EC which is 3 times more than the maximum level of water salinity for irrigating the pistachio gardens.

The final aim of this project is sustainable development of the plain by providing water for the farmlands irrigation and reviving the groundwater aquifers. So transferring 250(million m^3 /year) of water from a river that is located in south of this plain is suggested by stakeholder. The pre-study of this plan was done in 2006 but it has not yet implemented because of some reason such as lack of funding. In 2011, in order to enhance the value of this project a VM team was formed to assess the functions that have the greatest potential to be improved.

The VM study of this project was done to change the main function of this project from "transferring and providing water" to "economic sustainability".

The VM team's members tried to suggest a new plan that make satisfy the stakeholder in all the project's aspects by focusing on the functions of this project. According the VM study done, "economic development" was found as project's main function. Other sub functions of this project are mentioned in following:

1- Economic sustainability,2- Infrastructure development, 3-Water supply, 4-Water Displacement, 5-Using groundwater, 6-Using unconventional water, 7-Demand Management, 8-Water Transfers, 9-Water storage, 10-Water storage, 11-Using wastewater, 12-Digging the earth, 13-Water Pumping, 14-Using brackish water, 15-Changing cropping pattern, 16-Decreasing the waste of agriculture, 17-Changing irrigation and water providing pattern, 18-Creating urethral, 19-Creating voids, 20-Create a barrier to store water, 21-Create a barrier for water Deviation, 22-Wastewater Treatment, 23-Determining the resistance of plants, 24-Determining the Salinity water resources , 25-Piping, 26-Drilling Tunnel, 27-Dam construction, 28-Constructing Wastewater Treatment Plant, 29-Combination plan.

After revealing the functions, some alternatives as the new ideas based on the potential and specifications of the project were suggested by VM team through utilizing brainstorming method. Proposed alternatives and also initial plan are shown in table20. Based on the existed documentation of the VM study, finally after alternatives evaluation, the "DGK" was selected as the best alternative.

For this thesis, the "Omran Sara Karestan" corporation led the VM team again as an external facilitator to follow VM process through this software and then compare the new results with the pervious VM study's out puts. The documentation of new VM study that prepared by software is presented in appendix B.

Table 20: Proposed Alternatives and Initial Plan -Case Study

row	Alternatives	Symbol	State	Irrigation system	Water Sources	Area under cultivation
2	Drip irrigation- from Ground water - with Keeping current state of the area under cultivation	DGK	New Idea	Drip irrigation with 60% efficiency	500 $milion\ m^3$ of ground water	73000 Hectare-keep Current state
3	Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	DGRC	New Idea	Drip irrigation with 60% efficiency	500 $milion\ m^3$ of ground water & Transferring 220 $milion\ m^3$ of water from river	110000 Hectare-changing Current state
4	Combination plan - Traditional irrigation- from Ground water and River- with Kipping current state of the area under cultivation	TGRK	initial plan	Traditional irrigation with 36 % efficiency	500 $milion\ m^3$ of ground water & Transferring 220 $milion\ m^3$ of water from river	73000 Hectare-keep Current state

As it can be seen in appendix B, the gained results and final chosen alternative are in accordance with the outputs of previous VM study that confirms the accuracy and efficiency of developed Expert System. After using the VM software for the case study, The "Omran Saraye Karestan" corporation's experts support efficiency of the software and stated that:

"Regarding to evaluation process done, the results of new VM study implementation that was completed based on advanced Expert System, have been close to final outputs of previous VM study. The VM process was re-executed faster and more accurate by the software. Therefor the VM software is very helpful for doing the VM

study especially in pre stage of the construction projects. This Expert System was so developed that the integration between all parts and sections to be preserved. Required inputs and gained out puts of each part and section are logical and complete. This software is kind of friendly software that guides the amateur users to do VM study in the best way. The out puts and results that would be received through this software have high accuracy and also they are very dependable. We strongly recommend adopting this software over the VM study of construction projects to make best decision and achieve reliable results faster in a shorter time. The Expert System is designed in such a way that arranges all steps and parts of VM process in the best possible state. In sum up, this software can provide more than 90% of those demands that VM team needs during a VM Study."

Chapter 7

CONCLUSION

7.1 Conclusion

Different stages of construction project's life need expertise. In order to perform various tasks of a construction project such as managerial activities, expert knowledge is very important and essential. Value management (VM) field is a type of those managerial practices that has not been properly recognized in some aspects by construction industry especially in developing country.

VM is a systematic, analytical, and structured procedure that aims to increase the value of project by searching for essential project's functions and then reviewing and improving them. VM uses a unique combination of methods and concepts to generate sustainable value and benefits for stakeholders. Some tools, methods and techniques are just for VM process and others are employed in many activities. Available knowledge and expertise about VM study must be properly stored and documented, then shared among those engineers and designers who are inexperienced in this subject.

Nowadays, technology is used to keep the expert knowledge in computers. Construction industry tries to save knowledge or expertise and makes them accessible to be used by less experienced persons. Expert systems are those systems that are employed to transfer knowledge. The quality and advance the productivity of

the projects' performances can be improved if the stakeholders use this system (Motameni, 2010)

Since these systems are valuable and helpful in construction projects, this thesis aimed to develop an Expert System for M study's steps and tools. The basic knowledge has been collected from literatures and domain experts through questionnaire survey.

By using "**Value Management (VM) Study/Process software**" (the Expert System shell components), these expertise and knowledge are employed to create implementation alternatives and select appropriate decision for a construction project considering various aspects of that project. A user interface is required to establish communication between user and system that is written in **"Visual Studio 2012" and "C#"** languages. **Crystal** Report application is also utilized to take the print of information, received in the software, by the user. The database of this program is **SQL server Express 2012**.

The defined interface wants some information or in some part asks questions to gather the data and answers of the user as the inputs. Then it guides users to follow all steps to make a comprehensive document of key characters and specifications of the project. Finally, it helps them to select best alternative by following VM process.

To sum up, the major conclusions that emerge from these studies are:
1- The application difficulties of the VM study in construction industry were determined. In addition, comprehensive explanations and definitions and also a proper view of VM process were obtained.

2- Improvement of the knowledge of construction managers about VM study via developing an Expert System was concluded from this research.

3- The capabilities and benefits of the VM Expert System in construction industry were approved. In this regard, The VM program examined and evaluated upon domain expert's opinion; three experienced references accepted its performance and they found it useful and appropriate for novice engineers.

4- The software performance accuracy was approved through a case study. This case study revealed that the outputs of VM software are consistent with domain experts' expectations and demands.

5- In each step of software, VM team can prepare relevant printed documentation and reports through Print part of that step. Moreover, the user can correct each step anytime using update button.

6- The system is coded in a simple manner to ensure easy updating by the developer or any other knowledge engineer in this domain.

7- The "**Value Management (VM) Study/Process software**" can be applied in construction project and also used as training program in the construction companies to teach VM study's steps to inexperienced engineers.

7.2 Future Research

For further work, it seems that there is good possibility in inserting "Risk Management" field to the program to improve this research. Furthermore, other recommended areas which would be involved with VM field as a new component by developing an Expert System for future study are:

1- Health and safety management

2- Cost schedule management

3- Project controlling system

4- Financial planning

5- Marketing strategy

6- Construction equipment policy

7- Life cycle cost calculation

8- Time analysis and time planning

REFERENCES

Abidin, N., Z. & Pasquire, C. L. (2006). *Revolutionize value management: a mode towards sustainability*. International journal of project management, p. 275-279

Aini, J., Nur, A. & Mardhiah, Z. (2012). *Implementation of Value Management in Public Projects*, AicE-Bs 2012 Cairo ASIA Pacific International Conference on Environment-Behaviour Studies, Sciverse ScienceDirect, Procedia - Social and Behavioral Sciences 68 (2012) 77 – 86

Armstrong, M. (1992). *Management Processes and Functions*. London: Institute of Personnel and Development

Arockiasamy, M. (1993). *Expert Systems Applications for Structural, Transportation, and Environmental Engineering* (2nd Edition)

AS- 4183. (2007). *Australian Standard-Value Management*. Committee OB-006, Value Management, Standards Australia

Ashworth, A. (2002). *Pre contract studies: Development economics, tendering and Estimating*. Oxford. Blackwell publishing

Berners-Lee, T., Hendler, J. & Lassila, O. (2001). *The Semantic Web A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities*. Scientific American

BS EN 12973. (2009). *Value Management BSI*. British Standards Institution: British and European Standard, London

Celik, T. (2010). *Value Management*. Lecture note. Department of Civil Eng. Eastern Mediterranean University (EMU)

Cloete, C. & E. (2008). Classnotes- *Value management and life cycle costing*. University of Pretoria, Pretoria

Constructing Excellence. (2004). *Value Management*. Published by Constructing Excellence

DeMarle, D. & J. (1971). *Criteria Analysis of Consumer Products*. Proceedings of the Society of American Value Engineers, Vol. 6, pp. 267-272

Directorate-GeneralXIII .(1995). *Value Management Handbook*. Pulife life blished by the EUROPEAN COMMISSION Directorate- GeneralXIII Telecommunications, Information Market and Exploitation of Research L- 920Luxembourg. ISBN92-826-9534-4. ECSC-EC-EAEC,Brussels· Luxembourg.Printed in Italy

Ellis R., C. & T., Keel D. A. & Wood G.D. (2004). *Value management practices of leading UK cost consultants*. Construction Management and Economics, p. 484, 489, 491

Fuller, S. (2005). *Guidance on Life-Cycle Cost Analysis Required*. Executive Order 13123, Department of Energy Federal Energy Management Program Washington, DC 20585

Graham, D., Gronqvist, M., Kelly, J. & Male, S. (2006). *Managing value as a management style for project*. Value solutions

Guidelines of Iranian value society. (2001). *Value Engineering and management*. Iran

Hayes-Roth, F. (1983). *Using proofs and refutations to learn from experience*. Machine Learning. R. S. Michalski, J. G. Carbonell and T. M. Mitchell. Palo Alto, CA, Tioga Publishing: 221-240

ISO/IEC 9126-1. (2001). *Software engineering - Product quality - * Part 1: Quality Model, First edition

Kaufman, J. (1998). *Value Management, creating Competitive Advantage*. Houston, Crisp Publications Inc

Kelly, J., Male, S. & Graham, D. (2004). *Value Management of Construction Projects*. Blackwell

Kelly, J. (2007). *Making client values explicit in value management workshops*. Construction Management and Economics, Vol.25 No. 4. pp435-42

Kelly, J. & Male, S. (1993). *Value management in design and construction*. The economic management of projects, Glasgow, E & FN, Spon Inc

Locke, M.B. (1994). *Management of value in the British construction industry*. SAVE International, London

Motameni, H. (2010). *A Rule Based Expert System for Mobilization of Construction*. Thesis for the Degree of Master of Science, Civil engineering department, Eastern Mediterranean University

Neasbey, M., Barton, R. & Knott, J. (1999). *Value Management*. In Best, R. and De Valence, G. (ed.) Building in Value: Pre-Design Issues, Sydney: Arnold, 232-47

Norton, B. & McElligott, W. (1995). *Value Management in Construction: A Practical Guide*. Macmillan, Basingstoke, UK

Patton, M.Q. (1990). *Qualitative Evaluation and Research Method*. 2nd Ed. Newbury Park, CA: Sage

Programing and management office of Iran. (2007). *A series of instructions of Value Management before construction stage*.100/215919 by Programing and management

Qiping, G. & Shen, Ann T.W. Yu. (2012). *Guest Editorial Value management: recent developments and way forward*. Emerald Group Publishing Limited, Construction Innovation, Vol. 12 No. 3, 2012 pp. 264-271

Qiping, S. (2004). *Applications of Value Management in the Construction Industry in China*. Engineering construction and architectural management, 11, 2004, 9-19

Raeispoor, a., (2006). *The Methodology of value engineering for electricity transmission and distribution projects*. Khuzestan Regional Electricity Company

Rahmanian, D. (2011). *The Role of Value Engineering in National Saving*. presented for managers of Water and Waste water corporation of Iran, Mhab ghods Corporaion

Saris, W. & Gallhofer, I. (2007). *Design, Evaluation, and Analysis of Questionnaires for Survey Research*. Print ISBN: 9780470114957. Online ISBN: 9780470165195

SAVE International. (2007). *Value methdology standard andbody of knowledge*.SAVE International Value Standard of value society

Sixsmith, J. & Murray, C. D. (2001). *Ethical issues in the documentary data analysis of internet posts and archives*. Qualitative Health Research, 11(3), 423–432

Spaulding, W. (2005). *The use of function analysis as the basis of value management in the Australian construction industry*. Construction Management and Economics, 23 (7)

Srinath, P., Carolyn, S. & Stephen, K. (2011). *An analysis of value management in practice: the case of Northern Ireland's construction industry*. Journal of Financial Management of Property and Construction, Vol. 16 No. 2, 2011. pp. 94-110

Stewart, R. B. (2010). *Value optimization for project and performance management*. Hoboken, NJ, Wiley

Temple, B. & Young, A. (2004). *Qualitative research and translation dilemmas*. Qualitative Research, 4(2), 161–178

Thomas, G. & Thomas, M. (2005). *Construction partnering and integrated team working*. Oxford: Blackwell publishing Ltd

U.S. ArmyD.C., (2009). *Value Engineering*. 20314-2009

Value management guidelines. (2005). *Value management guidelines*. Department of Housing and Works Government of Western Australia

Whyte , A. & Cammarano, C. (2012). *Value management in infrastructure projects in Western Australia* . Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 797-806

Yazdanpanah, A. (2010). *Proposed Model for Implementation Expert System for the Planning of Strategic Construction Projects as a Tool for Knowledge Management*. 2th IPM congress

APPENDICES

Appendix A

Questionnaire: This is the questionnaire sent to experts in VM field to get their

opinion and experience about previous VM studies done.

Please, mark each item (if that is though about your organization, if there is other explanation, write them on comment part (in the left side))

Value management grid

type	number	question / item	options	comments and more explanation
respondent	1	personal information	surname / name	other comments and details
organization	2	organization name	name	other comments and details
		Has how many years your organization have used VM for those projects (years)	less than 1 / 6 to 10 / 11 to 20 / more than 21	other comments and details
project	3	what is the project type that your organization has used your process for them (please add more rows if you want to give information for more than 1 project)	road / water system / building-structure	other comments and details
		The total estimated cost of this project ($)	Less than $50 / $50 to $200 (Thousand) / $200 to $600 / more than $600	other comments and details
		The total estimated time of this project (year)	Less than 1 / 1 to 3 (year) / 3 to 5 / more than 5	other comments and details
		the time of using VM in this project	job study / Design / construction / operation / all phases or more than a phase	other comments and details
		Team Facilitator	Design consultant / Stakeholder / VM Consultant / facilitator	other comments and details
		Who are the team members. And how many people are	less than 3 person / 3 to 5 / 6 to 10 / more than 10 person	
		For how long the members of VM team have been trained	less than 8 hours / 8 to 20 hours / 20 to 40 / 40 to 50 hours / more than 51 hours / with out training	
		workshops number that where holding (days)	less than 3 / 4 to 6 / 7 to 10 / 10 to 15 / 16 to 30	
VM process	4	Methods and tools that used during VM process	function analysis / Cost-Benefit analysis (B/C) / FAST chart analysis / brain storming / calculating value index	other comments and details
			Issues Generation & Analysis / using advantages/disadvantages method to evaluate / weighted matrix / Decuple cost analysis / SWOT analysis	other comments and details
			Simple multi-attribute rating technique (SMART) / Time, cost and quality triangle / Level of value / cost estimation / Risk Analysis	other comments and details
		VM function(s)/standard that was used	SAVE International Value Standard / SEBS Value Engineering of Building Services – Application Guide / UK Department of Trade and Industry Value Management Guide / Australian Value Standard AS 4183:2007 / British/European VM Value Standard BS/EN 12973:2000 / The Value Management Benchmark Male et al. (1998)	other comments and details
		time / after using VM: the percentage of saving time and cost	less than 5% / 5 to 10% / 10.1 to 15% / 15.1 to 20% / more than 20%	other comments and details
		cost	less than 5% / 6 to 10% / 10.1 to 15% / 15.1 to 20% / more than 20%	
		after using VM: the percentage of increasing	less than 5% / 7 to 10% / 10.1 to 15% / 11.1 to 20% / more than 25%	
VM results	5	what are the kinds of report that your organization make at the end of VM process as final output to give to the head	basic information of project such as income cost and time or other specification / the information of VM team (members and meeting time) / the information of cost and time saving percentage after VM process and percentage of increasing of quality / idea creation report / Ideas analyzing and scoring report / extra attachments such as drawings, study department or other instrument	other comments and details
			Time limitations / Lack of knowledge about VM / Analogous specification / Faulty analogous drawing	other comments and details
			lack of good VM consultant / lack of clear definition of VM / lack of determining good criteria	other comments and details
constraints and barriers	6	issues affecting value management	Time limitations / lack of comprehensive final report of VM / lack of determining good criteria / Cost saving / improved profit	other comments and details
			Improved project value for client / Improved effectiveness / Confidential relationship / No standard of drawings / Budget limitation	other comments and details
		VM Benefits	Improved project value for client / Documentation of issues/opportunities / Improved reputation / Reduced claims or disputes	other comments and details

Appendix B

VM Report of Case study: This documentation involves total reports of VM

process and relevant steps were prepared by the VM software.

Basic Information		
Date	16-Apr-14	
Application Number	123	
Project Subject	Water project(Infrastructure)	
Place of Project	Mashhad Iran	
Project Advisor	Pooya Negar Karestan	
Project Main Goals	Providing water for the south plains of Iran	
Phase	Design	
Anticipated Investment Costs	650,000.00	
Investment Costs	0.00	
Opration and Maintenance Costs	0.00	
Demolitation Costs	0.00	
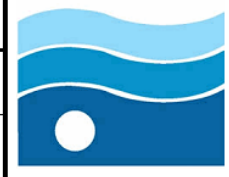
The Summary of Suggested Project	
Comment	The plan of Water transformation from the branches of the Karun River (soolgan) to Rafsanjan plain.
Facilities	-All required and common facilities including Machinery and required materials will be provide by stakeholder also parking during construction is ready near the work site and specific way and area for machines is available. -local material and machines and Suitable land and Infrastructure for Water Transmission.
Limitations	-The worksite is near the a vilage, so the vilage privacy and limitations should be considered in designing plan. -Space limitation of road and lake and time limits for the operation of the project is also must be considered.
Other	According to the objectives of the project, design must be a climatic design and achive sustainability.

Attachments

Tables Cost Estimation	Attached	Report	Not Attached	Standard	Attached
Project Summary	Attached	Drawing	Attached	Bill of Quntities	Not Attached
Feasibility Report	Attached	Permissions	Not Attached	Other	

Applicant

Name and Surname	Keyvan Satari
Organization Responsibility	Building expert
Date	24.01.2014

Final Decison

Result	Approved
Date	01.02.2014

Number of Workshop

Pre Study	6 days (Mandatory)	The First Stage of Construction	-
Design	6 days (Mandatory)	After 12.5% of Progress	-
		After 25% of Progress	-

Members					
Number	Name and Surname	Unit	Position	Membership Status	Decison
1	Hamid Safaei	Technical office	Head	Full	Approved
2	Shahed Afzali	Monitoring office	Head	Full	Approved
3	Fatemeh Amiri	VM office	Expert	Full	Approved
4	Ahmad Karimi	Centeral office	Head of organization	Full	Approved
5	Sina Kazemi far	VM offce	Head	Full	Approved
6				Full	Approved

Application Number	123	
Project Subject	Water project(Infrastructure)	
Facilitator Name	Omran Sara Karestan	

VM Team Members

Advisor Number	Name and Surname	Position	Decision Situation	Organization Type	Organization Name	Tellephone
1	Fatemeh Amiri	Full-Time Member	Yes	Stackholder	Manicipality	(051) 333-2533
2	Sina Kazemifar	Supervisor Of VM	Yes	Stackholder	Manicipality	(051) 335-2546
3	Saeed Mohseni	Leader	Yes	VM Consultant	Omran Sara Karestan	(051) 236-8773
4	Samad Hatefzade	Secretary	Yes	VM Consultant	Omran Sara Karestan	(051) 421-6017
5	Hashem Sedghiyan	Full-Time Member	Yes	Other	Design counsultant	(051) 238-9017
6	Ali Azimi	Full-Time Member	Yes	Consultant	Design consultant	051267452

Application Number	123
Subject	Water project(Infrastructure)
Number of Meeting	12

Workshop Number	Description	Date	Start Time	End Time	Place
1	(1)Analyzing Attachments	02.03.2014	11:30	12:30	Conference Room
1	(2)Analyzing Collected Data and Information	02.03.2014	12:30	13:30	Conference Room
2	(3)Determining Project	03.03.2013	11:30	12:30	Conference Room
2	(4)Determining Functions of Project	03.03.2014	12:30	13:30	Conference Room
3	(5)Drawing FAST Chart of Project	04.03.2014	11:30	12:30	Conference Room
3	(6)Estimating the Cost of each Function	04.03.2014	12:30	13:30	Conference Room
4	(7)Estimating the Time of Each Function	05.03.2014	11:30	12:30	Conference Room
4	(8)Selecting Functions with the Best Possibility of Improvement	05.03.2014	12:30	13:30	Conference Room
5	(9)Detemining Function's Element	06.03.2014	11:30	12:30	Conference Room
5	(10)Drawing FAST Chart of Selected Functions (for improvement)	06.03.2014	13:30	14:30	Conference Room
6	(11)Estimating the Cost in Details	07.03.2014	11:30	12:30	Conference Room
6	(12)Estimating the Time in Details	07.03.2014	12:30	13:30	Conference Room
7	(13)Suggesting New Idea for Each Selected Functions	08.03.2014	11:30	12:30	Conference Room
7	(14)Drawing FAST Chart of Each New Ideas	08.03.2014	13:30	14:30	Conference Room
8	(15)Estimating the Cost of Each New Idea	09.03.2014	11:30	12:30	Conference Room
8	(16)Estimating the Time of Each New Idea	09.03.2014	13:30	14:30	Conference Room
9	(17)Evaluating New Idea Based on Time-Cost-Quality	10.03.2014	11:30	12:30	Conference Room

9	(18)Value Creation and Label	10.03.2014	13:30	14:30	Conference Room
10	(19)Determining Criteria	11.03.2014	11:30	12:30	Conference Room
11	(20)Evaluating Each Idea Based on All Criteria (Evaluating Matrix)	12.03.2014	12:30	13:30	Conference Room
12	(21)Final Reports and Results	13.03.2014	11:30	12:30	Conference Room

Row	Functions	New Ideas	Elements
1	Combination plan- TGRK	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Providing 500 milion m^3 from ground water sources
2	Combination plan- TGRK	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Drip irrigation with 60% efficiency
3	Combination plan- TGRK	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Keeping current state of the area under cultivation (73000 Hectar)
4	Combination plan- TGRK	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area	Providing 500 milion m^3 from ground water sources
5	Combination plan- TGRK	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area	Transferring 220 milion m^3 of water from river
6	Combination plan- TGRK	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area	Drip irrigation with 60% efficiency
7	Combination plan- TGRK	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area	Changing current state of the area under cultivation (110000 Hectar)

List of New Ideas

Attendance List		
Workshop Number	Name and Surname	Attendance Situation
1	Ali Azimi	No
1	Fatemeh Amiri	Yes
1	Hashem Sedghiyan	Yes
1	Saeed Mohseni	Yes
1	Samad Hatefzade	Yes
1	Sina Kazemifar	Yes

Analyzing Attachments	

Documents	Comment
Feasibility Report	According to reports. the feasibility of project was proved(first plan).
Map	They are not complete.
Project Summary	-Compelet and clear -all document was assessd -Progress report for 6 month of study is available.
Standard	The standard of Civil and water engineers -227 number is considered.
Tables Cost Estimation	The pre estimation of project's cost is about 5300000 $.

Shortages	-The map of area line is not clear. -The permision document is not clear and compelet.

Analyzing Collected Data and Information

Row	Item
1	Cost

Comment
The pre estimation of project's cost is about 5300000 $ -The life cycle cost of project is note east mated in this step of project. The life cycle cost will be calculated in phase 2 of studies.

Row	Item
2	Administrative rules and restrictions

Comment
There is several limitations about the spase of road and lake - there is several limitations about the space of road and lake- Executive space, especially in the area Soolgan

More Requirement	1- life cycle cost calculation and analyzis 2- all details of plan

Determining Project	
Application Number	123
Project Description	
The plan of Water transformation from the branches of the Karun River (soolgan) to Rafsanjan plain.	
Works That Should be Done to Access Object	
There are 2 ways providing water by teransfering or ground water in place.	
Project's Object	
Water transferring.	
Achievements	
Rafsanjan plain irrigation for agricultural purposes.	
Facilities	
Local material and machines and Suitable land and Infrastructure for Water Transmission	
The Project of Applying VM Process for This Project	
To improve the value and quality of project and cutting extera and unnessesary cost	
Barriers and Limitations	
Space limitation of road and lake and time limits for the operation of the project.	

Determining Functions of Project	
Row	**Functions**
1	Economic sustainability
2	Infrastructure development
3	Water supply
4	Water Displacement
5	Using groundwater
6	Using unconventional water
7	Demand Management
8	Water Transfers
9	Water storage
10	Water diversion
11	Using wastewater
12	Digging the earth
13	Water Pumping
14	Using brackish water
15	Changing cropping pattern
16	Decreasing the waste of agriculture
17	Changing irrigation and water providing pattern
18	Creating urethral
19	Creating voids
20	Create a barrier to store water
21	Create a barrier for water Deviation
22	Wastewater Treatment
23	Determining the resistance of plants
24	Determining the Salinity water resources
25	Piping
26	Drilling Tunnel
27	Dam construction
28	Constructing Wastewater Treatment Plant
29	Combination plan- TGRK

Economic sustainability	Infrastructure development	Water supply	Water Displacement	Water Transfers	Creating urethral	Piping
					OR	
					Creating voids	Drilling Tunnel
				OR		
				Water storage	Create a barrier to sto...	Dam construction
				OR		
				Water diversion	Create a barrier for w...	

Digging the earth

AND

OR
Using groundwater — Water Pumping

	Using wastewater	Wastewater Treatment	Constructing Wastewater...
OR	**OR**		
Using unconventio...	using brackish water		Determining the resistan...

AND

Determining the Salinity ...

changing cropping pat...

OR

OR
Demand Management — Decreasing the waste of...

OR

changing irrigation an...

OR
combination plan-TGRK — Water Displacement — Water Transfers — Piping

Digging the earth

AND

AND
Using groundwater — Water Pumping

AND
Demand Management — changing cropping pat...

AND

changing irrigation an...

Estimating the Cost of each Function

Row	Functions
1	Economic sustainability

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
108,000.00	120,000.00	72,000.00	110,000.00	90,000.00	150,000.00	650,000.00

Row	Functions
2	Infrastructure development

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
110,000.00	92,000.00	70,000.00	99,000.00	75,000.00	155,000.00	601,000.00

Row	Functions
3	Water supply

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
155,000.00	100,500.00	80,500.00	110,000.00	80,000.00	130,000.00	656,000.00

Row	Functions
4	Water Displacement

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
130,000.00	120,000.00	65,000.00	92,000.00	83,000.00	100,000.00	590,000.00

Row	Functions
5	Using groundwater

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
95,000.00	110,000.00	45,000.00	100,000.00	53,000.00	97,000.00	500,000.00

Row	Functions
6	Using unconventional water

Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total
130,000.00	150,000.00	83,000.00	100,000.00	95,000.00	90,000.00	648,000.00

Estimating the Cost of each Function							

Row	Functions						
7	Demand Management						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
90,000.00	110,000.00	25,000.00	95,000.00	50,000.00	115,000.00	485,000.00	

Row	Functions						
8	Water Transfers						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
115,000.00	125,000.00	60,000.00	100,000.00	83,000.00	105,000.00	588,000.00	

Row	Functions						
9	Water storage						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
130,000.00	130,000.00	74,000.00	110,000.00	80,000.00	90,000.00	614,000.00	

Row	Functions						
10	Water diversion						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
100,000.00	120,000.00	67,000.00	93,000.00	80,000.00	100,000.00	560,000.00	

Row	Functions						
11	Using wastewater						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
129,000.00	145,000.00	80,000.00	100,000.00	95,000.00	95,000.00	644,000.00	

Row	Functions						
12	Digging the earth						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
40,000.00	45,000.00	30,000.00	35,000.00	10,000.00	55,000.00	215,000.00	

Estimating the Cost of each Function							

Row	Functions						
13	Water Pumping						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
55,000.00	55,000.00	11,000.00	52,000.00	35,000.00	55,000.00	263,000.00	

Row	Functions						
14	Using brackish water						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
120,000.00	140,000.00	79,000.00	100,000.00	89,000.00	100,000.00	628,000.00	

Row	Functions						
15	Changing cropping pattern						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
87,000.00	89,000.00	10,000.00	65,000.00	15,000.00	87,000.00	353,000.00	

Row	Functions						
16	Decreasing the waste of agriculture						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
50,000.00	95,000.00	10,000.00	73,000.00	10,000.00	95,000.00	333,000.00	

Row	Functions						
17	Changing irrigation and water providing pattern						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
95,000.00	95,000.00	25,000.00	76,000.00	50,000.00	90,000.00	431,000.00	

Row	Functions						
18	Creating urethral						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
110,000.00	110,000.00	55,000.00	90,000.00	85,000.00	100,000.00	550,000.00	

Estimating the Cost of each Function							

Row	Functions						
19	Creating voids						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
115,000.00	110,000.00	55,000.00	92,000.00	85,000.00	100,000.00	557,000.00	

Row	Functions						
20	Create a barrier to store water						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
125,000.00	125,000.00	79,000.00	110,000.00	80,000.00	100,000.00	619,000.00	

Row	Functions						
21	Create a barrier for water Deviation						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
95,000.00	115,000.00	65,000.00	95,000.00	85,000.00	110,000.00	565,000.00	

Row	Functions						
22	Wastewater Treatment						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
125,000.00	140,000.00	79,000.00	110,000.00	95,000.00	95,000.00	644,000.00	

Row	Functions						
23	Determining the resistance of plants						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
65,000.00	75,000.00	25,000.00	45,000.00	45,000.00	50,000.00	305,000.00	

Row	Functions						
24	Determining the Salinity water resources						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
55,000.00	50,000.00	20,000.00	39,000.00	45,000.00	50,000.00	259,000.00	

Estimating the Cost of each Function							

Row	Functions						
25	Piping						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
113,000.00	120,000.00	59,000.00	120,000.00	80,000.00	100,000.00	592,000.00	

Row	Functions						
26	Drilling Tunnel						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
110,000.00	100,000.00	55,000.00	92,000.00	85,000.00	100,000.00	542,000.00	

Row	Functions						
27	Dam construction						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
125,000.00	125,000.00	79,000.00	110,000.00	80,000.00	100,000.00	619,000.00	

Row	Functions						
28	Constructing Wastewater Treatment Plant						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
125,000.00	140,000.00	79,000.00	110,000.00	95,000.00	95,000.00	644,000.00	

Row	Functions						
29	Combination plan- TGRK						
Investment Cost	Opration and Maintenance	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
125,000.00	100,000.00	80,000.00	90,000.00	89,000.00	89,000.00	573,000.00	

Estimating the Time of Each Function		
Row	Function	Time
1	Economic sustainability	365
2	Infrastructure development	365
3	Water supply	365
4	Water Displacement	365
5	Using groundwater	150
6	Using unconventional water	365
7	Demand Management	120
8	Water Transfers	150
9	Water storage	365
10	Water diversion	210
11	Using wastewater	365
12	Digging the earth	100
13	Water Pumping	90
14	Using brackish water	365
15	Changing cropping pattern	100
16	Decreasing the waste of agriculture	100
17	Changing irrigation and water providing pattern	150
18	Creating urethral	150
19	Creating voids	150
20	Create a barrier to store water	365
21	Create a barrier for water Deviation	365
22	Wastewater Treatment	365

Estimating the Time of Each Function		
Row	**Function**	**Time**
23	**Determining the resistance of plants**	120
24	**Determining the Salinity water resources**	120
25	**Piping**	160
26	**Drilling Tunnel**	130
27	**Dam construction**	365
28	**Constructing Wastewater Treatment Plant**	365
29	**Combination plan- TGRK**	210

Selecting Functions with the Best Possibility of Improvement

Row	Function	Cost	Time	Select to Improve
1	Economic sustainability	650,000.00	365	No
2	Infrastructure development	601,000.00	365	No
3	Water supply	656,000.00	365	No
4	Water Displacement	590,000.00	365	No
5	Using groundwater	500,000.00	150	No
6	Using unconventional water	648,000.00	365	No
7	Demand Management	485,000.00	120	No
8	Water Transfers	588,000.00	150	No
9	Water storage	614,000.00	365	No
10	Water diversion	560,000.00	210	No
11	Using wastewater	644,000.00	365	No
12	Digging the earth	215,000.00	100	No
13	Water Pumping	263,000.00	90	No
14	Using brackish water	628,000.00	365	No
15	Changing cropping pattern	353,000.00	100	No

Selecting Functions with the Best Possibility of Improvement				
Row	Function	Cost	Time	Select to Improve
16	Decreasing the waste of agriculture	333,000.00	100	No
17	Changing irrigation and water providing pattern	431,000.00	150	No
18	Creating urethral	550,000.00	150	No
19	Creating voids	557,000.00	150	No
20	Create a barrier to store water	619,000.00	365	No
21	Create a barrier for water Deviation	565,000.00	365	No
22	Wastewater Treatment	644,000.00	365	No
23	Determining the resistance of plants	305,000.00	120	No
24	Determining the Salinity water resources	259,000.00	120	No
25	Piping	592,000.00	160	No
26	Drilling Tunnel	542,000.00	130	No
27	Dam construction	619,000.00	365	No
28	Constructing Wastewater Treatment Plant	644,000.00	365	No
29	Combination plan- TGRK	573,000.00	210	Yes

Detemining Function's Element		
Row	**Functions**	**Elements**
1	**Combination plan- TGRK**	**Providing 500 milion m^3 from ground water sources**
2	**Combination plan- TGRK**	**Transferring 220 milion m^3 of water from river**
3	**Combination plan- TGRK**	**Traditional irrigation with 36 % efficiency**
4	**Combination plan- TGRK**	**Keeping current state of the area under cultivation (73000 Hectar)**

How? $\longrightarrow$ $\longleftarrow$ Why? L.O.F

Combination plan-TGRK

Providing 500 milion m^3 from ground water sources

AND

Transferring 220 milion m^3 of water from river

AND

Traditional irrigation with 36% efficiency

AND

keeping current state of the area under cultivation (73000
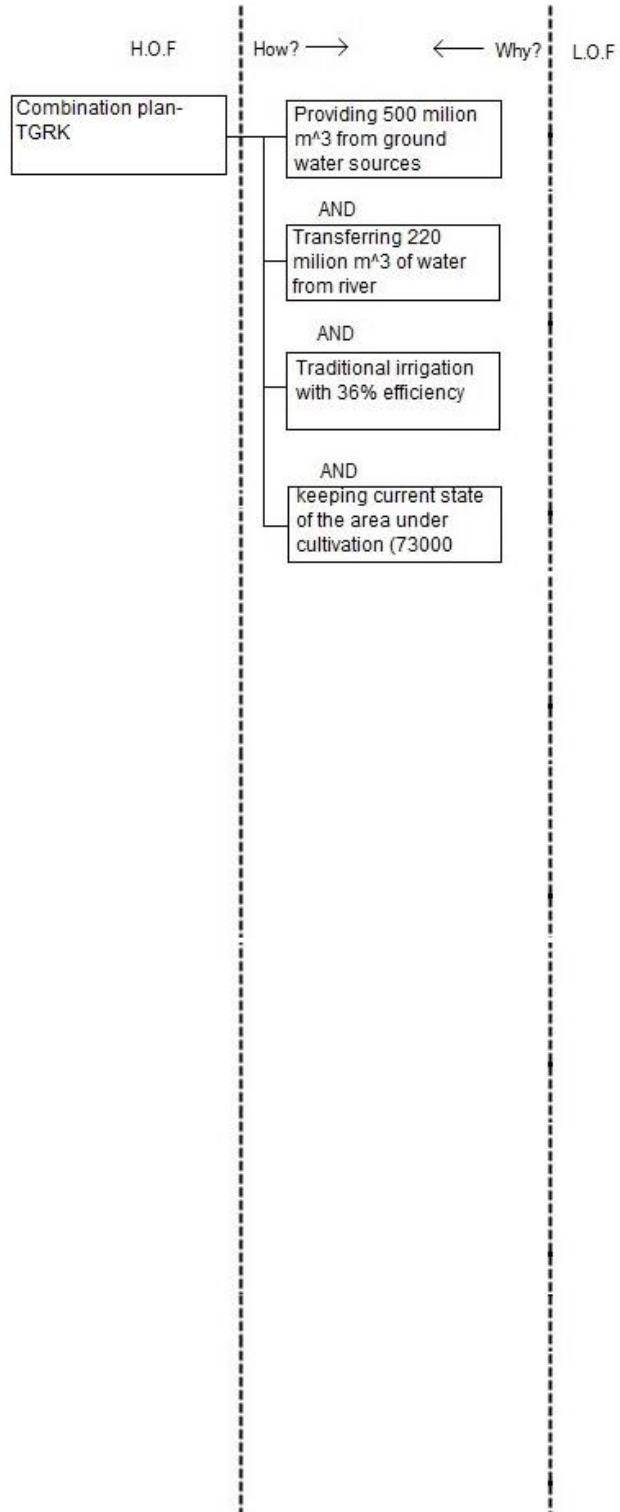
Cost Estimated in Details
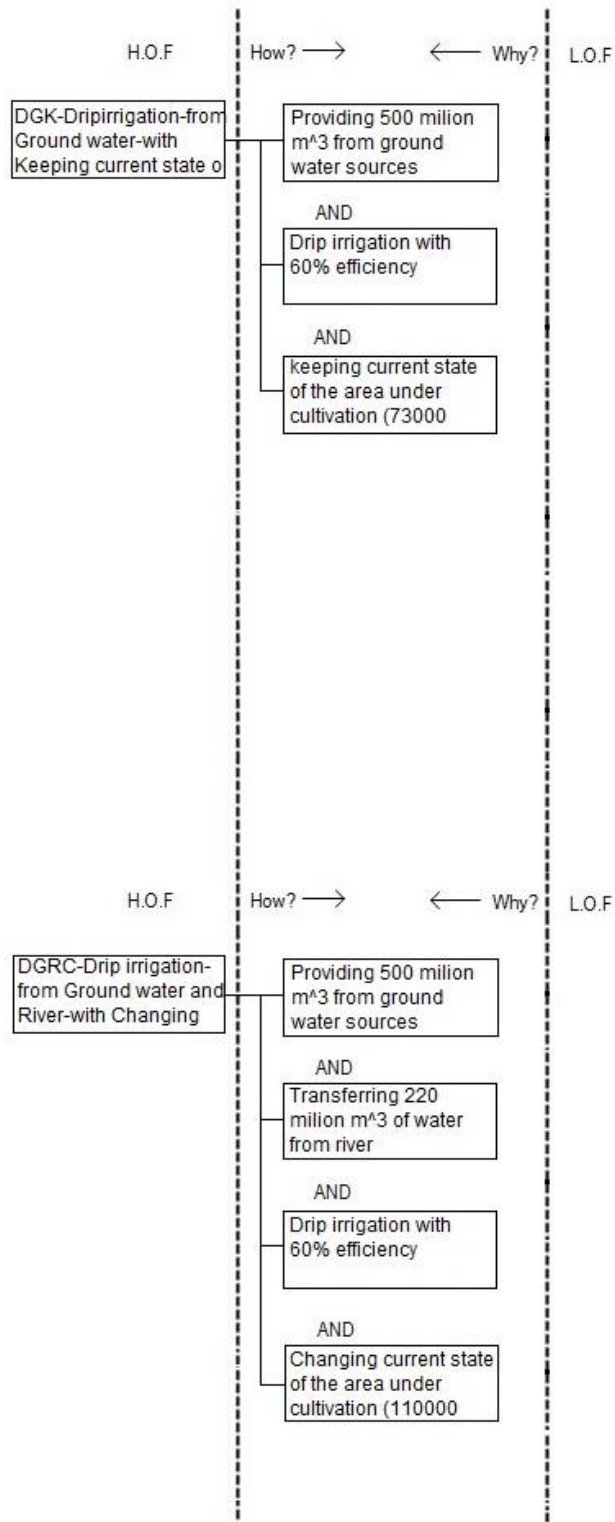
Row	Functions	Elements
1	Combination plan- TGRK	Providing 500 milion m^3 from ground water sources

Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total Cost
29,000.00	24,000.00	20,000.00	22,250.00	22,250.00	22,250.00	139,750.00

Row	Functions	Elements
2	Combination plan- TGRK	Transferring 220 milion m^3 of water from river

Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total Cost
34,500.00	26,000.00	19,000.00	25,000.00	27,000.00	25,000.00	156,500.00

Row	Functions	Elements
3	Combination plan- TGRK	Traditional irrigation with 36 % efficiency

Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total Cost
28,000.00	27,000.00	19,500.00	26,000.00	21,500.00	26,000.00	148,000.00

Row	Functions	Elements
4	Combination plan- TGRK	Keeping current state of the area under cultivation (73000 Hectar)

Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total Cost
24,500.00	23,300.00	19,000.00	23,000.00	22,000.00	23,000.00	134,800.00

Row	Function	Element	Time
1	Combination plan- TGRK	Combination plan- TGRK	210
2	Combination plan- TGRK	Providing 500 milion m^3 from ground water sources	90
3	Combination plan- TGRK	Transferring 220 milion m^3 of water from river	210
4	Combination plan- TGRK	Traditional irrigation with 36 % efficiency	120
5	Combination plan- TGRK	Keeping current state of the area under cultivation (73000 Hectar)	90

Time Estimated in Details

DGK-Dripirrigation-from Ground water-with Keeping current state o|

Providing 500 milion m^3 from ground water sources

AND

Drip irrigation with 60% efficiency

AND

keeping current state of the area under cultivation (73000

DGRC-Drip irrigation-from Ground water and River-with Changing

Providing 500 milion m^3 from ground water sources

AND

Transferring 220 milion m^3 of water from river

AND

Drip irrigation with 60% efficiency

AND

Changing current state of the area under cultivation (110000

Cost of New Ideas

Row	New Ideass			Elements			
1	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation			Providing 500 milion m^3 from ground water sources			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
29,000.00	24,000.00	20,000.00	22,250.00	22,250.00	22,250.00	139,750.00	

Row	New Ideass			Elements			
2	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation			Drip irrigation with 60% efficiency			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
35,000.00	24,000.00	19,000.00	26,000.00	25,000.00	26,000.00	155,000.00	

Row	New Ideass			Elements			
3	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation			Keeping current state of the area under cultivation (73000 Hectar)			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
24,500.00	23,300.00	19,000.00	23,000.00	22,000.00	23,000.00	134,800.00	

Row	New Ideass			Elements			
4	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation			Providing 500 milion m^3 from ground water sources			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
29,000.00	24,000.00	20,000.00	22,250.00	22,250.00	22,250.00	139,750.00	

Row	New Ideass			Elements			
5	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation			Transferring 220 milion m^3 of water from river			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
34,500.00	26,000.00	19,000.00	25,000.00	27,000.00	25,000.00	156,500.00	

Row	New Ideass			Elements			
6	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation			Drip irrigation with 60% efficiency			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
35,000.00	24,000.00	19,000.00	26,000.00	25,000.00	26,000.00	155,000.00	

Row	New Ideass			Elements			
7	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation			Changing current state of the area under cultivation (110000 Hectar)			
Investment Cost	Opration & Maintenance Cost	Demolitation Cost	Energy Cost	Replacement Cost	Associated Cost	Total	
26,500.00	25,000.00	19,000.00	24,000.00	23,000.00	20,000.00	137,500.00	

Time of New Ideas			

Row	New Ideas	Elements	Time
1	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	160
2	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Providing 500 milion m^3 from ground water sources	90
3	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Drip irrigation with 60% efficiency	160
4	DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Keeping current state of the area under cultivation (73000 Hectar)	90
5	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	270
6	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Providing 500 milion m^3 from ground water sources	90
7	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Transferring 220 milion m^3 of water from river	210
8	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Drip irrigation with 60% efficiency	160
9	DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Changing current state of the area under cultivation (110000 Hectar)	270

New Ideas Evaluated Based on Time-Cost-Quality

Functions				New Ideas	
Combination plan- TGRK				Combination plan- TGRK	
Current Cost(C)	Alternative Cost(A)	Percentage of Saving Cost	Percentage of Saving Time	Improving Quality of Project	Value Score Based on Time-Cost -quality
579050.0000	579050.0000	0	0	Not Effective	0

Functions				New Ideas	
Combination plan- TGRK				DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	
Current Cost(C)	Alternative Cost(A)	Percentage of Saving Cost	Percentage of Saving Time	Improving Quality of Project	Value Score Based on Time-Cost -quality
579050.0000	429550.0000	25.8182	23.8095	High	13

Functions				New Ideas	
Combination plan- TGRK				DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	
Current Cost(C)	Alternative Cost(A)	Percentage of Saving Cost	Percentage of Saving Time	Improving Quality of Project	Value Score Based on Time-Cost -quality
579050.0000	588750.0000	-1.67516	-28.5714	Excellent	3

Value Creation and Labels

Functions	Value Creation Percentage	Value label
Combination plan- TGRK	Less than 10%	D
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under	80-70%	A-
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area	Less than 10%	D

Comment	According to the lables created, the best alternative in terms of totally cost-quality-time is "DGK" , althugh the alternative "DGRC" is excellent in improving quality.

Criteria and Weights		
Row	**Criteria**	**Weight**
1	Social criteria - Lack of agreement	20
2	Social criteria - job creation	17
3	Technical criteria - supply water needs	22
4	Technical criteria - irrigation efficiency	22.5
5	Technical criteria - technical feasibility	21
6	Technical criteria - the requierd time for design	12.5
7	Economic criteria - benefits	21
8	Environmental criteria - surface and underground water conservation	22
9	Environmental criteria - impact on the environment	22

Matrix			
Functions	Criteria	Score	Total
Combination plan- TGRK	Economic criteria - benefits	63.00	542
Combination plan- TGRK	Environmental criteria - impact on the environment	66.00	542
Combination plan- TGRK	Environmental criteria - surface and underground water conservation	66.00	542
Combination plan- TGRK	Social criteria - job creation	51.00	542
Combination plan- TGRK	Social criteria - Lack of agreement	60.00	542
Combination plan- TGRK	Technical criteria - irrigation efficiency	22.50	542
Combination plan- TGRK	Technical criteria - supply water needs	88.00	542
Combination plan- TGRK	Technical criteria - technical feasibility	63.00	542
Combination plan- TGRK	Technical criteria - the requierd time for design	62.50	542
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Economic criteria - benefits	63.00	540

Matrix			
Functions	Criteria	Score	Total
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Environmental criteria - impact on the environment	66.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Environmental criteria - surface and underground water conservation	44.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Social criteria - job creation	51.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Social criteria - Lack of agreement	60.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Technical criteria - irrigation efficiency	90.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Technical criteria - supply water needs	66.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Technical criteria - technical feasibility	63.00	540
DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation	Technical criteria - the requierd time for design	37.50	540
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Economic criteria - benefits	63.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Environmental criteria - impact on the environment	22.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Environmental criteria - surface and underground water conservation	66.00	532

DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Social criteria - job creation	68.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Social criteria - Lack of agreement	60.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Technical criteria - irrigation efficiency	90.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Technical criteria - supply water needs	88.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Technical criteria - technical feasibility	63.00	532
DGRC- Drip irrigation- from Ground water and River-with Changing current state of the area under cultivation	Technical criteria - the requierd time for design	12.50	532

Selected Ideas		
Functions	*Best Ideas*	*Score*
Combination plan- TGRK	**DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation**	**553.00**

Members Decision

Name and Surname	*Decision*
Ali Azimi	**I agree with this idea**
Fatemeh Amiri	**I assess this idea and it needs to be improved**
Hashem Sedghiyan	**I agree with this idea**
Saeed Mohseni	**I agree with this idea**
Samad Hatefzade	**I agree with this idea**
Sina Kazemifar	**I agree with this idea**

Date	**28/02/2014**
Comment	Regarding the ultimate goal of the project which is the sustainable development, the functions relevant to plan are analyzed and the most important of them are specified. Then VM team had tried to utilize these functions in the creative phase to define the different alternatives. After simulating the alternatives, the best one rely upon the created criteria through the matrix evaluation is selected in evaluation phase. To create the criteria, it is tried to consider value instead more than tangible costs and prices. The criteria are determined regarding to environmental, social, technical and economic issues. According to the analysis done, the best option with the highest rate of compliance with the sustainability criteria is "DGK" alternative.

Final Report

Best Idea

DGK-Drip irrigation- from Ground water -with Keeping current state of the area under cultivation

Advantages

High level of Irrigation efficiency and the possibility of proper management of farm land are most advantages of this alternative.

Disadvantages

This alternative for providing required water relies upon just ground water sources.

Limitations and Barriers

The week agreement in private part that its benefits are not significant is the most limitatio.
Moreover, the harmful affect harmful effects resulting from the implementation of this option is another barrier against this alternative.

Suggestions

This alternative can be implemented in two phase at first phase the type of irrigation system is changed and in second phase, if there is proper facilities, agricultural waste Management can be considered.

Other Comment

This alternative must evaluated by "National environment corporation" and "The natural resources of the country" too