Ministry of Higher Education
and Scientific Research

University of Diyala

College of Science

MANAGE THE CONSTRUCTION PROJECTS PROBLEMS USING EXPERT SYSTEM WITH PSO AND GSA ALGORITHMS

A Thesis Submitted to Council of College of Science, University of Diyala in Partial Fulfillment of the Requirements for the Degree of Master of Computer Science

by

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Higher Diploma. Computer

Science, 2014

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2020A.D IRAQ 1441 A.

بسم الله الرحمن الرحيم

وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ ۖ

صدق الله العلي العظيم

[سورة التوبة105]

Dedication

I dedicate this research

To the Prophet And the savior of the nation Muhammad Abdullah Abdul-Muttalib,To the Commander of the Believers Ali bin Abi Talib, To our Lord and queen Imam Al – Mahdi,To the mother of believers Fatima Zahra peace on them.

To my parents whose their prayers and words always inspired and encourage me to give more and pursuit of excellence

My Sisters and Brother , who always encourage me to give the best and supported me.

Acknowledgments

I would like to express my deepest thanks and gratitude to my supervisor Prof. Dr. Naji Muter. Through his vast experiences in this field of study, he has offered a valuable time, expertise, guidance, and encouragement.

I also would like to acknowledge the Department of computer science – University of Diyala for all of the support that they have offered to me and also I'd like to thank Prof. Dr Hafeth Naji the head of the civil engineering for his generous assistance and guidance for all the road. Thanks to my sister rowedah Hussein PHD student in civil engineering for her advice through all the work.

Thankful and grateful indebtedness to Dr Nasrallah Salman for helping, support and understanding.

ABSTRACT

Computer science researchers and statistics have established innovative techniques to achieve visions from sets of large disparate data. There are various kinds of data and from diverse sources, and of diverse quality. The computational tools applied to address jobs usually needs human complexity is generally termed 'Artificial Intelligence' (AI). As an area, AI has been for numerous years. Though, modern rises in the power of computing joined with rises in the obtainability and amount of data have to lead in a renaissance of interest in possible artificial intelligence applications .The aim of the research is to build an expert system that considers an effective to manage the construction projects problems in term of both time and cost through building an expert system to manage these problems by using the techniques: particle swarm optimization and gravitational search algorithm.

To accomplish the aim of the research, a theoretical study involve review the previous studies and field study that include open and closed questionnaire and finally , the expert system was built.

The results show that the construction phase considers very critical and has an impact of about 25% on cost and 20% on time and the interdependency between problem quite equal in the construction problems rather than pre-construction problems.

Designing the expert system is depending on the configuration of knowledge and the need for construction projects. This system is designed to provide a database for ant previously problems that have been occurred in the projects. PSO algorithm shows an effective tool in finding the best

solution in term of speed and method of searching while GSA is also an effective tool in finding the best solution to bet it requires more time.

All the velocity of the PSO is zero while the GSA is always more than zero which indicate the PSO is fast and also in the method of searching as seen in problem 7 and 9 the GSA take different way in finding the solution.

The recommendations are Conducting educational and training courses to implement an expert system in construction projects and Using the expert system in different problems and in a different phase and finally depending on this system find the solutions for future problems.

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LIST OF ABBREVIATION

Abbrev.	Total Name
AI	Artificial Intelligence
ES	Expert Sytem
GSA	Gravitational Search Algorithm
PSO	practical Swarm Optimization
CPI	Cost Performance Index

CHAPTER ONE

INTRODUCTION

Chapter one

Introduction

1.1 An Overview

The expert system in the world of the artificial intelligence is a system in the computer that has the ability to imitator or repeats the intelligence jobs of human in the field on the decision making like the expert human skill do. The problems with sophisticated level can be solved as the system use information about their range of expertise. Thus the expert system will be designed depending on this information. In order that the system becomes an equivalent to the human thinking and uses data that is explicit in the field. The tools are used to gain such a type of information and the questions are asked to one or more experts. The artificial intelligence is the main area and the expert system consider sub-area. The applications in which this type of system used are geology, law, medicine, politics, chemistry, and economics. Every place or field that require to make a decision, the expert system may be used. (Adamus, S. U., 2018).

The simulation of the human expert is the base of the expert system which the latter use methods of inference for a convinced procedure of knowledge that is named domain and the methods that are used are knowledge, evidence, and reasoning, to resolve the issues that require the capability of a human skilled. The rules are used in the same manner as the human as a specialized human uses heuristically accomplished rules to find and troubleshoot the issues and flaws. (Ekhtiyarzadeh, D., & Radfar, R., 2015).

The problems in the construction industry are complicated as the construction projects time and resource are numerous and need much recourse like worker, budget, tools and technical needs .Also the constraints of the project like cost, time and quality and therefore lead to fail to gain the anticipated results of the project, therefore the project consider risky. So the management of the projects , problems are important for the success of the project. (Al-Zubaidi, E. A., Naji, H. I., & Ali, R. H.,2017).

1.2 Thesis Justification

In Iraq, construction projects face many problems as the most projects are being constructed in an unstable environment in term of cost and time and thus project management has been failing to meet the expectations of the owner and contractor both and that creates the need to build a system able to solve these problems.

The research justification can be explained as follows:

1- The size of construction projects and its complexity require the existence of an integrated system.

2- The unstable environment of the construction projects requires a system that able to make decisions without the loss of time and cost.

3- The cost and time of finding the best solution for the construction projects problems is high and therefore its required an integrated system.

1.3 Thesis Hypothesis

Based on the earlier justifications in the hypothesis is formulated as below:

There is a necessity to build an expert system to manage the problems in the construction projects that reduce the cost and the time of the project.

1.4 Thesis Aim and Objectives

The aim of this thesis is to build an expert system and consider an effective to manage the construction projects problems in term of both time and cost. Achieving current aim, there are some objectives must be obtained as follows:

1- Investigation and identification of the problems in construction projects.

2- Determining the effect of these problems on cost and time of the construction projects.

3- Find the solutions for these problems with effect on both cost and time

4- Build an expert system to manage these problems by using the techniques: particle swarm optimization and gravitational search algorithm.

1.5 Thesis Scope

Major projects in the Diyala governorate, especially university of Diyala university projects will be taken due to its significant budgets from periods 2006-2014 in addition to the projects of ministry of

education and ministry of construction and housing , the type of project were building and from the owner and contactor point of view.

1.6 Thesis Methodology

The methodology of the research is embraced that involves three parts:

Part 1-The Study of the Theoretical

A scientific literature review that deal with the following:

1- Expert system concept and its application in various sector and approaches in construction projects.

2- Reviewing cost and time problems, kinds, and factors that may affect the projects .

3- Reviewing the artificial intelligence techniques and the steps of its procedures and its uses in the construction projects

Part 2- Field Study

The field study involves the following:

1- **Open Questionnaire** This part comprises making many experts interviews. These comprise managers and professors of the university, and other projects parts in the following ministries: The Ministry of Construction and Housing, The Ministry of Higher Education and Scientific Research and Ministry of Education. The interviews are conducted as they have a significant part in aiding the later stage, also questionnaire discussion was firstly set from the literature and as well as some adjustments that made on the form to

add different question with the assistance of the experts to ensure the success of the method and questions presented.

2- **Closed Questionnaire**: when the interviews are completed with the experts, the research problems were separated into numerous groups which include, identification of the effect of the problem on time and cost, finding the solutions for these problems and finding the effect of each solution.

Part 3- Building an Expert System

The expert system was built as the following:

1- Knowledge Base: This step includes the collection of a of accurate and precise data, information and past experience that necessary for building the system which is based on the previous steps that mention in the field study .

1- Inference Engine: This part includes a collection of rules and efficient procedures In the situation of knowledge-based, the knowledge is been obtained and manipulated by the inference engine to get a specific solution.

2- User Interface: The interaction is offered by the user interface among the ES user and the ES itself.

The flowchart of the thesis in figure (1.1) which show the steps that will be followed in this thesis.

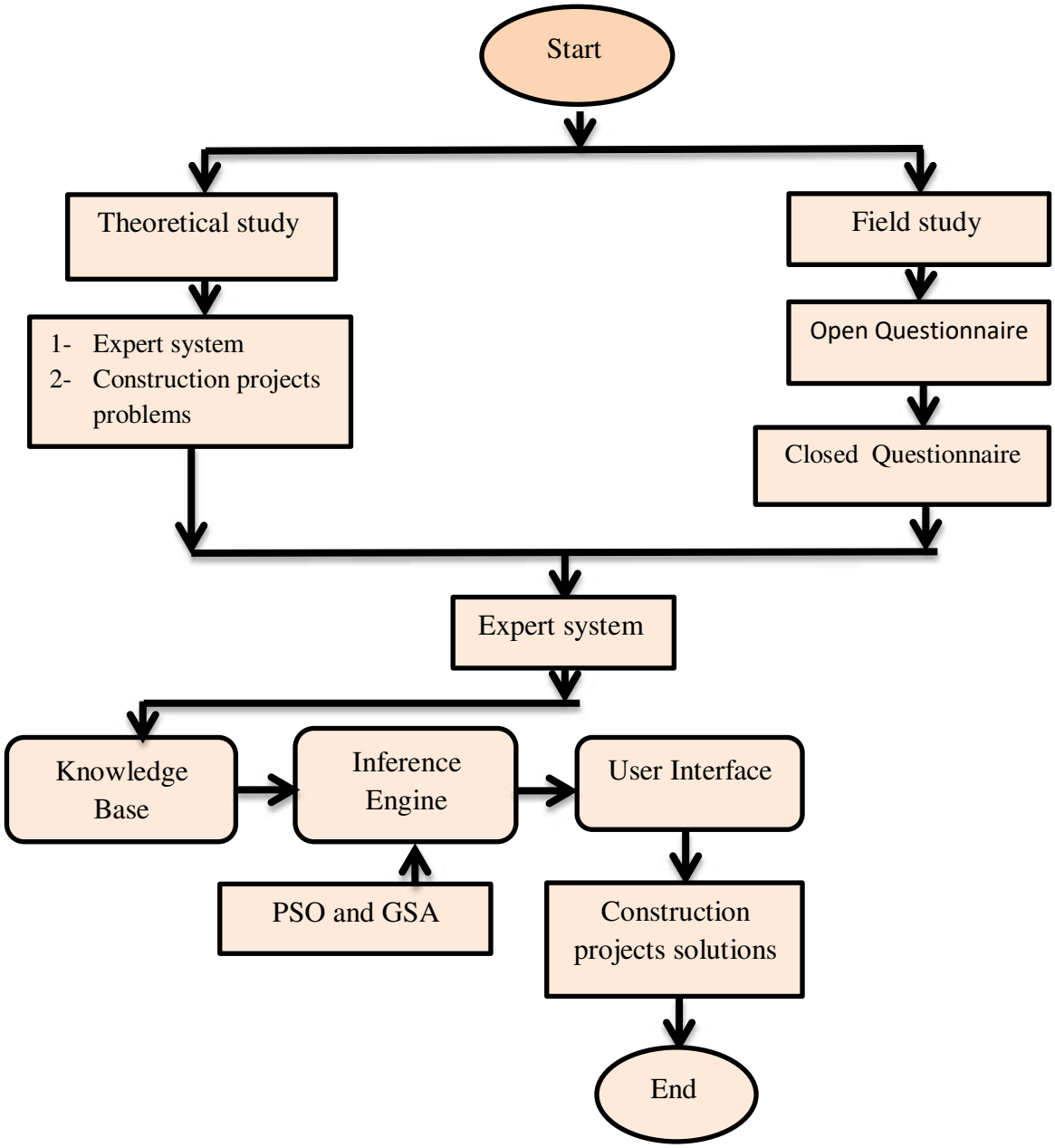


Figure (1.1) Methodology Flow Charts of the Research (Author)

1.7 Thesis Structure:

The research includes several chapters, which are:

Chapter One: This chapter includes a general introduction to the research, research problem, justifications, hypothesis, scope, research objectives, research methodology, the structure of the thesis and previous studies.

Chapter Two: This chapter deals with the projects definition, construction management, the stages adopted in the plan of action and its techniques. It also includes the time and cost problems and the techniques used to solve this problem.

Chapter Three: This chapter includes the data collection and how the data are been collected from the questionnaire and from the projects and its include various stages of the field survey. It includes the aspects related to the field questionnaire, the selection of the sample, the scheduling of the results obtained, the method of finding the qualitative assessment of the notification from the probability and impact calculation, and finally analyzing the results obtained from the field questionnaire.

Chapter Four: This chapter includes the steps in building the expert system and what's its elements and what each part of the system include.

Chapter Five: This chapter includes the results of the expert system and the results of PSO and GSA for pre and construction.

Chapter Six: This chapter contains a collection of the conclusions that gain by the researcher as well as recommendations and proposals for subsequent research.

1.8 Previous Studies

This section include several studies regarding the expert system in various field including construction and medicine to obtain a clear ideas of the studies in the fields of construction is little compared to other fields.

1- Z.A. Memon(2008): The author constructs ACPROM system that offers to back for the phase of investment implementation, the process of estimation the building progress works depending on project and documentation of the graphic, permitting to transfer the resultant databases to MS Project. It permits to combine: managerial drawings, digital images for the site of construction, photography of digital progress.

2- **M. Abdullahi, et al(2008):** The author build COMIX which is an ES with rule and frame that offers recommendations on mixes of normal weight concrete design. This system was implemented by the engineers of concrete, engineers of design, and consultants. The system was built in New Zealand was Central Laboratories.

3- **Shaheen, A. A., Fayek (2009):** Establishes how systems of fuzzy expert can be combined within models of discrete event simulation to improve their forming and capabilities of predictive for the applications of construction engineering. A suggested methodology is obtainable for information extracting from specialists to improve the rules of the fuzzy expert system. The produced fuzzy expert system is combined within the model of discrete event simulation to improve its capability of modeling by explicitly accounting for the various issues impacting certain activities simulation.

4- N. Ismail, et al(2009): The author , designed system for the evaluation of the pavement and rehabilitation as an instrument to support the engineers of the highway. Firstly, the system was established for the administration of the federal highway and the Illinois transportation department that offers sustained system support and development. The information is provided by the

well- informed and skilled pavement engineers to the system for the determination of the kind and overall reasons for pavement deterioration. Three kinds of the pavement are regarded by the expert system: (JRCP), (JPCP),(CRCP).

5- T. S. Sakthivel V. Kalyanaraman (2013): This paper Deliberates a KBES shell (IES) which combine different technologies of AI, that has the possibilities to execute new strategies for problem- solving needed for efficient handling of the entire process of engineering. Problems in the combined engineering process are firstly discussed, to progress a shell specification. The architecture blackboard is seen to be the perfect backbone for a shell-like this. The IES application is established using the combined engineering domain of steel industrial structures as an instance. This application includes the activities of engineering for conceptual design, comprehensive design, records, and construction planning.

6- Sadik, Ahmed Rabee (2013): This paper includes two stage, the first one is to execute a system for checking the web on PLC controlled production line prepared by FESTO and the purpose is teaching in TUT - Tampere University of Technology – FASTory lab facilities. The second one is built and execute a suitable.

7- P. Ziembicki, A(2013): The system has been built for the energy source selection at the University of Zielona Góra which has been produced in the research task No. 6 framework.

8- M. Akram, I.A. Rahman(2014): The Managers Advisory System platform is a prototype that is operational for the support of the decision for preparation and building projects management which can be used by managers of the building in their daily obligations

and through the phase of the pre-design. So far the program has been used to analyze small projects.

9- Davood Ekhtiyarzadeh and Reza Radfar (2015): They build and implement a system that can aid the professionals of the network or the users to solve problems. The system has the capacity and the ability to find the best solutions for the problems of internet communication that is completed by a full-time resident expert of human.

10- SAADU UMAR ADAMU (2018): The aim of this work is to provide a system for the diagnosis of malaria, the process of knowledge acquisition is done by conducting direct interviewing with the specialists in the medical field and the rule-based process is used to represent the knowledge. Whether the person is sick or not is been found by these rules, in addition, the kind of the disease like simple malaria, austere malaria is known. the software of the VP expert is used for the system and it was verified on 35 patients with accuracy about 93% and there was a comparison between the diagnosis of the specialists' and the advice.

The previous papers in the construction industry are either used an expert system alone to deal with problems or used only algorithms for the task of optimization or prediction in the field of roads or structural or civil engineering in general . In addition there are many papers that deals with problem in the construction without the use of any techniques to manage the problems .

Most of the papers deals with investigation , classification , identification and analyze of the problems without finding the solution for these problems.

The researcher in this thesis used an expert system with optimization algorithms which are practical swarm and gradational search algorithm in order not just identify the problems but analyze the projects in different phases and then find the problems in these phases and finally find the best solutions for these problems.

CHAPTER TWO

Construction Projects Problems and Techniques

Chapter Two

Construction Projects Problems and Techniques

2.1 Introduction

The nature of construction projects are considered very risky and contain a lot of problems that are hard to handle and that leads to the increase the interest in the management of these problems.

The construction projects problems are divided into many phases, as general heading they are divided into pre-construction, construction and after the construction phase, In this chapter the construction projects problems will be explored with their possible effects and include both time and cost and the management process for these problems will be discussed and considered is one of the main goals of the projects and one of its main concerns .

2.2 Construction Projects

In order to obtain the project goal, there must be elements that are well controlled to get significant information for this purpose. The definition of the project management by Walker as The company resources use on a definite activity with the aim of keeping the duration, the funding, and performance without deviation. Another important factor is good relations with the customer (Walker,2007).

The word construction project is usually the use of describing an event that is implemented as to the needs of the developer of the property and the users of the future are met. The work of construction project concentrated on the planning, arrangement and implementing the work of construction, resolving the construction accounts and offering a completed

construction that is complete for operation(K. Kähkönen,1999 T. Kasprowicz 2010))

According to the author, the construction project is consisted of many phases planning, designing, construction and maintenance which contain a lot of problems that have an impact on both cost and time that are required to be managed.

2.2.1 Cost in Construction Projects

The money has a value that used to generate a product or something else, therefore it will not be available after spending. The amount of money that spend to make a purchase is called cost of business. Thus, money is the input that disappears to buy the product, (O'Sullivan et al.,2003). The cost also defined as the waiver or the sacrifice in order to gain specific benefits in exchange for that waiver or the sacrifice. Cost is the economic value of any sacrifice, whether it was material or moral, which can be measured in monetary currency in order to get benefits in the present or future. (Office of Financial Supervision, 1989). From the owner perspective, the cost is defined as the amount of money paid to the contractor to implement the project. On the other hand, the definition of cost from the contractual point of view is the amount of the money that requires executing the project. (Office of Financial Supervision, 1989). The cost can be classified as follows (The Institution Of Company Secretaries Of India, 2014):

1- According to the time (past event, pre arranged).
2- According to the nature of the element (Material, manpower and other).
3- According to the product traceability degree (Direct, Indirect).
4- According to the product (Product, Period).

5- According to the change in the volume or the activity (stable, changeable, Semi- changeable).
6- According to its function (industrialization, Management, Selling,
7- Research and evaluation, Pre-production).
8- According to the period of the accounting period (Capital, profit)

One of the major tasks is the cost for the manager of construction, where the project success is arbitrated by ensuring that the standards of cost with the financial plan, timetable on time, and quality as stated by the vendor are met(Rezaian, 2011)

Sometime In the firms of construction do not grow themselves more to be familiar with the continually varying environment of work, therefore the issues will get poorer and control on cost will be very hard. So, using the same approaches and concepts without any modification on knowledge of members and practices make the control on cost impossible (Song, 2014).

Failure costs value different considerably. Some previous studies propose that the costs of failure can be more than 15% from the total value (Hegazy et al., 2011), other studies propose not more than 50% and sometimes it gets more(Frimpong et al., 2003). Current studies have found that there is the bond between failure costs and quality failures, deviations of quality, flaws, revise, and non-conformance, and give them the definition of achievement something not less than additional time as to requirements non-conformance(Hwang et al., 2009). The author used the percentage between these two value from 20 to 25% and considered it as a failure. The finding of other studies is shown in the appendix A.

2.2.1.1 The Element of Cost

The element of cost can be classified as follows the various elements of cost can be illustrated by the following chart: (Banerjee, Bhabatosh.2014)

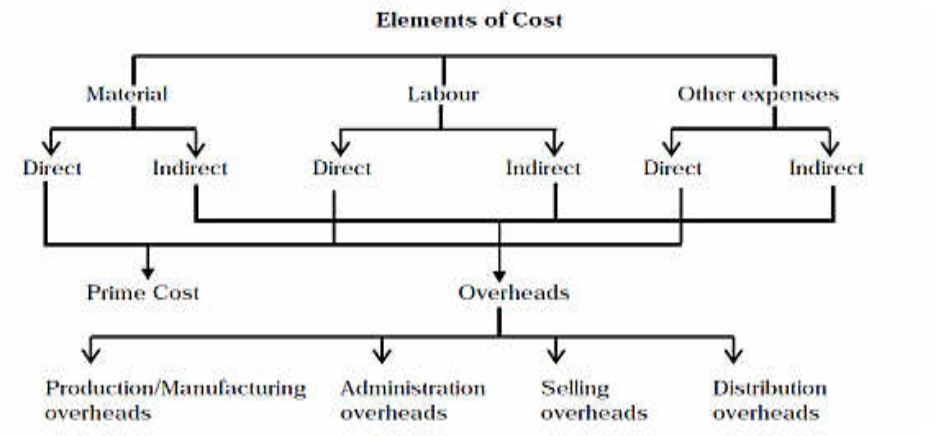


Figure (2.1) Cost Classification

2.2.1.2 Earned Value Management

According to the Project Management Body of Knowledge: Earned Value Management (EVM) is a method for integrating scope, schedule, and resources for measuring project performance. It compares the amount of work or effort that was planned with what was actually earned and spent to determine if cost and schedule performance are as planned.(Project Management Institute, 2004).

Earned Value Management allow the project manager to answer the following three questions, as they relate to the project:

1. Where have we been?

2. Where are we now?

Value , unlike in traditional management, there are three data sources:

- the budget (or planned) value of work scheduled
- the actual value of work completed
- the "earned value" of the physical work completed Earned Value takes these three data sources and is able to compare the budgeted value of work scheduled with the "earned value of physical work completed" and the actual value of work completed. (Project Management Institute, 2005) The following are key parameters as used in the Earned Value management of project management.

1. Planned Value (PV): This is the total value of the project. This is the answer to the question "How Much work Is to Be Done?"

2. Earned Value (EV): This is the measure of mount of work done as on a particular instant of time. This is the answer to the question "How Much Work has been done?"

3. Actual Cost (AC): This is the cost incurred to achieve the earned value at the particular instant of time. This is the answer to the question "What has been spent for the Earned Value?" Using the above three parameters following is calculated to provide an insight to the project status and health in terms of cost and schedule. These parameters are calculated at a particular instant of the project life.

1. Cost Variance: Cost variance (CV) is a measure of the project performance in terms of cost. CV is calculated as a difference between the EV and AC.

CV=EV-AC (2.1) .(Project Management Institute, 2004)

2. Schedule Variance: Schedule variance (SV) is a measure of project performance in terms of the project schedule. SV is calculated as a difference between EV and PV.

SV=EV-PV (2.2) .(Project Management Institute, 2004)

3. Cost Performance Index (CPI): CPI is a measure of the cost efficiency of the project. This is a ratio of EV and AC. A measure of CPI provides an insight to the final executed cost of the project.

CPI=EV/AC (2.3) .(Project Management Institute, 2004)

4. Schedule Performance Index (SPI): SPI is a measure of the schedule efficiency of the project. This is a ratio of EV and PV. A SPI of greater than one indicates a favourable condition and a SPI of less than 1 indicates an unfavourable condition. For example a SPI of 1.1 indicates the project is slated to complete ahead of schedule. (Reichel, C. W.,2006)

SPI=EV/PV (2.4) .(Project Management Institute, 2004)

2.2.2 Time in Construction Projects

As previously studied mentioned that the projects over the world are facing the problem of delay because of diverse reasons. Sanders and Eagles put the definition for the delay as an incident that leads to increase the time to finish all or phase of a project (Sanders,2001) Numerous influences are established to be the reason for the delay in finishing the construction project. Ahmed, et al., categorized into two groups like

interior reasons (owner, contractor, and adviser) and outside reasons that are outside the organization. (Alaghbari.2007)

In the industry of construction, the goal of controlling the project is to make sure the projects completed on the duration, not exceeding budget and attaining other objectives of the project. It is a difficult job implemented by the managers of the project, that includes continually calculating progress; assessing plans, and taking remedial actions when needed (Kerzner, 2003)

The delay causes a cost overrun and time overrun of the Project. The time and cost are directly related to each other. When the time of execution of the project is delayed it leads to failure of guarantee/warranty of the items/equipment's, failure of the service period of types of equipment, damage of equipments due to weather condition and this will lead to non-timely execution of job(Kumar, 2015)

Thus the delay has an effect on both time and cost and can be summarized as shown in the appendix B (Olawale, 2010)

2.3 Artificial Intelligence

Tools of the computer have developed more and more corporate in the industry of construction. Professionals of construction use precise software to funding diverse parts of the process of construction (Meijering, H. S.,2014)

Computer science researchers and statistics have established innovative techniques to achieve visions from sets of large disparate data. There are various kinds of data and from diverse sources, and of diverse quality. The computational tools applied to address jobs usually needs human complexity is generally termed ‘Artificial Intelligence’ (AI). As an

area, AI has been for numerous years. Though, modern rises in the power of computing joined with rises in the obtainability and amount of data have to lead in a renaissance of interest in possible artificial intelligence applications. (Eiopa and Esma, 2016)

AI is defined as the process of systems studying which behave in an intelligent manner as an observer to another. AI includes the use of tools depending on the intelligent behavior of human beings and other animals too in order the complex problems to be solved (Coppin, 2004)

Various references discover that in the scientific literature that involved with the project management areas are based on the Artificial Intelligence, project success Estimation, critical success factors Identification, project budget Relatedness, project schedule connection planning of the Project, risk identification relatedness (Martínez et al., 2015)

The systems of the intelligent area have been widely used over the latest years by the variety of techniques and amount of applications and they frequently offer an inexpensive benefit when making a comparison with other traditional methods (Negnevitsky, 2005; Uraikul, Chan, & Tontiwachwuthikul, 2007).

In the civil engineering area, numerous issues, particularly in design for engineering, management of construction, and program of making the decision, were subjective by numerous doubts that cannot be solved unless the use of the mathematics, physics, and calculations of mechanics and additionally required the practitioner's experience. This experience and knowledge are unscientifically imperfect and vague, and there are no they general procedures can handle them. Though, advantage is owned by artificial intelligence. It has the solution to difficult problems to the experts'

levels by methods of experts imitate. Generally, artificial intelligence has comprehensive prospects of application in the preparation of civil engineering(Zheng, 2012)

2.4 Optimization

Optimization is the process of result making that considers the greatest underneath assumed circumstances. In the phase of scheme, building, and conservation of any engineering system, at numerous phases, many decisions that are technological and management must be occupied by the engineers. The final objective of these decisions are either wanted advantage maximization or to the effort essential minimums (Singiresu S and Rao, 2009). The element of Optimization model as follow:

A- The Elementary Elements Model of Optimization

1- Design Variables And Design Parameters

A fundamental system can be labeled by quantities set, some of which are shown as variables during the process of the optimization. The structural system is identified by those quantities, consider to be fixed through the automatic design are named pre-assigned parameters or parameters of design and they don't change by the algorithm of optimization. These amounts that are not previously assigned are named design variables. The previously assigned parameters, joint with the design variables, will define a design completely. (Csila Erdonsen Selley,2012)

2- Constraints of Optimization

Several designs are helpful resolutions to the problem of optimization, but some could be insufficient in terms of behavior, function, or other respects. If requirements are satisfied by the design that assigned to it, it will be named design that is possible. In utmost cases, the design in the starting considers a feasible design. The limitation which must be fulfilled

to introduce a possible design is called constraints. (Csilla Erdosne Selley, 2012)

3- Objective Function

The aim of the conventional procedures of design is determining an adequate or acceptable design which satisfies the functioning of the problem and other requirements. Generally, many designs will be available that consider acceptable, and optimization goal is to select the best one of the many available designs that are considered acceptable. Thus a standard has to be selected so that various alternative designs which regard acceptable are compared and then choose the best selection. The standard with respect to that the design is optimized, when explained as a design function variable, which is known as the standard or merit or objective function. The objective function selection is controlled by the nature of the problem. (Singiresu S and Rao, 2009)

2.4.1 Particle Swarm Optimization

PSO produced by Kennedy and Eberhart in 1995. The algorithm base is on information social theory that is sharing between classes of members offer an evolutionary advantage (Kennedy & Eberhart, 1995). In the last years, the PSO has the benefit of the subsequent applications of variety in the engineering design as the design of circuit of the logic (Coello & Luna, 2003), design the control (Zheng et al., 2003) and systems of power design (Abido, 2002).

For the tasks of optimization engineering, PSO considers an optimal candidate as it has many advantages compared with other global algorithms. The algorithm is strong and adequate to treat discontinuities of nonlinear, design spaces of nonconvex. It is also very effective, a number of the evaluations functions that required is minimal, and this lead that the

quality of the results is better or sometimes the same (Hassan et al., 2005). Furthermore, it has the easiness in the execution that make it more desired as it doesn't need knowledge of specific information about the domain, variables of the internal transformation or other handling constraints manipulations. The steps that used in PSO as follow:

A-Mathematical Formulation

The usual procedure of particle swarm is stochastic; the present position apprise is done by the use of the vector of velocity for each particle of the swarm. The velocity vector is updated based on every memory of the particle that received in the procedure, theoretically approaching autobiography memory, also the earned knowledge by the swarm as an entire (Eberhart & Kennedy, 1995). Therfor, the particle position in the swarm is updated based on the social behavior of the swarm that regulates to its environment by a reappearance to capable space areas that previously exposed and improved positions are been looking for over time. Numerically, at iteration k+1, the x position of my particle is updated as:

$X_i^{k+1} \quad +x_i^k \ +v_{k+1}^i \ \Delta t$ (2.5) (Eberhart & Kennedy, 1995)

Where v^i_{k+1} is the vector of velocity representation updated, and Δt is the time step value that considered as a unity (Shi & Eberhart, 1998a). every vector of particle velocity is computed as

The Figure (2.1) shows two-dimensional vector space of the particle position and velocity update. It's important to notice the influencing of updates particle position I, on the configuration parameter magnitude not just by its relationship with regard to the position of the swarm that considers the best. (Eberhart & Kennedy, 1995)

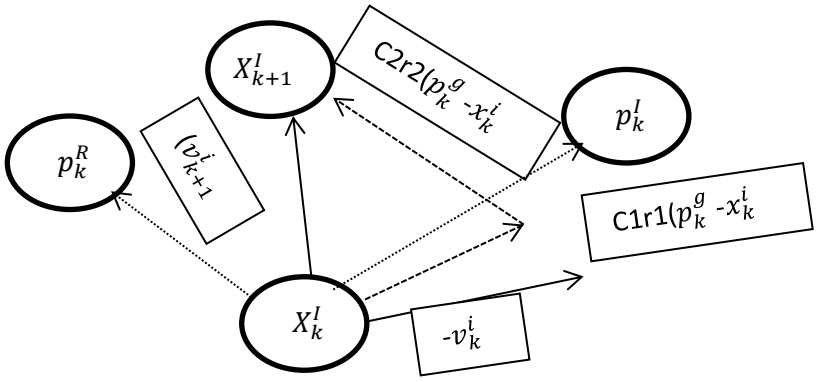


Figure (2.2) PSO Velocity Update and Position(Eberhart & Kennedy, 1995)

B-The Computational of The Algorithm

Like all approaches of the numerals depending on the process of the optimization. PSO is iterative in nature, the construction of the basic algorithm is as follows (van den Bergh & Engelbrecht,2006):

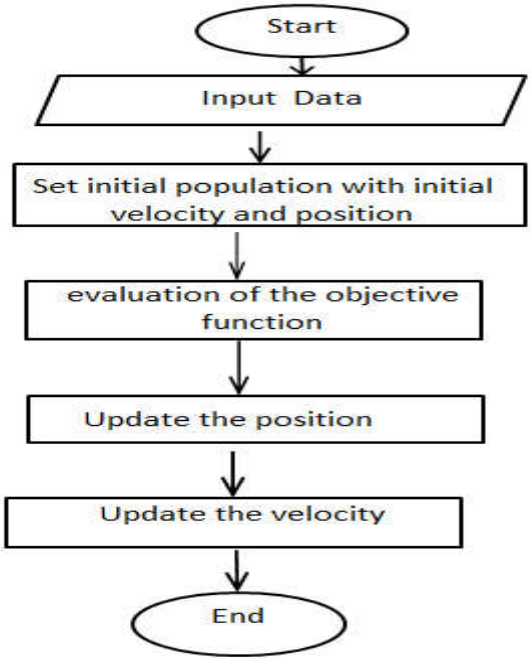


Figure (2.3) Shows the Process of the Algorithm van den Bergh &Engelbrecht,2006

Where the attribute of specific structure (like weight) is defined as a merit or objective function *f* that is minimized or maximized using an appropriate selection of the parameters of the design. The structure geometry and topology specify the design parameters and members physical properties. Some of these design variables are independent (*x*) that are the difference to optimize the problem; while others can be parameters (*p*) of value that is fixed.

2.4 .2 Gravitational Search Algorithm

Rashidi et al generate the GSA. In 2009 and the goal was to get the solutions to the problems of optimization. The algorithm regarded heuristic algorithm (E. Rashedi etl, 2009)

GSA is categorized below the method of the population and is described to be more hypothetical (R. K. Khadanga and S. Panda, 2011). In the population-created algorithm, The algorithm has the purpose to enhance the examination and misuse abilities, performance, based on the gravity rules. (M. Gauci etl,.2012)

The foundation of this algorithm is the law of gravity and mass interactions. The algorithm comprises of a collection of agents, the search that relates with one another over the force of gravity (E. Rashedi etl, 2009).

The agents are considered as substances and masses regarding the performance of the substance. A global movement is due to the gravity force in that all substances allocation with denser masses to the other substances. The phase of algorithm exploitation is assured by the denser mass relaxed movement and resembles solutions that regard good. The

masses really track the gravity law as shown in equations (2,6 and 2.7) and the law of motion (E. Rashedi etl, 2009).

$$F= G(M1\ M2/\ R^2) \quad (2.6)$$ (E. Rashedi etl, 2009

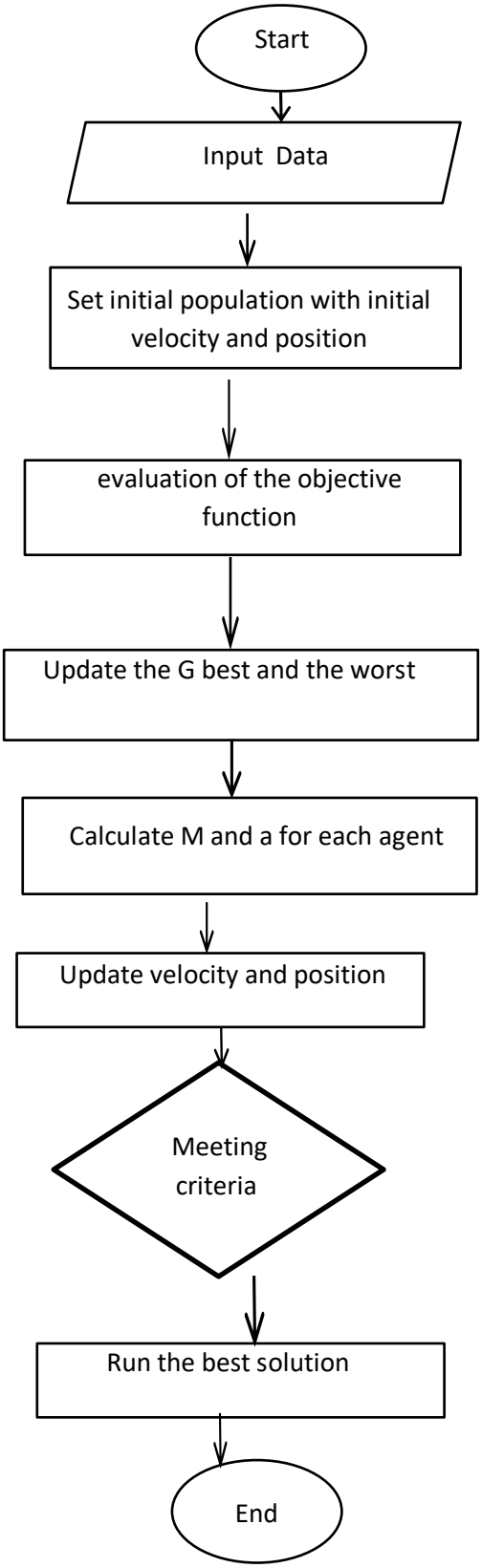
$$A=F/M \quad (2.7)$$ (E. Rashedi etl, 2009

Based on Equation (2.6), F symbol for the gravitational force magnitude, G is constant of the gravitational, the mass of the first and second objects are represented by M1 and M2 and R is the distance between the two objects.

Law of Newton for the gravity shows that there is directly proportional to the gravitational force in the mid of the two objects and the mass-produced, while there is inverse proportional to the gravitational force and the squared distance in the mid of the objects. in the second equation, shows that when an object subject a force, F, its acceleration, a, rely on the mass M and the force, that represent Newton's second law. (E. Rashedi etl, 2009). The steps of GSA are shown below:

A-The Steps of Gravitational Search Algorithm (GSA)

In GSA, there are four parameters of the agent has that are the position, mass for passive gravitational, inertial mass, and mass for active gravitational (E. Rashedi etl, 2009). The mass position represents the problem solution, where the function of the fitness is used to find the inertial masses and the gravitational. The algorithm is expressed by regulating the gravitational and masses of the inertial, whereas the solution is presented by each mass. Masses are pulled from the densest mass. Thus, a solution that considers optimal is presented by the heaviest mass in the space of search. The GSA steps in the figure (2.4) (E. Rashedi etl, 2009):



Figure(2.4) Flowchart of GSA (E. Rashedi etl, 2009)

The equation that used to implement the GSA algorithm as shown in table (2.3)

Table (2.1) Shows the Equations of GSA(E. Rashedi etl, 2009)

Equations	Description
$X_i=X^2_i+ X^4_i+ X^6_i$ (2.8) for i=1.2.3..N	X_i is the position for the ith agent in the dth dimension representation while n is the dimension of the space
Minimize problem Best(t)=min $fit_j(t)$ (2.9) j€(1…..N) Worst(t)=max $fit_j(t)$ (2.10) j€(1…..N) Maximize problem Best(t)=max $fit_j(t)$.(2.11) j€(1…..N) Worst(t)=min $fit_j(t)$ (2.12) j€(1…..N)	The fitness value is represented by fit $_j(t)$ of the j agent at iteration t , the best and the worst is represented by the best and the worst of the fitness
$G(t)=Goe^{(\alpha t/T)}$ (2.13)	Go and α are initialized at the starting and will be decreased with time to the search accuracy control .T is the total number of iteration
Mai=Mpi=Mii=Mi (2.14) for i=1.2.3..N	The active and passive gravitational masses are represented by Mai and Mpi respectively while Mii is the inertia of the I agent
$a^d(t) =F^a(t)/Mi(t)$ (2.15)	Acceleration of the ith agent at iteration t
F^ai(t)=Σi€ kbest , i=randjFij(t) (2.16)	$F^a(t)$ is the total force acting on the ith agent
$Fij^a(t)$=G(t)…M(t)xMi(t) /Rij(t)+£).(xj(t)-$xi^d(t)$ (2.17)	The force acting on agent I from the agent j is represented by Fij (t)is at d dimension at t iteration Eculidien distance is represented Rij

2.5 Expert Systems

The expert system generation of knowledge needs that a suitable statement of the problem is built. A problem that justifies the quantity of effort cost essential to execute expert systems of knowledge for every stakeholder. Like all other software, a proper process should be tracked to make sure needs from all organization levels are encountered. methodologies of software growth are frequently emerging and therefore impact how expert systems of knowledge are established. (Golabchi,2008).

Recent expert systems are established using the method of a repeated development, depicted in Figure 1 as defined by (La Salle. Millette, L,2012).

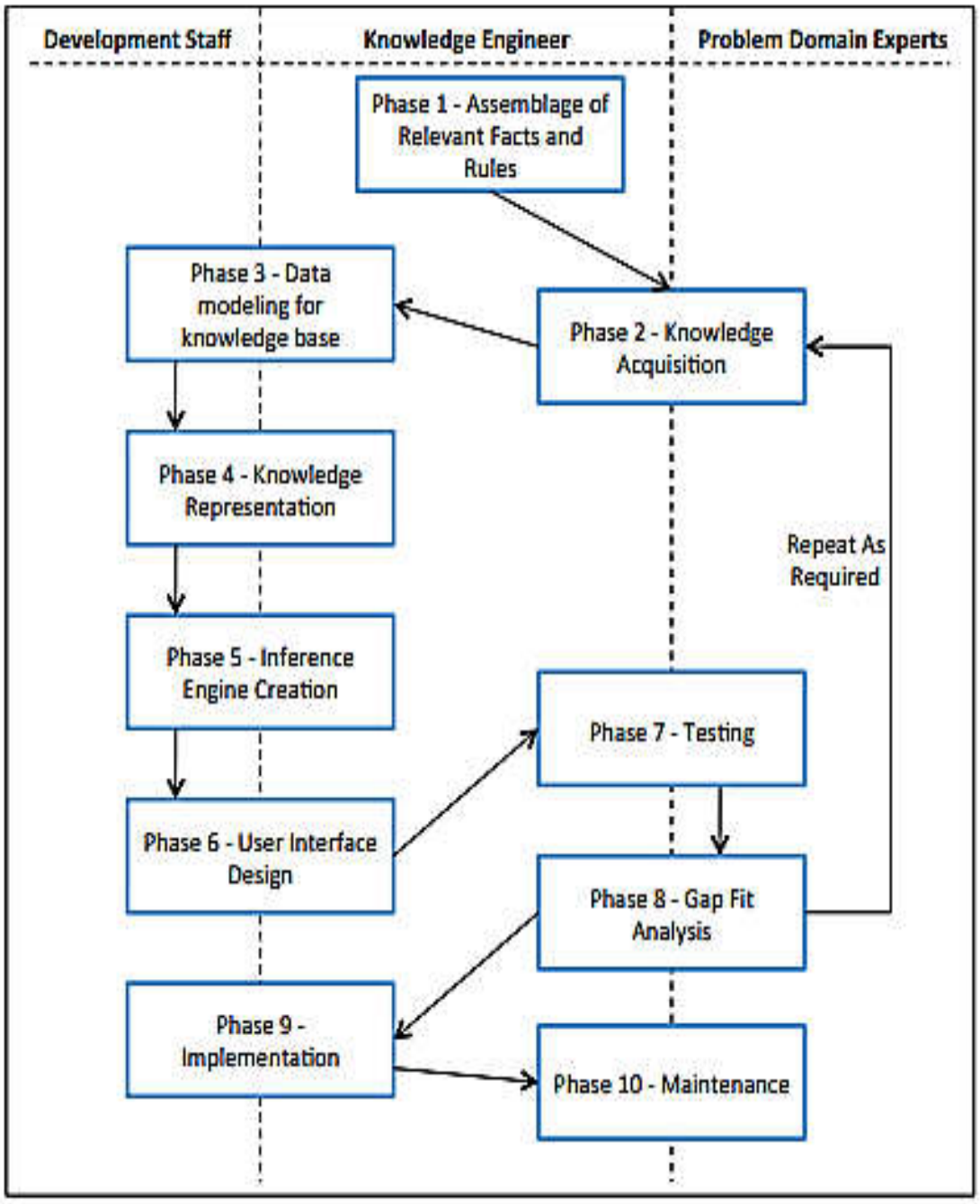


Figure (2.5) Knowledge-Based Expert System Lifecycle(La Salle. Millette, L,2012)

2.6 Expert Systems Principle

The business world is growing in the management of knowledge, as arranging knowledge into the process of work become vital. the knowledge that is codified is the knowledge that has been gained from an expert of the domain and moved into a form of electronic. This movement of knowledge then aids businesses streamline, automate, and reservation knowledge into a source of central shareable. By using the tools of analysis, decisions and training can then be derived. (Cernik IV, J. A., 2009)

Computer programs were written in the late 1950s and early 1960s, with the goal of explicit for solving of the problem. expert systems are one appearance of the uses that follow their origins back to those initial programs. Expert systems are systems of the computer that have skill in a specific area and are helpful when examining and handling large quantities of data in relatively less amount of duration. knowledge is been used which has been collected and kept in the knowledge base to provide the solutions for the problems in the precise area for that they were formed. (Millette, L., 2012).

The expert system principles are defined in figure(2.6) .When the user provides fact this considers the generator to operate the expert systems operate in return the user gets the advice of the expert. The expert system involves two central interior parts, the knowledge-base that will comprise the knowledge that aids the inference engine in illustration the associated assumptions. These assumptions are regarded to be the responses of the expert systems to the user's questions for expertise (Zadeh 1989).

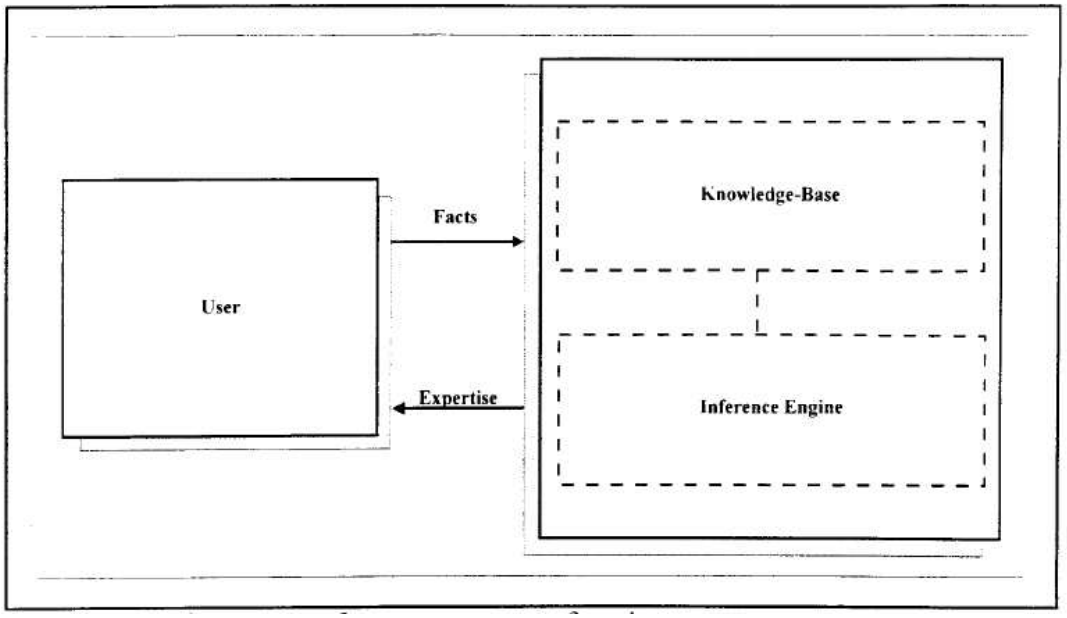


Figure (2.6) Basic concept of expert system (Zadeh 1989).

2.7 Elements of Expert System

The thought of the expert of the human is simulated by using an expert system to provide the solution for the complicated problems for the decision in a definite area. The expert systems feature that make them diverse from straight programming and old-style tools of decision support. (Gupta, S., & Singhal, R. 2013)

Expert systems are prearranged in three separate stages and in the figure (2.7) :

1. The knowledgebase contains rules for solving the problem, and basic data related to the domain of the problem.

2. Working memory denotes to job-specific data for the issue under concern.

3. The inference engine is a mechanism for generic control that relates the knowledge of axiomatic in the knowledge base to the job-specific data to reach a certain solution or assumption. (Gupta, S., & Singhal, R. 2013)

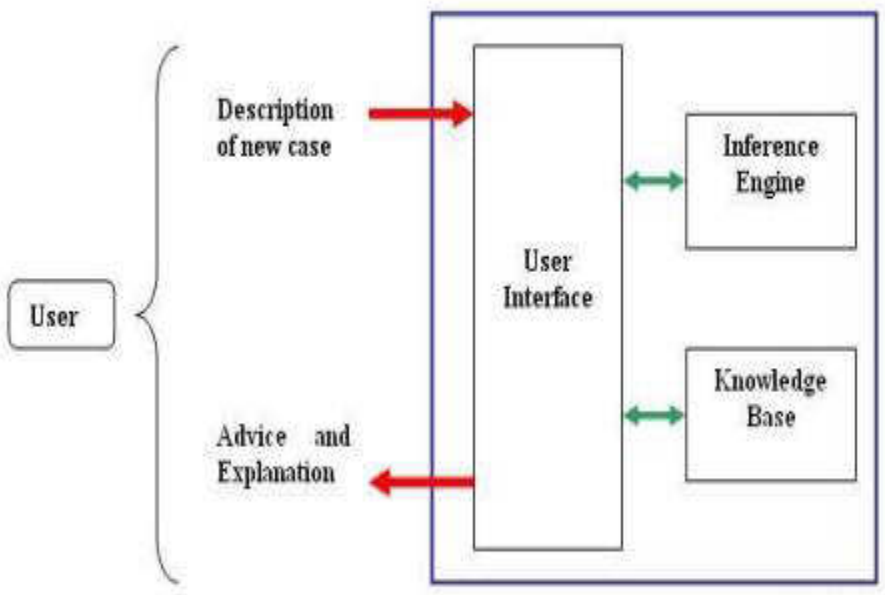


Figure (2.7) Elements of expert systems(Gupta, S., & Singhal, R. 2013)

2.8 The Expert System Architecture

The architecture of the expert system is essential to be familiar with its functions that primarily significant apparatuses are highlights of an expert system like the knowledge base, the database of knowledge, the inference engine and the user interface. Other apparatuses that can be part of the architecture of the expert system are the process of knowledge acquisition and its components. (Robindro, K., & Sarma, S. K. 2013).

The greatest important thing about expert systems is that they are extremely effective: there are some systems that uses at medical diagnosis, searching for minerals and greatly else besides. Quickly people and great companies are using programs of AI to get wealth. Expert systems have lastly inclined of the old statement: if it works, it's not AI! An expert system is depending on a wide knowledge body about the exact problem field. Typically this knowledge is prearranged as a rules collection that permits the system to draw assumptions from assumed data or sites. This

knowledge-based method to design the systems characterizes an evolutionary alteration with revolutionary magnitudes; for it substitutes the software tradition of

Data + Algorithm = Program

with an innovative architecture centered around a 'knowledge base' and an 'inference engine', so that now

Knowledge + Inference = System

which is obviously similar, but diverse enough to have profound concerns. (Forsyth, R.S. 1984).

CHAPTER THREE

Data Collections

Chapter Three

Data Collection

3.1 Introduction

The previous chapter discussed the concept of construction projects and their problems with the major influence of both cost and time in construction projects, furthermore the factors leading to cost overruns and time overruns were also discussed and the techniques that has been used to analyze these problems .

This chapter will include the methods that has been used to collect the data that used in this thesis which could be classified in two type , the first one is paper data from construction projects and the second is field survey that include questionnaire with a group of experts engineering, managers, and university professors.

3.2 Paper data

The information was gathered from previously conducted projects and projects that under construction to necessary information and build the expert system , the projects include various sectors include the Ministry of Higher Education and Scientific Research, The Ministry of Construction and Housing and Ministry of Education , the data were prepared and formulate as shown in the electronic appendix.. Figure (3.1) show the process for the collection of data from both paper data and field survey , the paper data are collected from the projects and the field survey represent the questionnaire in its all part and stages

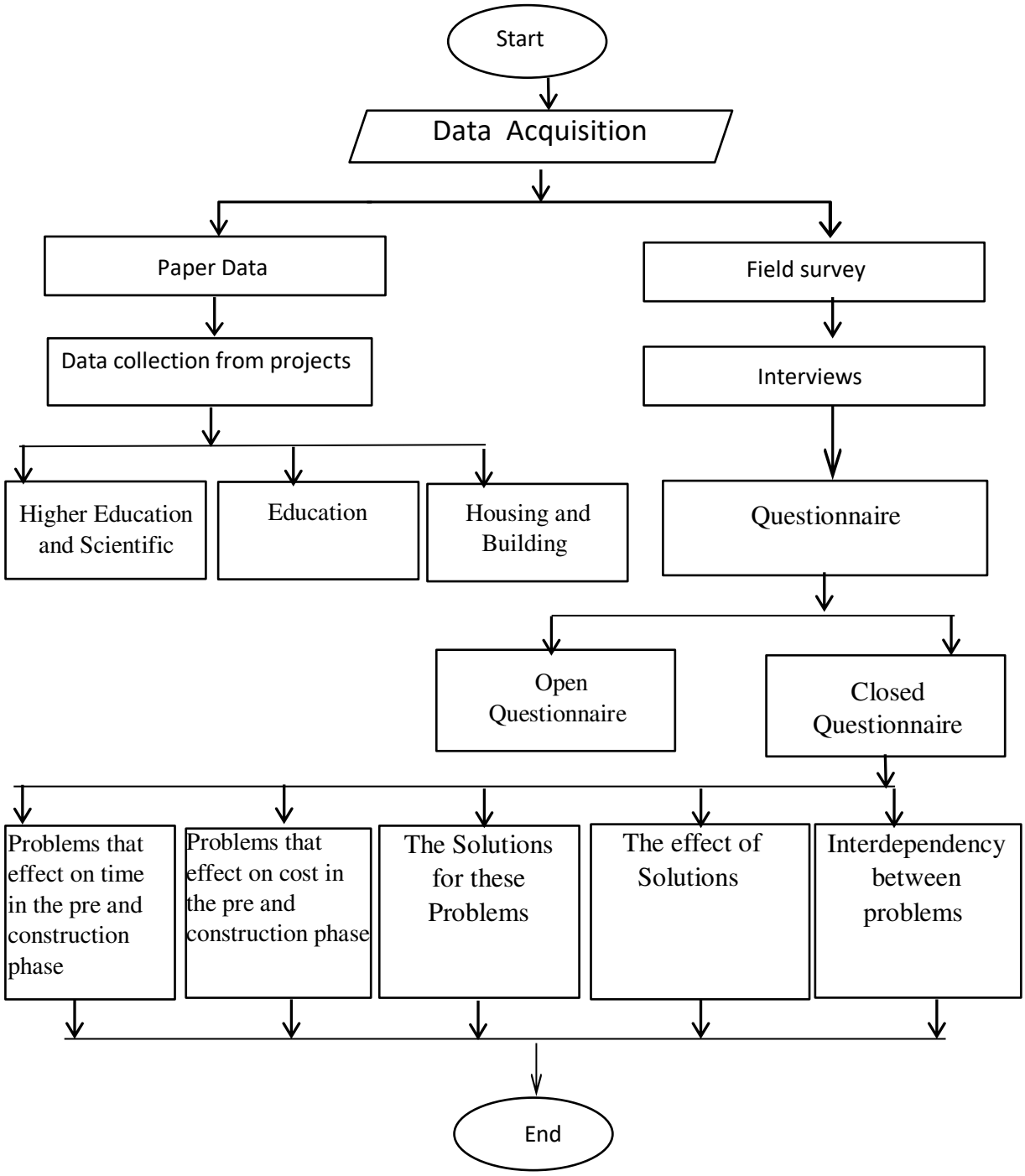


Figure (3.1) Data Collection Diagram

3.3 Field Survey

The first stage includes a questionnaire with a group of experts, engineers, managers, university professors and specialists, also include the

aspect of preparing the questionnaire and initialized the questions related to the questionnaire which deduced from the theoretical study and the open questioner. This step also includes the method that uses to select the members of the sample, identify the characters and then display the result of the questionnaire.

3.3.1 Design of The Questionnaire

The preparing of the design form was In two stages:

3.3.1.1 Open Questionnaire

This stage involves many interviews with the experts. The expert is someone who has special knowledge which is attached to their career or their knowledge related to research, experience, or profession and in a particular aspect of the study. Experts are needed for giving their advice about their related subject. Experts have extended or an intensive experience in working and teaching in a particular field (Littig, B., 2013).

The interviews also include managers and university professors, these interviews have a very significant part in aiding in the later stage, also argument about the questionnaire that was firstly set from the previous studies and makes some adjustments to the procedure and adds other questions with the help of the specialists to ensure the accomplishment of the process and questions presented and that to conclude the following:

1- Problems that effect on time in the pre and construction phase
2- Problems that effect on the cost in the pre and construction phase
3- The solutions for the these problems
4- The effects of these solution
5- The relationship between more than one problem

3.3.1.2 Closed Questionnaire

This stage includes the following

A) Initial questionnaire: After conducting the interviews with many specialists. The research problems of was split into numerous groups which embrace, pre-construction, and their impacts on the projects, the strategies that used for each problem . Thus, the questionnaire is formalized in its initial form, this questionnaire has been distributed to 8 experts as a simple test, to know the ambiguities and the weaknesses of the questionnaire .

B) Final Questionnaire: This step includes the receiving questionnaires from the 8 experts and reviewing the comments and judgment from each expert, there are some questions are modified to remove the vagueness and misunderstanding in the final formulation of the questionnaire. Thus the questionnaire is completed and divided. The questionnaire includes the following parts:

Part 1: General Information

The purpose of this step is to get the data and general information about the sample which include, gender, the company or the department, labor sector, engineering specializations, experience years and the type of the projects they executed.

Part 2: Problems that effect on Time in the Pre and -Construction Phase

This part investigates the pre-construction problems in the construction project and different ministries and also include the investigation of these problems on time.

Part 3:Problems that Effect on the cost During the Pre and -Construction Phase

This part investigates the pre-construction problems in the construction project and different ministries and also include the investigation of these problems on cost.

Part 4 :The Solutions for these Problems

The basic purpose of this part is to find the most important solutions that lead to mitigate the effect of both cost and time overruns in the construction projects.

Part 5: The effects of these Solutions

This part includes the strategies and means that followed to select the approach, also includes the effect of these solutions

Part 6: The relationship between more than one problem

This part investigates the relationship between the problems and how they effect on each other in positive or negative way

3.4 The Research Sample Election

The process of sample election is very important and the sample should include the engineers who are, specialized, experts, working in consultative offices and also University professors who have long experience. The researcher distributes 45 questionnaires

related to problems that effect on time and the cost in the pre-and construction phases, the solutions for the these problems , the effects of these solutions and the relationship between more than one problem.

41 projects were taken and the questionnaire was distributed to 15 persons from each project who worked in it, the questionnaire was taken from the owner perspective.

These questionnaires were distributed directly in order to explain what are the mysteries about the questionnaire regarding the only 36 were restored and when the result was analysis 6 were rejected because it's include missing data, thus the number of the questionnaires that they were dependent 30.

The research sample, subject to the normal distribution on the basis of central limit theorem.

3.5 Mathematical and Statistical Methods Adopted in the Analysis of the Results

The statistic science includes scientific methods to collect, organize, display and analysis of data in order to get acceptable results. The results displayed by using the forms and figures to make it easy to study and analysis because it reflects a large amount of information, this method called formalize the method. A number of measures have been used, including the following:

3.5.1 Measures Of Central Tendency

The researcher depends on these measures because it is the typical value that used to represent the data, the researcher used the most common means which are arithmetic mean $\overline{X}$ Which defined as

the value, if it was given to each individual in the group (a group of values) the total new values of individuals will be equal to the sum of the original values, also can be known as the sum of the values of the observations divided by its number (Mahdi Mohammed, 2007)

$$\text{Mean}(\overline{X}) = \sum_{i=1}^{h} xi \,.\, fi \,/ n \qquad (3.1)$$ (Mohamed Sobhi.1983)

$(\overline{X?})$ Mean

(X_i) Class Center

(f_i)The number of iterations for each class

(n)): Total sample size or duplicates of the varieties

(i)Sequence of class

(h)nmber of class

3.5.2 Measure Of Spread

The measures of central tendency don't consider enough to describe a set of data because some sample may have equal means in spite of their different distribution (the degree of homogeneity of the data), the mean represents the center of the data but doesn't show the Scattering of the data around that means, therefore there must be another measure to determine the homogeneity of the data.

The purpose of this measure is to identify the nature of the distributed questionnaire to reflect its different and Scattering, therefore if the measure of spread is high that means there is no homogeneity between data and vice versa. The researcher uses standard deviation as measure of spread and is calculated as follows

$$Standard\ Deviation\ (S) \sqrt{\sum_{i=1}^{h} (x_i - \overline{X})^2 . f_i \,/ (n-1).} \qquad (3.2)$$

(Mohamed Sobhi.1983)

C- Scheduling And Analyze The Data and Draw Conclusions Measures

The result of the questionnaires was an analysis according to the following

1- The ratio of frequency was calculated according to

$$P\% = (f_i/n) * 100 \qquad (3.3)$$ (Mohamed Sobhi.1983)

Where (P%) The ratio of frequencies

3.5.3 Cronbach Alpha

Lee Cronbach developed in 1951 to offer a measurement of an internal consistency of a scale or test, it is represented by a number among 0 and 1. Internal consistency explains the items extent to in a test measure has the similar concept or hypothesis and therefore it is linked to the inter-relatedness of the items within the test. (Tavakol M etl al ,.2008)

$$\alpha = \frac{N.\bar{c}}{\bar{v}+(N-1).\bar{c}} \qquad (3.3)$$ (Tavakol M etl al ,.2008)

Where:

- N = the number of items.
- $\bar{c}$ = average covariance between item-pairs.
- $\bar{v}$ = average variance.

3.6 Data Analysis

The questionnaires were collected and then tabulation of the data received from the questionnaires by using the statistical program PSPP (a free software application for analysis of sampled data version

0.10.4) in the analysis process, the Cronbach Alpha for the data was 0.77 which mean the data have internal consistency, the scale that has been used is Likert scale and is shown in the table (3.1):

Table (3.1) shows the Norms and Standard

Scale	Numerical
Very high	5
High	4
Medium	3
Low	2
Very low	1

The results of the analysis as the follow:

Part one : General Information

This part includes the general information as follow

1-Gender

The table and the figure (3.2) represent the sample that answer the questions of the questionnaires , its show that the male has higher percentage than the female.

Table (3.2) Show the Gender of the Sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
male	1.00	18	60.00	60.00	60.00
female	2.00	12	40.00	40.00	100.00
Total		30	100.0	100.0	

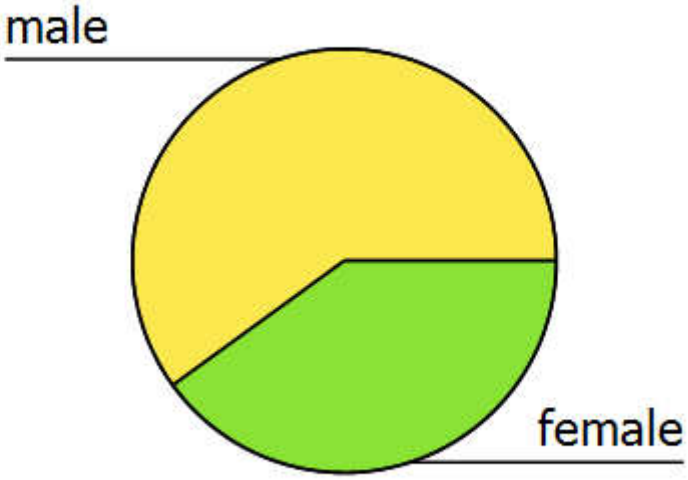


Figure (3.2) Show the gender of the sample

The value in the table mean that the female and male are represented by 1 and 3 respectively , the frequency mean the number of occurrences of a repeating answer per time , CUM is Cumulative frequency is the running total of the frequencies, the valid present mean the people that actually exist without any missing and the present the number if the total including missing and the existing people.

2-Ministry

This represent the ministries that the questionnaire were distributed to them , its show the highest value for the higher education and research with 43.33 percent and 33.33 percent for ministry of construction and housing and 23.33 percent for ministry of education.

Table (3.3) Shows the Ministry of the Sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
higher education and research	1.00	13	43.33	43.33	43.33
ministry of construction and housing	2.00	10	33.33	33.33	76.67
ministry of education	3.00	7	23.33	23.33	100
Total		30	100.0	100.0	

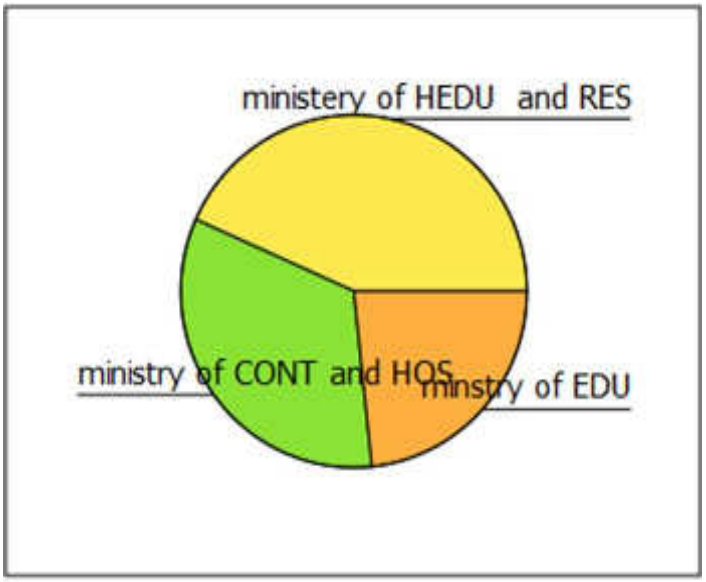


Table (3.3) Shows the Ministry of the Sample

2- Position

This represent the position of the people that questionnaire were distributed to them , its show the highest value for the owner with 43.33

percent and 33.33 percent for contractor and housing and 23.33 percent for consulter.

Table (3.4) Show the Position of the sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
higher education and research	1.00	13	43.33	43.33	43.33
ministry of construction and housing	2.00	10	33.33	33.33	76.67
ministry of education	3.00	7	23.33	23.33	100
Total		30	100.0	100.0	

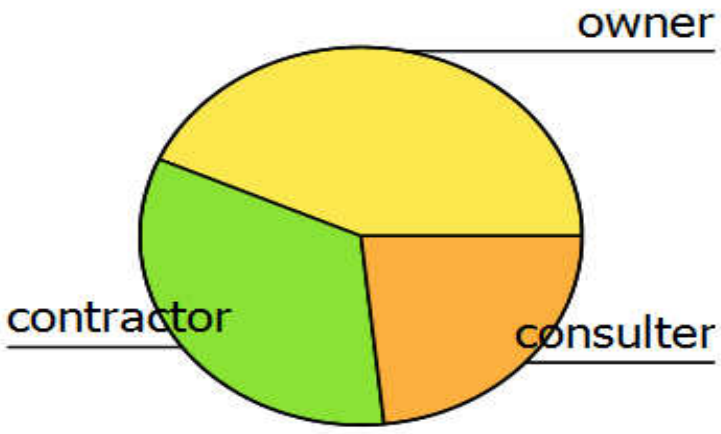


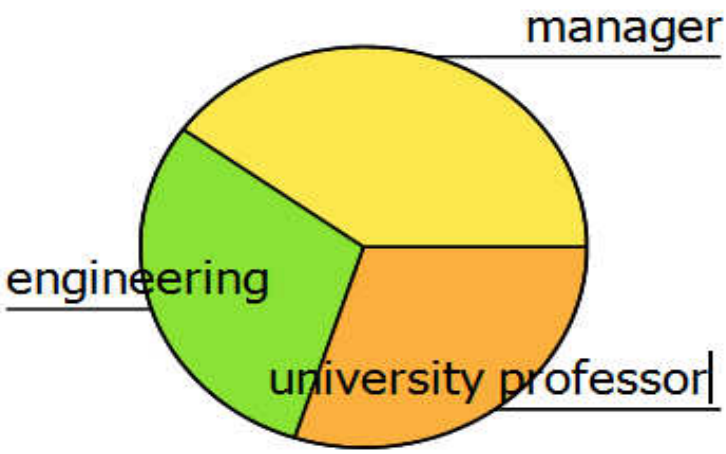
Figure (3.4) Shows the Position of the Sample

4- Academic degree

This represent the Academic degree of the people that questionnaire were distributed to them , its show the highest value for the BA with 33.31 percent and 36.67 percent for MA and housing and 26.67 percent for PHD and 3.33 for the others.

Table (3.5) Show the Academic Degree of the Sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
BA	1.00	10	33.31	33.31	33.31
MA	2.00	11	36.67	36.67	70
PHD	3.00	8	26.67	26.67	100
Others	4.00	1	3.33	3.33	96.67
Total		30	100.0	100.0	100



Figures (3.5) Shows the Academic Degree of the Sample

5- Years of experience

This represent the years of experience of the people that questionnaire were distributed to them , its show the highest value for the less than 5 30 percent and 53.33 percent for 5-10 and housing and 16.67 percent for 10-20.

Table (3.6) Show Years of Experience of the Sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Less than 5	1.00	9	30.00	30.00	30.00
5-10	2.00	16	53.33	53.33	83.33
10-20	3.00	5	16.67	16.67	100.00
Total		30	100.0	100.0	

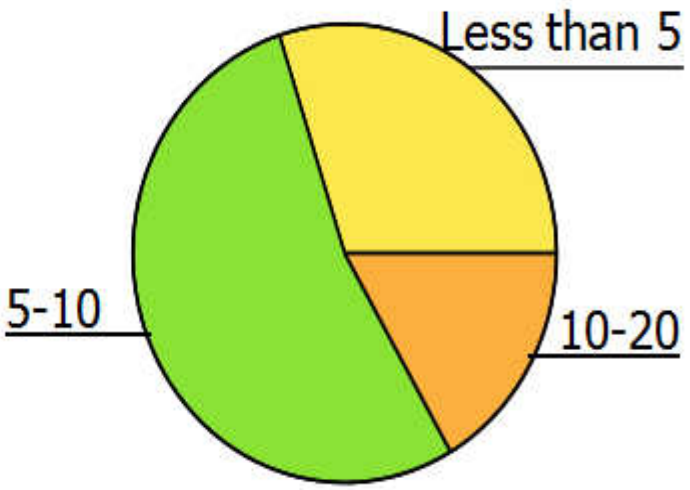


Figure (3.6) Shows Years of Experience of the Sample

6- Engineering specialization

This represent the years of engineering specialization of the people that questionnaire were distributed to them , its show the highest value for the civil with 66.67 percent and 20.00 percent for architectural and mechanical is 13.33 percent.

Table (3.7) Show Engineering Specialization of the Sample

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
Civil	1.00	20	66.67	66.67	66.67
Architectural	2.00	6	20.00	20.00	86.67
Mechanical	3.00	4	13.33	13.33	100.00
	Total	30	100.0	100.0	

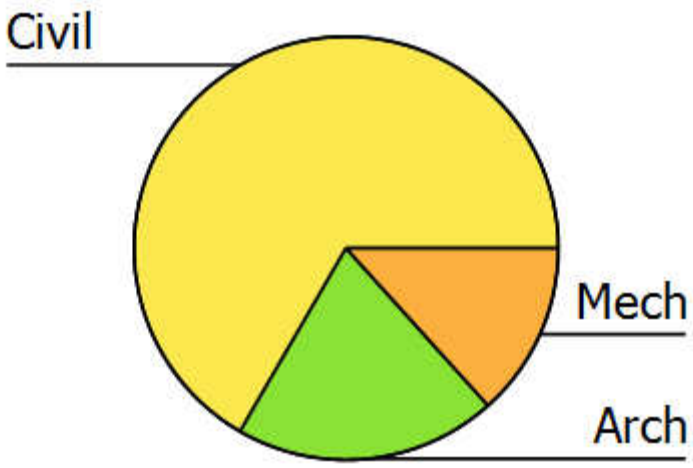


Figure (3.7) Shows Engineering Specialization of the Sample

Part 2: Problems that effect on Time in the Pre and Construction Phase

This part includes problems that effect on time in the pre-construction phase in the projects in the table (3.8).

Table (3.8) Show Problems that effect on Time in the Pre-Construction Phase

Problems	Effect on time linguistic	Effect on time
Governmental strategic development policy, Do Not Follow Governmental Rules and Regulations .The law followed by the country	high	3.92
Project function and size, Project characteristics: The project mark-up size	high	3.93
Market forecast	high	3.8
Market competition	high	3.7
Budget estimate, Poor Forecasting of Cash Flow	high	4.1
Analysis of demand and supply, demand of the market exchange for kind of things, less information Demand of the Market	high	3.89
Not good in promotion.	high	3.7
National economic growth, regional economic impact	high	4.1
Currency devaluation. Fluctuation in foreign currency., Uncontrolled inflation.	high	3.8
Incensement in regional minimum payment for workers	high	3.44
access location, project location, Lack of Land Information, Location of the project, Site accessibility	high	3.6
Imprecise technology, Unsupported facilities, Degree of technological difficulties	high	3.78
Limited human resources	high	3.7
High overhead cost.	high	3.77
interest rate.	high	3.95

Break Even Point	high	3.97
Ground water pollution, waste assessment, Lack of Sustainability Concern	Very high	4.2
attitudes toward the project	high	3.9
cultural and heritage conservation goring ,Some Aspects of Contractual Requirement, The contract style	high	4.15
approval	high	3.4
The feasibility study is not applied	high	3.7
Intentionally Fake appeared in feasibility study	high	3.79
There is no enough skills in assumptions of resources	high	3.78
The estimation of the cost and revenue is poor	high	4.15
Poor Time Estimate	high	3.4
Legal Issues dose not receive any attention	high	3.92
Lack of Communication ,Lack of Cooperation from Top Management	Very high	4.2
Lack of Team Member to Carry Out Feasibility Study ,Lack of Time to Carry Out Feasibility Study	high	3.1
Failure to Progress through the Study Phases	high	3.3
The next phase is not planned	High	4.1
Failure to Recycle through Study Phases	medium	3.33
Failure to Fix Study Scope	medium	3.1
Influence of conceptual, High conceptual design completion	medium	2.9
Feedback between design, Feedback to designer, Little feedback between designer and constructor	medium	3.2
Time, cost, quality affected Time increased	medium	3.1
Reasons for design changes Design drawings not consistent	medium	2.99
Dealing with DC conflicts	medium	3.33
Inflation (or escalation	medium	3.1
Contingency.	medium	2.9
Financial stability. Financial status.	medium	3.2

Technical ability, Ability	medium	3.1
Experience.	medium	2.99
Personnel.	medium	3.33
Management capability	medium	3.1
Management safety accountability.	medium	2.9
Reputation	medium	3.2
Past owner/contractor relationship. Other relationships. The client reputation among other contractors, with whom they had worked	medium	3.1
Type of labor required	medium	2.99
The projects' stakeholders	medium	3.1
Design quality	medium	3.3
Completeness of drawings and specification	medium	2.99
. Type of procurement methods	medium	3.33
Expecting date of commencing	medium	3.1
The client financial capacity	medium	3.3
. Clearness of the work and specifications	medium	2.99
Contract modification	medium	3.33
Subcontracting	medium	3.1
The price originally wrong estimate	medium	3.3
Very hard in obtaining bank loan	medium	2.99
Cash is not available	medium	3.33
Poor performance in the job	medium	3.1
Obtainability of qualified human resources	medium	3.3
Wrong cost estimation	medium	2.99
Overhead	medium	3.33
Current work load	medium	3.1
Reliability level of subcontractors	medium	3.3
Strength in industry	medium	2.99

Unfamiliar with the site	medium	3.33
Company ability of design involvement	medium	3.1
Time allowed for submitting bids	medium	3.3
Bidding document price	medium	2.99
Availability of equipment and materials	medium	3.33
Quality of available labor,. Availability of labor	medium	3.1
Lack of project-stipulated data ●	medium	3.3
Insufficient comprehension of design documents	medium	2.99
Insufficient pre-construction study	medium	3.33
Lack of contractor involvement during the design phase	medium	3.1
drawings and specifications are not clear	medium	3.3
design documents are wrong	medium	2.99
Granting contract to the least price irrespective of the services quality	medium	3.33
Inappropriate work packaging and subcontracting	medium	3.1
Contract dose not written well	medium	3.3
Wrong selection of type of the project contract	medium	2.99
Lack of professional construction management	medium	3.33
Difficult managers and poor in decision-making	medium	3.1
Argumentative relationship among consultant and contractor	medium	3.3
contractual relation	medium	2.99
environmental protection	medium	2.9
communication	medium	3.1
Scope definition/clarification	medium	3.2
Inexperienced clients	medium	3.3
Insufficient determination and symbol of needs and requirements through the development procedure	medium	3.21
client needs and requirements are not defined	medium	2.9

Communication gaps between participants	medium	3.1
Poor time	medium	3.2
No documentation of the changes	medium	3.3
Users dose participate and has no of a voice	medium	3.21
Less mechanism to record and update requirements	medium	2.9
difficult to define the requirements	medium	3.1
Less of end-users' participation	medium	3.2

Part 3:Problems that Effect on the cost During the Pre and Construction Phase

This part includes problems that effect on cost in the pre-construction phase in the projects as shown in the table (3.9).

Table (3.9) Show Problems that effect on Cost in the Pre-Construction Phase

Problems	Effect on cost linguistic	Effect on cost
Governmental strategic development policy, Do Not Follow Governmental Rules and Regulations .The law followed by the country	high	3.89
Project function and size, Project characteristics: The project mark-up size	high	2.67
Market forecast	high	2.69
Market competition	high	3.55
Budget estimate, Poor Forecasting of Cash Flow	high	3.95
Analysis of demand and supply, demand of the market exchange for kind of things, less information Demand of the Market	high	3.77
Poor promotion.	high	3.89

National economic growth, regional economic impact	high	2.67
Currency devaluation. Fluctuation in foreign currency., Uncontrolled inflation.	high	2.69
Incensement in regional minimum payment for workers	high	3.55
access location, project location, Lack of Land Information, Location of the project, Site accessibility	high	3.95
Imprecise technology, Unsupported facilities, Degree of technological difficulties	high	3.77
Limited human resources	high	3.7
High overhead cost.	high	3.77
interest rate.	high	3.95
Break Even Point	high	3.9
Ground water pollution, waste assessment, Lack of Sustainability Concern	high	4.1
attitudes toward the project	high	3.9
cultural and heritage conservation goring ,Some Aspects of Contractual Requirement, The contract style	high	4.1
approval	high	3.9
The feasibility study is not applied	high	4.1
Intentionally Fake appeared in feasibility study	high	3.9
There is no enough skills in assumptions of resources	high	4.1
The estimation of the cost and revenue is poor	high	3.9
Poor Time Estimate	high	4.1
Legal Issues dose not receive any attention	high	3.9
Lack of Communication ,Lack of Cooperation from Top Management	Very high	4.3
Lack of Team Member to Carry Out	high	3.99

Feasibility Study ,Lack of Time to Carry Out Feasibility Study		
Failure to Progress through the Study Phases	high	4.1
The next phase is not planned	High	3.4
Failure to Recycle through Study Phases	medium	3.33
Failure to Fix Study Scope	medium	3.1
Influence of conceptual, High conceptual design completion	medium	2.9
Feedback between design, Feedback to designer, Little feedback between designer and constructor	medium	2.77
Time, cost, quality affected Time increased	medium	2.67
Reasons for design changes Design drawings not consistent	medium	3.33
Dealing with DC conflicts	medium	3.12
Inflation (or escalation	medium	3.21
Contingency.	medium	3.21
Financial stability. Financial status.	medium	2.77
Technical ability, Ability	medium	2.67
Experience.	medium	3.7
Personnel.	medium	3.9
Management capability	medium	3.65
Management safety accountability.	medium	3.7
Reputation	medium	3.9
Past owner/contractor relationship. Other relationships. The client reputation among other contractors, with whom they had worked	medium	3.65
Type of labor required	medium	3.7
The projects' stakeholders	medium	3.9
Design quality	medium	3.65

Completeness of drawings and specification	medium	3.7
. Type of procurement methods	medium	3.9
Expecting date of commencing	medium	3.65
The client financial capacity	medium	3.7
. Clearness of the work and specifications	medium	3.9
Contract modification	medium	3.65
Subcontracting	medium	3.7
The price originally wrong estimate	medium	3.9
Very hard in obtaining bank loan	medium	3.65
Cash is not available	medium	3.7
Poor performance in the job	medium	3.9
Obtainability of qualified human resources	medium	3.65
Wrong cost estimation	medium	3.7
Overhead	medium	3.9
Current work load	medium	3.65
Reliability level of subcontractors	medium	3.7
Strength in industry	medium	3.9
Unfamiliar with the site	medium	3.65
Company ability of design involvement	medium	3.7
Time allowed for submitting bids	medium	3.9
Bidding document price	medium	3.65
Availability of equipment and materials	medium	3.7
Quality of available labor,. Availability of labor	medium	3.9
Lack of project-stipulated data ●	medium	3.65
Insufficient comprehension of design documents	medium	3.7
Insufficient pre-construction study	medium	3.9
Lack of contractor involvement during the	medium	3.65

design phase		
drawings and specifications are not clear	medium	3.7
design documents are wrong	medium	3.9
Granting contract to the least price irrespective of the services quality	medium	3.33
Inappropriate work packaging and subcontracting	medium	3.1
Contract dose not written well	medium	3.3
Wrong selection of type of the project contract	medium	2.99
Lack of professional construction management	medium	3.33
Difficult managers and poor in decision-making	medium	3.1
Argumentative relationship among consultant and contractor	medium	3.3
contractual relation	medium	2.99
environmental protection	medium	2.9
communication	medium	3.1
Scope definition/clarification	medium	3.2
Inexperienced clients	medium	3.3
Insufficient determination and symbol of needs and requirements through the development procedure	medium	3.21
client needs and requirements are not defined	medium	2.9
Communication gaps between participants	medium	3.1
Poor time	medium	3.2
No documentation of the changes	medium	3.3
Users dose participate and has no of a voice	medium	3.21
Less mechanism to record and update requirements	medium	2.9

difficult to define the requirements	medium	3.1
Less of end-users' participation	medium	3.2

Part 4 :The Solutions for pre-construction Problems

This part include the possible solutions for the problems as shown in the table (3.10)

Table (3.10) Show Problems and their Possible Solutions

Problems	Solutions
Governmental strategic development policy, Do Not Follow Governmental Rules and Regulations .The law followed by the country	Controlling for Outside Influences
	Flexibility
	Cooperation
	Adaptability and Initiative
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Offer prizes and motivations for high agreement
	Observer the influences of rule on consequences and use this information to incessantly recover performance of th regulatory
	Compliance Analysis Tools
	Communication among maker of the policy and agencies of policy implementation
Project function and size, Project characteristics: The project mark-up size	Create a Flow of Communication
	Make a Habit of Continuous Planning
	Observe and Ask Questions
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of

	Influence
	Embrace Automated Reporting Systems
	centralized project management software solution is the need
	Compliance Analysis Tools
	establish strategic alignment
Market forecast	Create a Flow of Communication
	make details study on the market
	Observe and Ask Questions
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	centralized project management software solution is the need
	Compliance Analysis Tools
	establish stratigic alignment
Market competition	Focusing only on innovation and the competition
	Focusing only on customers
	Identify and solve the pain points of your customers.
	Build your own niche to have more room for your business
	Connect with Influencers
	decide Segments are cost effective and easy to reach
	Clear target that focused on the motivations that effect customer decision
	Marketing tasks be organized within firm
	Attract the best marketing talent
	Digital media to both new insight about costumer and competitors
Budget estimate, Poor Forecasting of Cash	DETAILED ESTIMATE

Flow	
	select Project team's experience in the construction type
	BIM
	provide sufficient details for estimators
	defined scope
	Design contingency accounts
	apply escalation up to the mid-point of construction
	Acquire training and skilling
	Perform detailed risk analysis
	train and education
Analysis of demand and supply, demand of the market exchange for kind of things, less information Demand of the Market	Create a Flow of Communication
	make detail study on the market
	Observe and Ask Questions
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	centralized project management software solution is the need
	Compliance Analysis Tools
	establish strategic alignment
Poor promotion.	Making the processes within agencies of the national planning and ministries of operating
	make detail study on the market
	Transparency
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources

	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	introductory analysis, assessment of sectorial, feasibility studies and technical assessment to offer needed information for succeeding design
	Supervision
	establish strategic alignment
National economic growth, regional economic impact	Making the processes within agencies of the national planning and ministries of operating
	make details study on the market
	political stability and used the Granger's method to analyses the causal links among the construction industry growth and the growth of the larger macro economy
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Co integration test
	Supervision
	establish strategic alignment
Currency devaluation. Fluctuation in foreign currency., Uncontrolled inflation.	Timing your foreign purchases
	direct controls
	Public Sector Units should be sold out and private sector should be given prominence in economic growth
	Foreign investment must be welcomed in all sectors of economy
	Government should concentrate only on creating physical/human infrastructure with minimal government and should refrain from intervention in market place.
	Wage contracts
	past study of country condition
	automation reduce space needs

	detailed study
	using forecast techniques
Incensement in regional minimum payment for workers	Education and Training
	make details study on the market
	ACT Work Keys
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Making Public Programs Work for Low-Wage Families
	Supervision
	establish strategic alignment
access location, project location,	Site Management
	Arena program
	Communication and education
	Planning and control
	Sufficient and Consistent Efforts and Resources
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Forecasting for future problem
	Supervision
	establish strategic alignment
Imprecise technology	Education and Training
	make details study of the world technology
	ACT Work Keys
	using Skills worker
	Sufficient and Consistent Efforts and Resources
	commit available resources to technology
	provide incentive for the addition technology

	expert
	Policy adoption of awarding
	Supervision
	establish strategic alignment
Limited human resources	Education and Training
	Finding Qualified Workers
	Maintaining Worker Safety
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Lowering Workers' Compensation Costs
	Embrace Automated Reporting Systems
	Coping with changing labor laws
	Supervision
	Organizational Planning
High overhead cost.	assessment of Project Complexity
	Analysis Project Size
	made Payment Schedule
	Asses Regional Economic Condition
	Carefully choice Type of Contract
	Carefully Tendering Method
	Embrace Automated Reporting Systems
	Asses Contractor’s Cash Availability
	Supervision
	Defend Work Scope
interest rate.	Education and Training
	make details study of the world technology
	Control Cash flow
	using Skills worker
	Sufficient and Consistent Efforts and Resources
	Control Fluctuations/Pricing Mechanism

	provide incentive for the addition technology expert
	Policy adoption of awarding
	Supervision
	establish strategic alignment
Break Even Point	Prediction Sales
	Make Study Cost of Goods Sold
	Control Cash flow
	using Skills worker
	Sufficient and Consistent Efforts and Resources
	Control Fluctuations/Pricing Mechanism
	provide incentive for the addition technology expert
	Control Cash inflows
	Supervision
	establish strategic alignment
Ground water pollution	Make sure non-recyclable waste is contained properly
	Follow all water laws and regulations given out by your municipality.
	Never bury animals in the backyard.
	Never pour oil or fuel down the drain or into storm drains.
	Make people aware about the concept of Reduce, Recycle and Reuse
	Avoid buying packages items as they will lead to garbage and end up in landfill site
	Create dumping ground away from residential areas.
	Clean up your yard regularly, and encourage your neighbors to do the same.
	Supervision
	Always dispose of pesticides and other harsh chemicals appropriately.
attitudes toward the project	assessment of Project Complexity

	Analysis Project Size
	made Payment Schedule
	Asses Regional Economic Condition
	Carefully choice Type of Contract
	Carefully Tendering Method
	Embrace Automated Reporting Systems
	Asses Contractor's Cash Availability
	Supervision
	defined Work Scope
cultural and heritage conservation gnoring	assessment of Project Complexity
	Analysis Project Size
	Details study of the previous project
	Asses Regional Economic Condition
	Carefully choice of the contractors
	Carefully Tendering Method
	Embrace Automated Reporting Systems
	Asses Contractor's Cash Availability
	Supervision
	defined Work Scope
approval	Create a Flow of Communication
	make details study on the market
	Observe and Ask Questions
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	centralized project management software solution is the need
	Compliance Analysis Tools
	establish strategic alignment

Do Not Carry ,Put Feasibility Study Properly	Create a Flow of Communication
	make details study on the market
	Provide The Project Scope
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	Review
	Compliance Analysis Tools
	Evaluation
Deliberately Fraudulent Occurred in Feasibility Study	Create a Flow of Communication
	make detail study on the market
	Provide The Project Scope
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	Review
	Compliance Analysis Tools
	Evaluation
Poor Skills of Making Assumptions of Resources	effective use of resources of material, frequently using recycled material
	based on renewable resources and energy
	make detailed study of past similar project
	assign expert team to make the estimate
	provide incentive and reward for the estimate
	use modern software for the estimate
	Take notes and record your progress
	prepare alternatives

	Brainstorm creative options
	establish strategic alignment
Poor Cost and Revenue Estimate	DETAILED ESTIMATE
	select Project team's experience in the construction type
	BIM
	provide sufficient details for estimators
	defined scope
	Design contingency accounts
	apply escalation up to the mid-point of construction
	Acquire training and skilling
	Perform detailed risk analysis
	make alternative estimation approaches.
Poor Time Estimate	DETAILED ESTIMATE
	select Project team's experience in the construction type
	BIM
	provide sufficient details for estimators
	defined scope
	Design contingency accounts
	apply escalation up to the mid-point of construction
	Acquire training and skilling
	Perform detailed risk analysis
	make alternative estimation approaches.
Lack of Concern for Legal Issues	Controlling for Outside Influences
	Flexibility
	Cooperation
	Adaptability and Initiative
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of

	Influence
	Provide prizes and motivations for high agreement
	Observer the influences of rule on consequences and use this information to incessantly recover performance of the regulatory
	Compliance Analysis Tools
	Communication among makers of the policy and policy implementation agencies
Lack of Communication ,Lack of Cooperation	Intensification of calls and e-mails
	Greater care was taken in updating the documents
	Increase meetings
	Planning and control
	Increasing the presence of the project management
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Regulation of the meetings
	Greater care in the management of documentation
	establish strategic alignment
Lack of Team Member to Carry Out Feasibility Study	Create a Flow of Communication
	make detail study on the market
	Provide The Project Scope
	Technology & Domain Skills
	Sufficient and Consistent Efforts and Resources
	Disciplined Use of Force and Subtle Use of Influence
	Embrace Automated Reporting Systems
	Review
	Compliance Analysis Tools
	Evaluation
Failure to Progress through the Study Phases	Implementing the work plan
	Greater care was taken in updating the documents

	Increase meetings
	Planning and control
	Project reporting
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Project evaluation
	Greater care in the management of documentation
	Project implementation checklist
Failure to Plan for the Next Study Phases	Implementing the work plan
	Greater care was taken in updating the documents
	Increase meetings
	Planning and control
	Project reporting
	commit available resources to feasible projects
	Embrace Automated Reporting Systems
	Project evaluation
	Greater care in the management of documentation
	Project implementation checklist

Part 5: The Effects of pre-construction Solutions

This part include the effect of the solutions of each problem and its give scale from 0-1 which mean each person will give an number say 0.44 and others 0.55 then the mean for their answer are taken . its effectiveness as shown in the table (3.11)

Table (3.11) Show Solutions and their Effectiveness

Solutions	Effectiveness
Controlling for Outside Influences	0.78
Flexibility	0.7
Cooperation	0.77
Adaptability and Initiative	0.75
Sufficient and Consistent Efforts and Resources	0.8
Disciplined Use of Force and Subtle Use of Influence	0.74
Provide prizes and motivations for high agreement	0.85
Observer the influences of rule on consequences and use this information to incessantly recover performance of the regulatory	0.88
Compliance Analysis Tools	0.82
Communication among makers of the policy and policy implementation agencies	0.9
Controlling for Outside Influences	0.8
Create a Flow of Communication	0.79
Make a Habit of Continuous Planning	0.77
Observe and Ask Questions	0.74
Technology & Domain Skills	0.8
Sufficient and Consistent Efforts and Resources	0.84
Disciplined Use of Force and Subtle Use of Influence	0.85
Embrace Automated Reporting Systems	0.98
centralized project management software solution is the need	0.82
Compliance Analysis Tools	0.9
establish strategic alignment	0.88
Create a Flow of Communication	0.79
make details study on the market	0.77

Observe and Ask Questions	0.74
Technology & Domain Skills	0.82
Sufficient and Consistent Efforts and Resources	0.84
Disciplined Use of Force and Subtle Use of Influence	0.85
Embrace Automated Reporting Systems	0.98
centralized project management software solution is the need	0.82
Compliance Analysis Tools	0.7
establish stratigic alignment	0.88
Focusing only on innovation and the competition	0.78
Focusing only on customers	0.77
Identify and solve the pain points of your customers.	0.74
Build your own niche to have more room for your business	0.82
Connect with Influencers	0.84
decide Segments are cost effective and easy to reach	0.85
Clear target that focused on the motivations that effect customer decision	0.98
Marketing tasks be organized within firm	0.78
Attract the best marketing talent	0.7
Digital media to both new insight about costumer and competitors	0.8
DETAILED ESTIMATE	0.85
select Project team's experience in the construction type	0.9
BIM	0.85
provide sufficient details for estimators	0.88
defined scope	0.78
Design contingency accounts	0.75
apply escalation up to the mid-point of construction	0.89
Acquire training and skilling	0.8
Perform detailed risk analysis	0.87
train and education	0.8

Create a Flow of Communication	0.79
make detail study on the market	0.77
Observe and Ask Questions	0.74
Technology & Domain Skills	0.82
Sufficient and Consistent Efforts and Resources	0.84
Disciplined Use of Force and Subtle Use of Influence	0.87
Embrace Automated Reporting Systems	0.98
centralized project management software solution is the need	0.82
Compliance Analysis Tools	0.7
establish strategic alignment	0.8
preparation procedures within national planning agencies and operating ministries	0.79
make detail study on the market	0.79
Transparency	0.74
Technology & Domain Skills	0.79
Sufficient and Consistent Efforts and Resources	0.84
commit available resources to feasible projects	0.87
Embrace Automated Reporting Systems	0.98
preparatory analysis, sectorial assessment, feasibility studies and technical appraisal to provide required information for subsequent design	0.82
Supervision	0.7
establish strategic alignment	0.78
preparation procedures within national planning agencies and operating ministries	0.7
make details study on the market	0.77
political stability and used the Granger's method to analyses the causal links between the growth of the construction industry and the growth of the larger macro economy	0.75
Technology & Domain Skills	0.8
Sufficient and Consistent Efforts and Resources	0.74

commit available resources to feasible projects	0.85
Embrace Automated Reporting Systems	0.88
Co integration test	0.82
Supervision	0.9
establish strategic alignment	
Timing your foreign purchases	0.88
direct controls	0.8
Public Sector Units should be sold out and private sector should be given prominence in economic growth	0.89
Foreign investment must be welcomed in all sectors of economy	0.74
Government should concentrate only on creating physical/human infrastructure with minimal government and should refrain from intervention in market place.	0.79
Wage contracts	0.84
past study of country condition	0.87
automation reduce space needs	0.8
detailed study	0.82
using forecast techniques	0.7
Education and Training	0.8
make details study on the market	0.89
ACT Work Keys	0.82
Technology & Domain Skills	0.78
Sufficient and Consistent Efforts and Resources	0.79
commit available resources to feasible projects	0.8
Embrace Automated Reporting Systems	0.73
Making Public Programs Work for Low-Wage Families	0.8
Supervision	0.8
establish strategic alignment	0.73
Site Management	0.8
Arena program	0.82

Communication and education	0.86
Planning and control	0.72
Sufficient and Consistent Efforts and Resources	0.77
commit available resources to feasible projects	0.84
Embrace Automated Reporting Systems	0.87
Forecasting for future problem	0.8
Supervision	0.82
establish strategic alignment	0.7
Education and Training	0.88
make details study of the world technology	0.89
ACT Work Keys	0.82
using Skills worker	0.74
Sufficient and Consistent Efforts and Resources	0.8
commit available resources to technology	0.83
provide incentive for the addition technology expert	0.87
Policy adoption of awarding	0.82
Supervision	0.82
establish strategic alignment	0.77
Education and Training	0.87
Finding Qualified Workers	0.85
Maintaining Worker Safety	0.82
Technology & Domain Skills	0.74
Sufficient and Consistent Efforts and Resources	0.8
Lowering Workers' Compensation Costs	0.84
Embrace Automated Reporting Systems	0.87
Coping with changing labor laws	0.82
Supervision	0.82
Organizational Planning	0.79
assessment of Project Complexity	0.82

Analysis Project Size	0.83
made Payment Schedule	0.84
Asses Regional Economic Condition	0.82
Carefully choice Type of Contract	0.77
Carefully Tendering Method	0.84
Embrace Automated Reporting Systems	0.87
Asses Contractor's Cash Availability	0.8
Supervision	0.82
Defend Work Scope	0.75
Education and Training	0.82
make details study of the world technology	0.83
Control Cash flow	0.84
using Skills worker	0.82
Sufficient and Consistent Efforts and Resources	0.77
Control Fluctuations/Pricing Mechanism	0.84
provide incentive for the addition technology expert	0.87
Policy adoption of awarding	0.8
Supervision	0.82
establish strategic alignment	0.75
Prediction Sales	0.89
Make Study Cost of Goods Sold	0.88
Control Cash flow	0.82
using Skills worker	0.74
Sufficient and Consistent Efforts and Resources	0.8
Control Fluctuations/Pricing Mechanism	0.84
provide incentive for the addition technology expert	0.87
Control Cash inflows	0.84
Supervision	0.82
establish strategic alignment	0.77

Make sure non-recyclable waste is contained properly	0.77
Follow all water laws and regulations given out by your municipality.	0.82
Never bury animals in the backyard.	0.83
Never pour oil or fuel down the drain or into storm drains.	0.84
Make people aware about the concept of Reduce, Recycle and Reuse	0.81
Avoid buying packages items as they will lead to garbage and end up in landfill site	0.82
Create dumping ground away from residential areas.	0.83
Clean up your yard regularly, and encourage your neighbors to do the same.	0.82
Supervision	0.82
Always dispose of pesticides and other harsh chemicals appropriately.	0.8
assessment of Project Complexity	0.87
Analysis Project Size	0.82
made Payment Schedule	0.73
Asses Regional Economic Condition	0.89
Carefully choice Type of Contract	0.82
Carefully Tendering Method	0.82
Embrace Automated Reporting Systems	0.83
Asses Contractor's Cash Availability	0.82
Supervision	0.82
defined Work Scope	0.82
assessment of Project Complexity	0.8
Analysis Project Size	0.89
Details study of the previous project	0.87
Asses Regional Economic Condition	0.84
Carefully choice of the contractors	0.83
Carefully Tendering Method	0.84
Embrace Automated Reporting Systems	0.85

Asses Contractor's Cash Availability	0.98
Supervision	0.82
defined Work Scope	0.78
Create a Flow of Communication	0.88
make details study on the market	0.89
Observe and Ask Questions	0.85
Technology & Domain Skills	0.84
Sufficient and Consistent Efforts and Resources	0.83
Disciplined Use of Force and Subtle Use of Influence	0.84
Embrace Automated Reporting Systems	0.85
centralized project management software solution is the need	0.8
Compliance Analysis Tools	0.82
establish strategic alignment	0.78
Create a Flow of Communication	0.88
make details study on the market	0.89
Provide The Project Scope	0.85
Technology & Domain Skills	0.84
Sufficient and Consistent Efforts and Resources	0.83
Disciplined Use of Force and Subtle Use of Influence	0.84
Embrace Automated Reporting Systems	0.85
Review	0.8
Compliance Analysis Tools	0.82
Evaluation	0.78
Create a Flow of Communication	0.88
make detail study on the market	0.89
Provide The Project Scope	0.88
Technology & Domain Skills	0.84
Sufficient and Consistent Efforts and Resources	0.83
Disciplined Use of Force and Subtle Use of Influence	0.84

Embrace Automated Reporting Systems	0.85
Review	0.8
Compliance Analysis Tools	0.82
Evaluation	0.78
efficient utilization of material resources, often using recycled material	0.82
based on renewable resources and energy	0.85
make detailed study of past similar project	0.9
assign expert team to make the estimate	0.85
provide incentive and reward for the estimate	0.88
use modern software for the estimate	0.78
Take notes and record your progress	0.75
prepare alternatives	0.89
Brainstorm creative options	0.8
establish strategic alignment	0.87
DETAILED ESTIMATE	0.85
select Project team's experience in the construction type	0.82
BIM	0.88
provide sufficient details for estimators	0.85
defined scope	0.85
Design contingency accounts	0.79
apply escalation up to the mid-point of construction	0.75
Acquire training and skilling	0.89
Perform detailed risk analysis	0.82
make alternative estimation approaches.	0.87
DETAILED ESTIMATE	0.88
select Project team's experience in the construction type	0.78
BIM	0.82
provide sufficient details for estimators	0.85
defined scope	0.8

Design contingency accounts	0.74
apply escalation up to the mid-point of construction	0.85
Acquire training and skilling	0.88
Perform detailed risk analysis	0.82
make alternative estimation approaches.	0.89
Controlling for Outside Influences	0.8
Flexibility	0.89
Cooperation	0.82
Adaptability and Initiative	0.8
Sufficient and Consistent Efforts and Resources	0.79
Disciplined Use of Force and Subtle Use of Influence	0.81
Provide rewards and incentives for high/voluntary compliance :	0.73
Monitor the impacts of regulation on outcomes and use this information to continuously improve regulatory performance	0.84
Compliance Analysis Tools	0.83
Communication between policy-makers and policy implementation agencies	0.73
Intensification of calls and e-mails	0.88
Greater care was taken in updating the documents	0.89
Increase meetings	0.85
Planning and control	0.84
Increasing the presence of the project management	0.83
commit available resources to feasible projects	0.84
Embrace Automated Reporting Systems	0.85
Regulation of the meetings	0.8
Greater care in the management of documentation	0.82
establish strategic alignment	0.78
Create a Flow of Communication	0.88
make detail study on the market	0.86

Provide The Project Scope	0.82
Technology & Domain Skills	0.8
Sufficient and Consistent Efforts and Resources	0.77
Disciplined Use of Force and Subtle Use of Influence	0.86
Embrace Automated Reporting Systems	0.73
Review	0.84
Compliance Analysis Tools	0.83
Evaluation	0.73
Implementing the work plan	0.88
Greater care was taken in updating the documents	0.86
Increase meetings	0.82
Planning and control	0.8
Project reporting	0.77
commit available resources to feasible projects	0.86
Embrace Automated Reporting Systems	0.73
Project evaluation	0.84
Greater care in the management of documentation	0.83
Project implementation checklist	0.73
Implementing the work plan	0.88
Greater care was taken in updating the documents	0.82
Increase meetings	0.83
Planning and control	0.84
Project reporting	0.82
commit available resources to feasible projects	0.77
Embrace Automated Reporting Systems	0.84
Project evaluation	0.87
Greater care in the management of documentation	0.8
Project implementation checklist	0.82

The above show the pre-construction problems and their solutions with their value taken from the projects , while the construction problems and solutions are shown in the appendix C and D

Part 6: The Relationship between more than One Problem

This part include the relationship between more than problem as shown in the appendix E is sample the details is in the electronic appendix.

CHAPTER FOUR

Expert System

Chapter Four

Expert System

4.1 Introduction

In previous chapters , it has been discussed about the construction sector and their problems and also about the techniques that has been used ,later details about how and what data has been collected and it was explained as the first step in the building of the expert system.

In this chapter , a details about the expert system and its rules , how its build , steps and the whole structure.

4.2 Knowledge-Base Structure

Every expert system contains knowledge bases for the specific domain to that it is dedicated. By using this knowledge base, there will be knowledge about the actual domain as well as problem-solving knowledge. The most important part of the knowledge is the production rules , The expert system production rules include its domain knowledge, stated as IFTHEN form rules.

The basic procedure of a rule is as follows in the subsequent order:

• RULE the name of the rule

IF the cause

THEN the effect;

Let's look at very modest sample rule:

RULE identification of the construction problem_

IF identification = delay

THEN Treatment = using BIM program ;

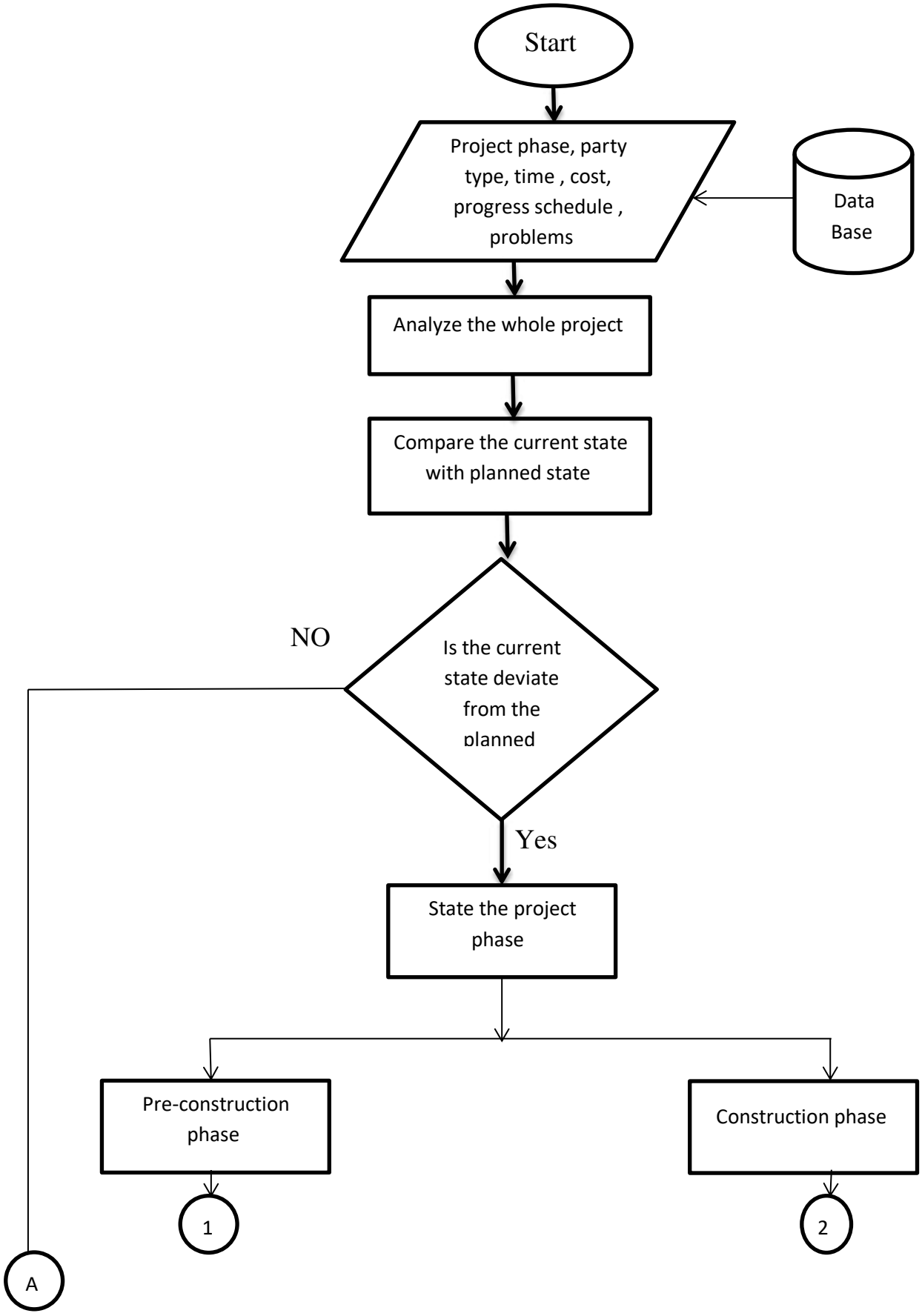
The above rule mean that if any delay happen in the project , the program (BIM) which is building information modeling that use to estimate the time and cost for construction projects.

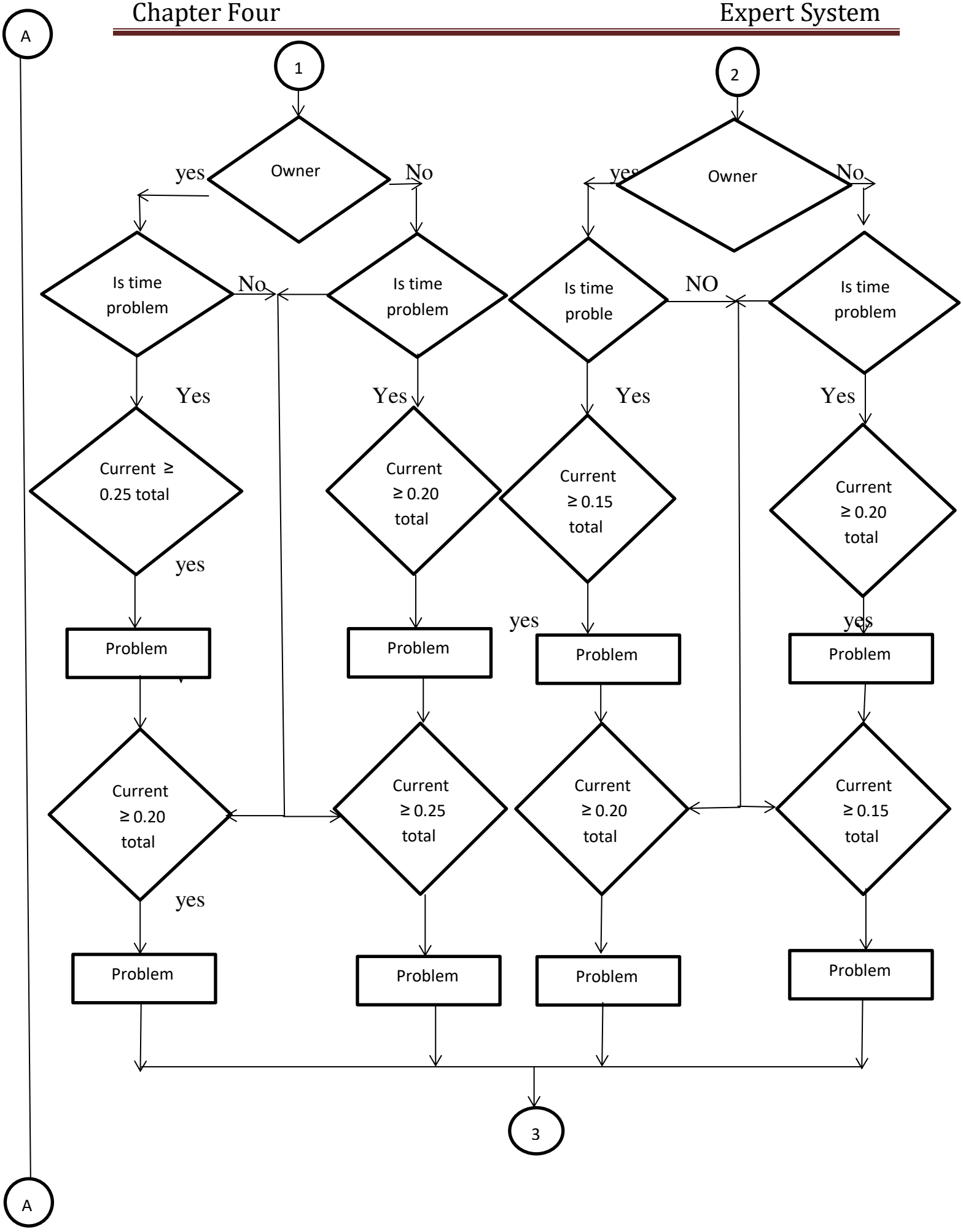
The knowledge base of the used expert system which is named project management optimization guidance (PMOG) was based on the data collected from several places as it include the knowledge base of expert system include both knowledge from fact and heuristic. Knowledge from Fact is the task area that is commonly shared, classically it exist in textbooks or journals. knowledge from Heuristic is the less difficult, more empirical, more hypercritical performance knowledge. (Tripathi,2011)

The knowledge base depend on the data that has been explained in the chapter three. To symbolize the rules of the knowledge production, frames, logic, semantic net etc. is used.

4.2.1 Basic Rules

The basic rule for the expert system is IF THEN that has been used and its divided into several steps in order to achieve the goal of the system , which is finding the best solution for the various problems facing construction industry, the steps as shown in the figure (4.1):


Start
Project phase, party type, time , cost, progress schedule , problems
Data Base
Analyze the whole project
Compare the current state with planned state
Is the current state deviate from the planned
NO
Yes
State the project phase
Pre-construction phase
Construction phase
1
2
A


A
1
2
Owner
yes
No
Owner
yes
No
Is time problem
No
Is time problem
Is time proble
NO
Is time problem
Yes
Yes
Yes
Yes
Current ≥ 0.25 total
Current ≥ 0.20 total
Current ≥ 0.15 total
Current ≥ 0.20 total
yes
yes
yes
Problem
Problem
Problem
Problem
Current ≥ 0.20 total
Current ≥ 0.25 total
Current ≥ 0.20 total
Current ≥ 0.15 total
yes
Problem
Problem
Problem
Problem
3
A

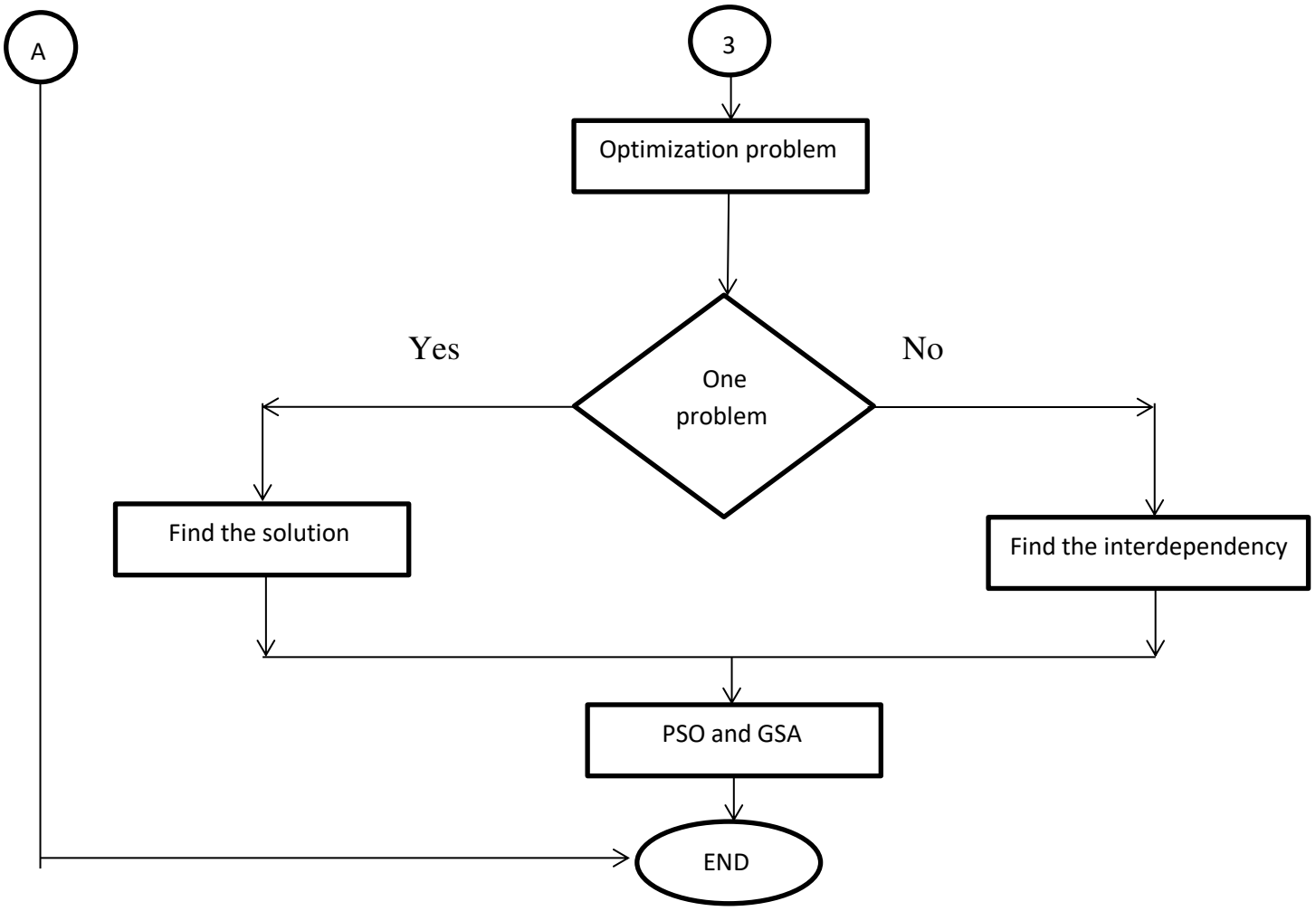


Figure (4-1) Flow chart of the expert system

4.3 Inference Engine.

The brain of the expert system is the inference engine. The use of it help to control structure which mean it is use as rule interpreter and offers reasoning methodology. The main job is as an interpreter that investigates. It is used to accomplish the identical backgrounds mission from the reactions given by the users and firing rules. The main job of inference engine is to hint its method through a wood of rules to reach at a conclusion. (Tripathi,2011) .The rules that has been used in this system is based on the general used and gain from the knowledge base and interpret the rule into code to run the whole system and it was divided into the following parts :

4.3.1 Whole Project Analysis

This part include the analysis of the whole project in its current state and compare it with planned one and its include as the following:

IF progress schedule Deviate

THEN the project is on problem

In order to do that , each project was put in excel file and it had been called from the system using the following steps :

Step (1) Define the data

```
Input: data
   Output: plot
   Begin
   Step 1: definition  of the data
    Step 2: input of the data;
   Step 3 :select the
    range of data
Step4 : plot t
```

The step (1) show how it has treat the order of the analyze and then in order to get clear idea how it work it will be drown as seen in the step (2)

Step(2) Define the plot

```
Input : plot
Output: plot definition
Step 1: call the plot
step 2 : put it in the axes that decided to be ploted
step3: define the plot properties
```

That was how the inference engine interpret the rule

4.3.2 Project Phase Analysis

In this stage , two phase will be analyze depending on the problem period and also the problem type will be examine whether its time or cost, this analyze depend on the earned value rule which simply compare the actual time or cost with planned one and it usually between the owner and the contractor .

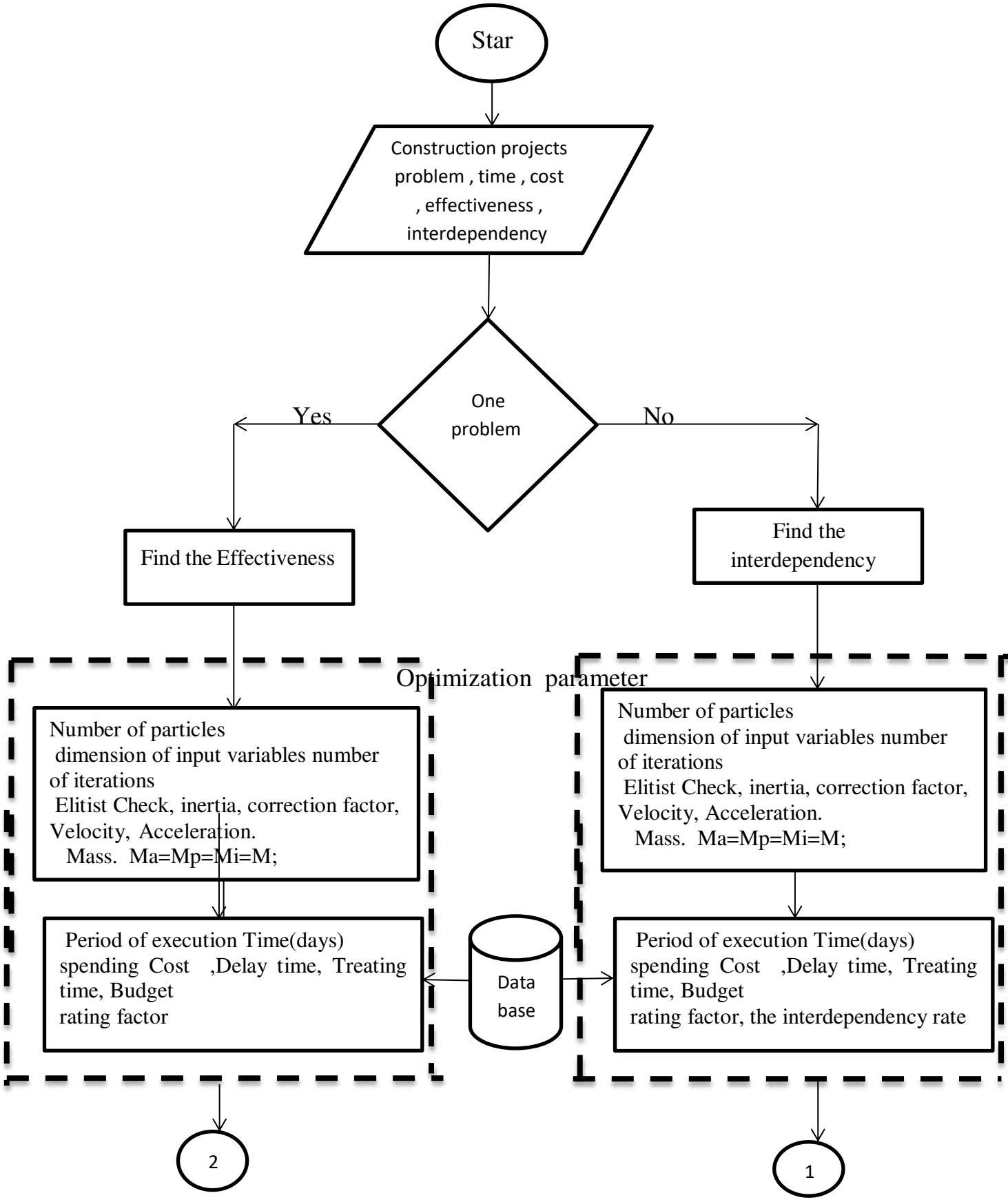
The IF THEN rule can be shown as in the step (3)

Step (3) Transfer the string to double

```
Input : string
Output: double
Step1 :define the string
step 2: apply the equation for
the conversion
```

4.3.3 Optimization Algorithms

This step includes using optimization algorithms which are (PSO) and (GSA) in order to find the best solution for each problem as shown in the figure (4.2).


Star
Construction projects problem , time , cost , effectiveness , interdependency
One problem
Yes
No
Find the Effectiveness
Find the interdependency
Optimization parameter
Number of particles
dimension of input variables number of iterations
Elitist Check, inertia, correction factor, Velocity, Acceleration.
Mass. Ma=Mp=Mi=M;
Period of execution Time(days) spending Cost ,Delay time, Treating time, Budget rating factor
Data base
Number of particles
dimension of input variables number of iterations
Elitist Check, inertia, correction factor, Velocity, Acceleration.
Mass. Ma=Mp=Mi=M;
Period of execution Time(days) spending Cost ,Delay time, Treating time, Budget rating factor, the interdependency rate
2
1

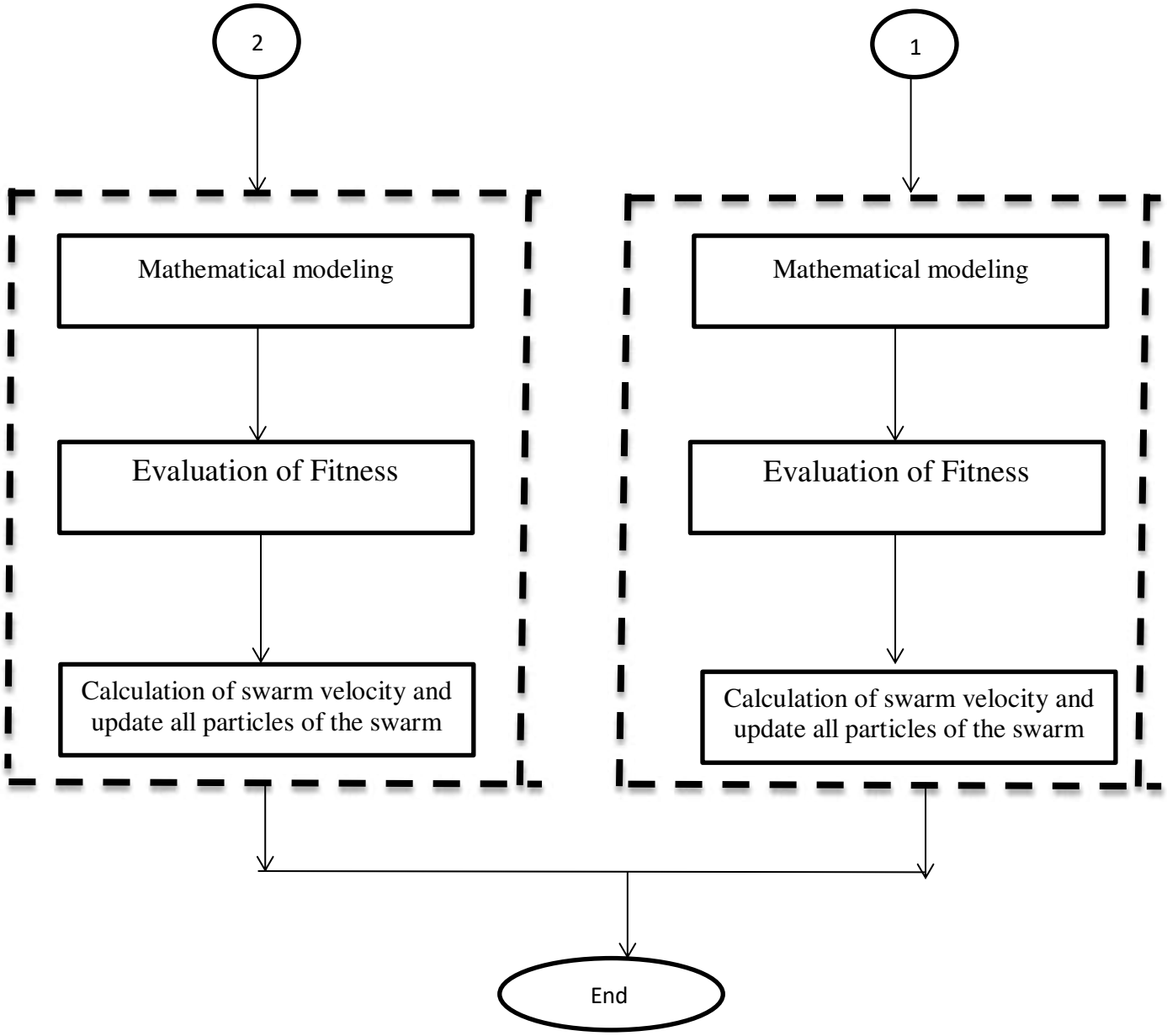


Figure (4-2) Flow chart of the Optimization process

The figure (4.2) shows the optimization process and it can be seen some similarity in the general form but in fact the details for each algorithm and the mathematical model is quite different and it will be explained in the steps for each algorithm and each type of problem. First in trying to discover the best solution for one problems the algorithms PSO and GSA have been used.

Algorithm (4-1) PSO Algorithm

Input : Data and algorithm paper meter

Output : Execution of the fitness

Begin

Step1 : Define the optimization parameter

Stept2: Load these parameters in order to be called

Step2 : Define the source of data to be used in each column

Stept3: formulation of the mathematical model that used to max or minimize the objective function

Max z=eij*xij
Cij*max(xij) ≤0.2* B

Sj-(sij*xij) ≤0.2* t
eij represent the effectiveness of the solution

Cij cost of the problem solution

Sj duration or delay caused by the problem

Sij time required for the problem solution

B budget of the project

t duration of the projects

xij(0-1)

Step4: Random initialization for the swarm particle that give random search space for the first iteration

Step5: evolution of fitness

Step6 calculation of the swarm velocity

Step7 : update the position and the speed

Step8:check whether the objective function is validate

End

The above algorithm show how it will process the data to find the best solution ,the mathematical model that has been used to solve one problem as follow

Table (4-1) Algorithm Variables PSO for One Problem

Algorithm Variables
i : Problem treatment j : problems t max: T Period of execution Time(days) Ci: spending Cost Sj: Delay time Sij : Treating time Bmax: Budgets eij=: rating factor for one project for example take the C from the j and C2 from the j and for the Sm and Fj like that too Cm=?1.1E+09 *MAX (.5) Cm= 547500000 Cm1=114606550*MAX(.3) =328500000 Sm=(21.96-(0.03*.5) =21.95 Sm=21.96-(0.025 *.3) =21.9675 Mean select strategy 1 for P and strategy 2 for P2 If Cm less B and Sm Less than T MAX Z Elese Cm=1.1E+09 *MAX (.5) Cm= 547500000 Sm=?(21.96-(0.03*.5)+ =21.95 If Cm less B and Sm less than T MAX Z

The table above show the variables that has been used in the algorithm and also in the next algorithm as shown the next table.

Algorithm (4-3) GSA algorithm

Algorithm (4.3): Manage the project Using GSA
Input: Data set of the entire projects Output: maximize the number of project to continue
Begin Step (1): Input the GSA parameters Step (2): define the file name Step (3): define the range of the data Step (4): calculate the mass , velocity and acceleration Step (5): define the mathematical model the problem Max z=eij*xij Cij*max(xij) ≤0.2* B Sj-(sij*xij) ≤0.2* t eij represent the effectiveness of the solution Cij cost of the problem solution Sj duration or delay caused by the problem Sij time required for the problem solution B budget of the project t duration of the projects xij(0-1) Step (6): define upper and lower limit for Xij Xij from 0-1

Step (7) : calculate the objective function

Step (8) : update the mass , velocity and acceleration

Step (8) : optimize the projects

END

The above algorithm show the GSA steps which seem more complex than the PSO and as it work on the gravitational law and mass.

Next we will see how these algorithms will be apply to find the interdependency between two problems and then find the best solution for the most significant problem by using the following mathematical model .

MAX Z= ? ? (eij*Wj * xij)…….(4.1)

Subjected to

Ci *MAXj(xi.j) less 0.2*B

Sj- ?? Si,j *xi.j less 0.2*T)

Dj12=f(j1j2)-0.5*f(j2j1)

Dj21= f(j2j1)-0.5*f(j1j2)

DJ= n*(1/tao^-) D12+(1-n) *(1/tao^+)*D21

Wj=lmda(tha*Dj+1-tha*Dj)+(1-lmda)

Table (4-5) PSO Algorithm variables for Two Problem

Algorithm Variables
i : Problem treatment
j : problems
t max: T Period of execution Time(days)
Ci: spending Cost
Sj: Delay time
Sij : Treating time

Bmax: Budgets

eij=: rating factor

W: weighing factor

tha=consist of all the problems that takes precedence over and the effects of the problem interdependences are unfavorable(negative) and also in favorable(positive)

lmda: denotes the importance degree of the unfavorable problem interdependence relative to the favorable one which satisfies $\gamma \in [0, 1]$

DI and nf: importance degree of the opposed problem interdependence relative to the satisfactory problem interdependence which satisfies $\eta \in [0, 1]$

Dj=strength of problem interdependence

for one project

for example

take the C from the j and C2 from the j and for the Sm and Fj like that too

Dj12=0.12 -0.5*0.15

=0.045 select ?-

DJ= 0.5*(1/2) 0.045.+0

=0.045

Wj=0.9 (0.9 *0.045 +1-(0.9*0.045))+(1-0.9)

=0.8905

Cm=?1.1E+09 *MAX (.5)

Cm= 547500000

Cm1=114606550*MAX(.3)

=328500000

Sm=?(21.96-(0.03*.5)+

=21.95

Sm=21.96-(0.025 *.3)

=21.9675

Mean select strategy 1 for F1 and strategy 2 for F2

If Cm less B and Sm less T

MAX Z

Elese

Cm=1.1E+09 *MAX (.5)

Cm= 547500000

Sm=?(21.96-(0.03*.5)+

=21.95

If Cm less B and Sm less than T

MAX Z

4.4 User Interface

This represent the most important part of the expert system as it represent the interface between the user , which will submit his need and purpose and between the system who will achieve the purpose.

The user interface consists of several window to achieve the main goal.

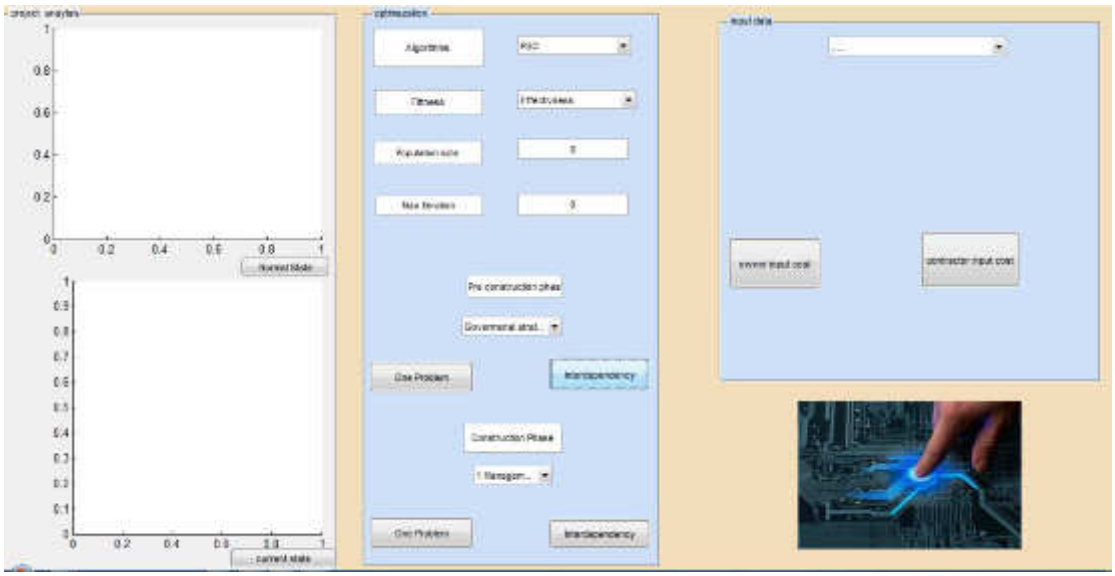


Figure (4-3) The Proposed Project Management Optimization Guidance

The main window is divided into three panel , each one of them is concerning special purpose as follow:

Project Analysis: This panel include the projects analysis that contain the progress against the time

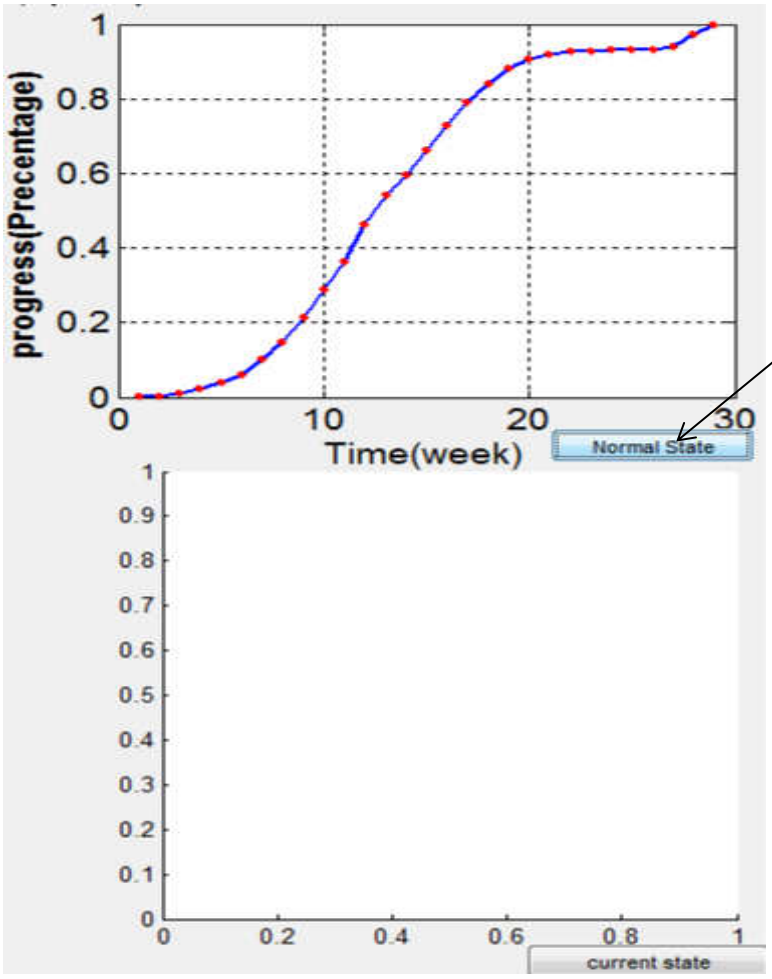


Figure (4-4) The Project Analysis Panel (Planned project)

After that we will compare it with the current state and the following window will appear as follow

This indicates the projects that used in the system which about 30 project including 25 medium project and 5 large project

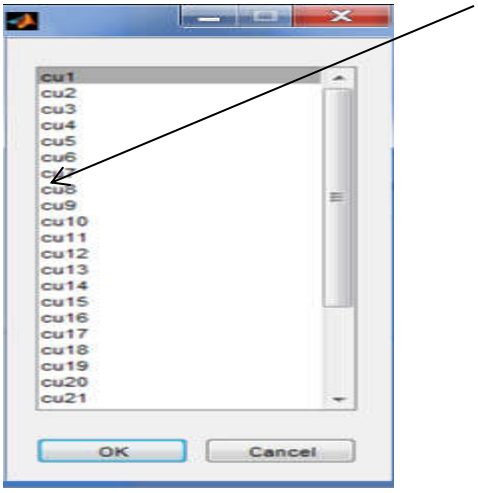
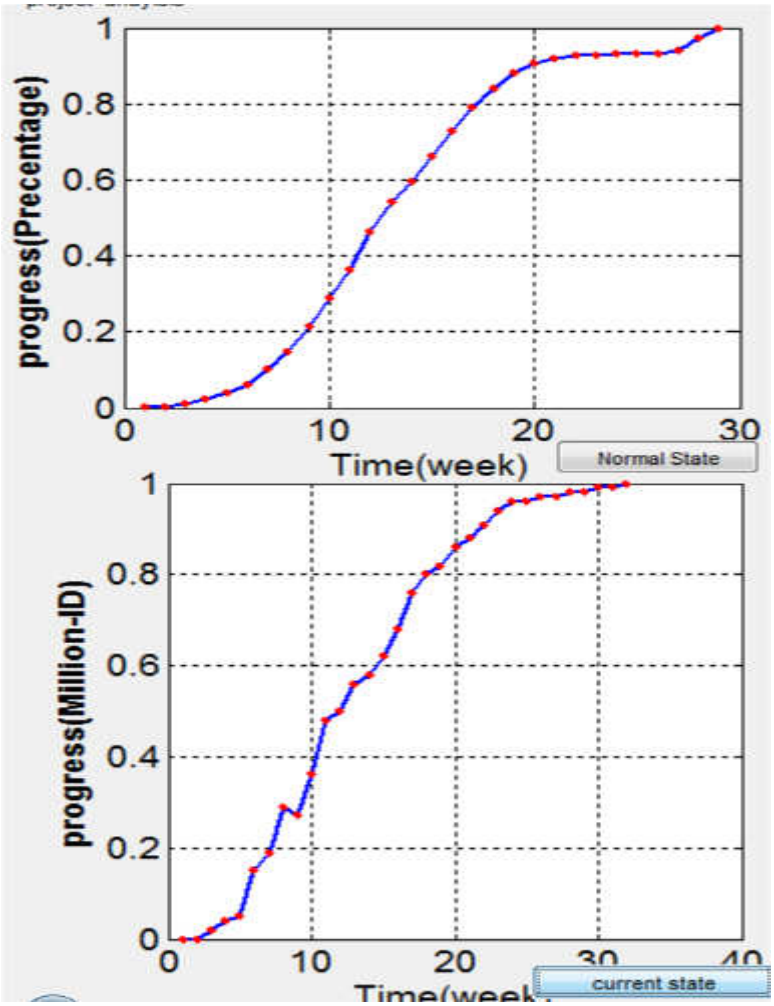


Figure (4-5) The Project Selection Process

Then the current state is loaded



A-Planned Project

B-Actual Project

Figure (4-6) Comparing the Planned With the Actual

This figure (4-6) shows the different between the planned and current state and its show that there is clear deviation in the curve which indicate there is a problem in the project but there no clear evidence at which stage and how much the effect. The next stage is to analyze at the stage of the pre and during construction depending on the earned value.

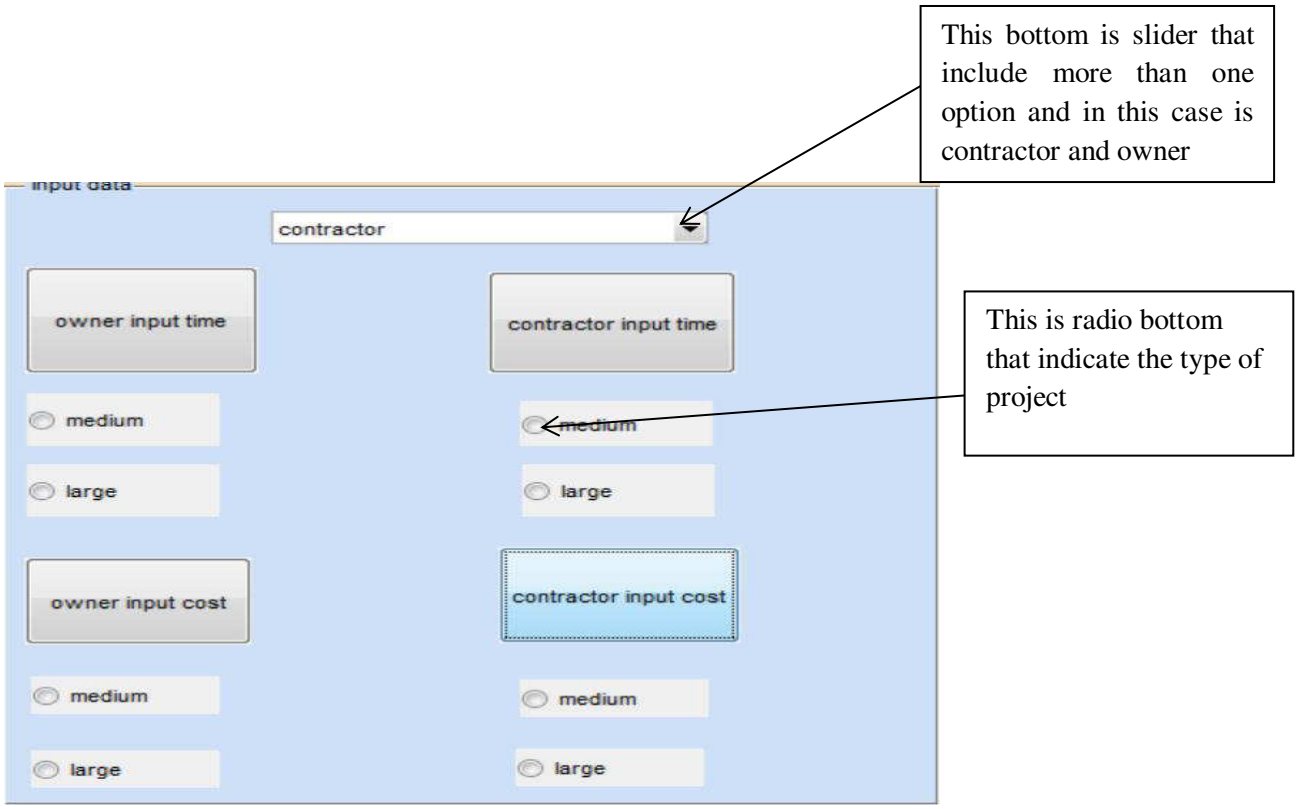


Figure (4-7) Project Phase Data

After pushing on the radio bottom the following window will occur

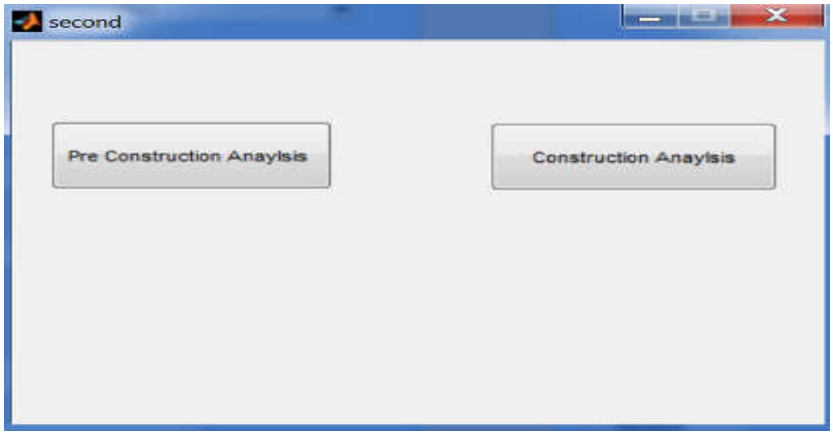
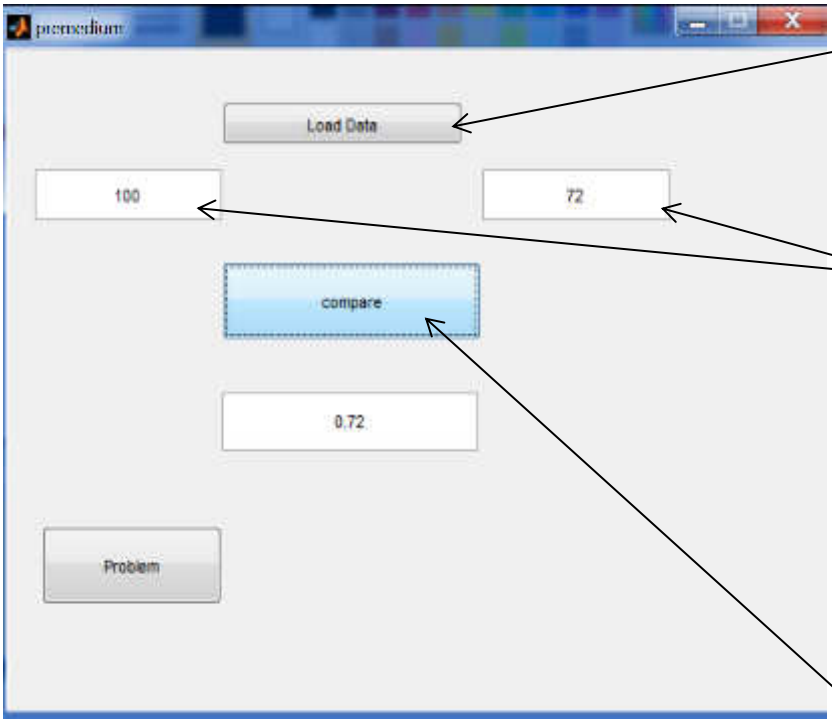


Figure (4-8) Project Phase Selection

This window(4-8) is showing message to the user whether he is in the pre-construction or construction stage. After pushing on each of them the following will appear in (4-9) .



This will be used to upload the data

This will indicate the current and the total time or cost

This will be used to compare the current and the total time and cost and when its show less than 1 its indicate problem and when it more there is no problem

Figure (4-9) Project Phase Analysis

The figure (4.9) used to compare the planed and actual data that exist in certain phase such preconstruction phase , and with used of the earned value equation if the comparing between the planned and actual less than one mean there is a problem , otherwise its not.

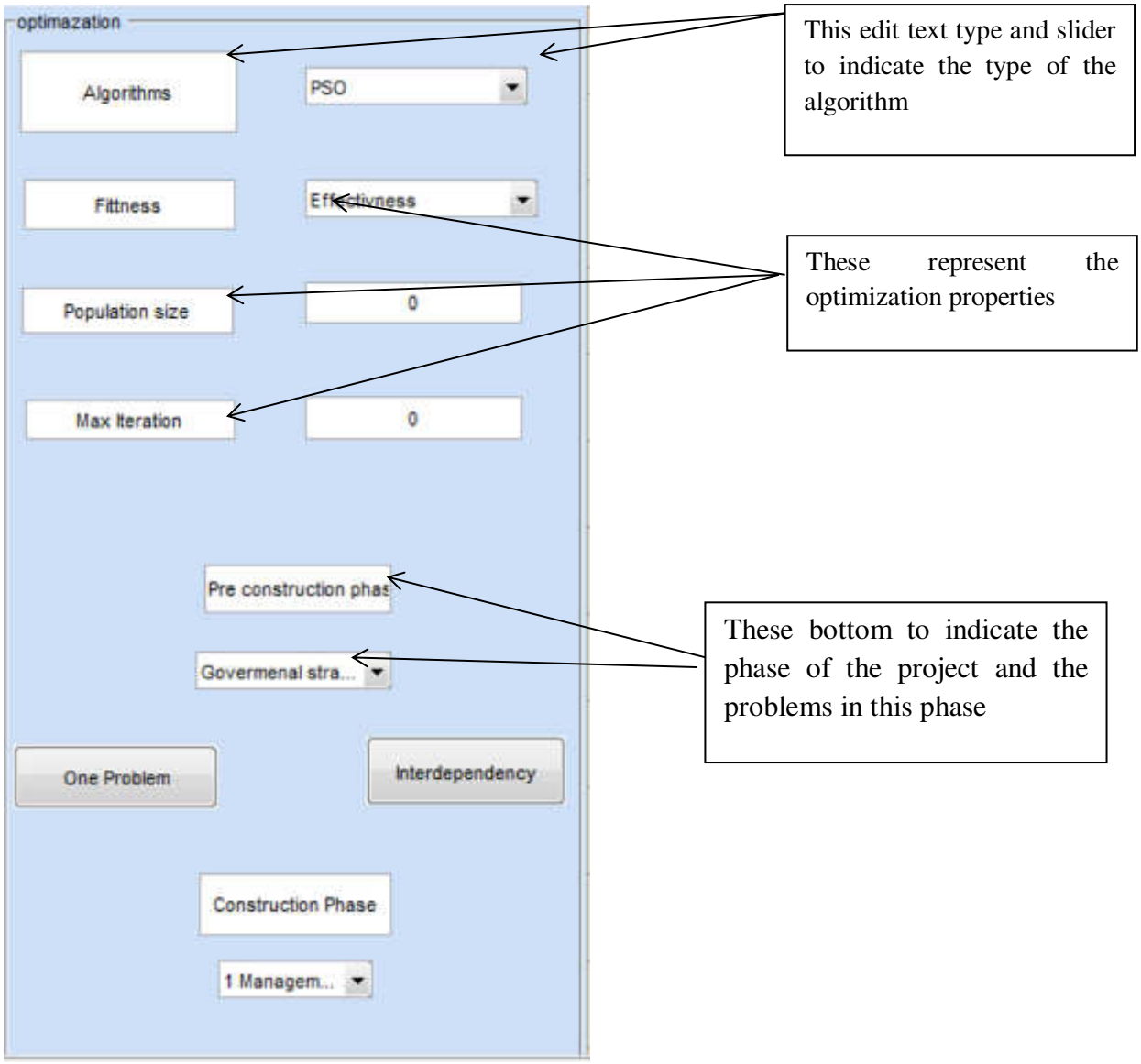


Figure (4-10) Project Problem Optimization

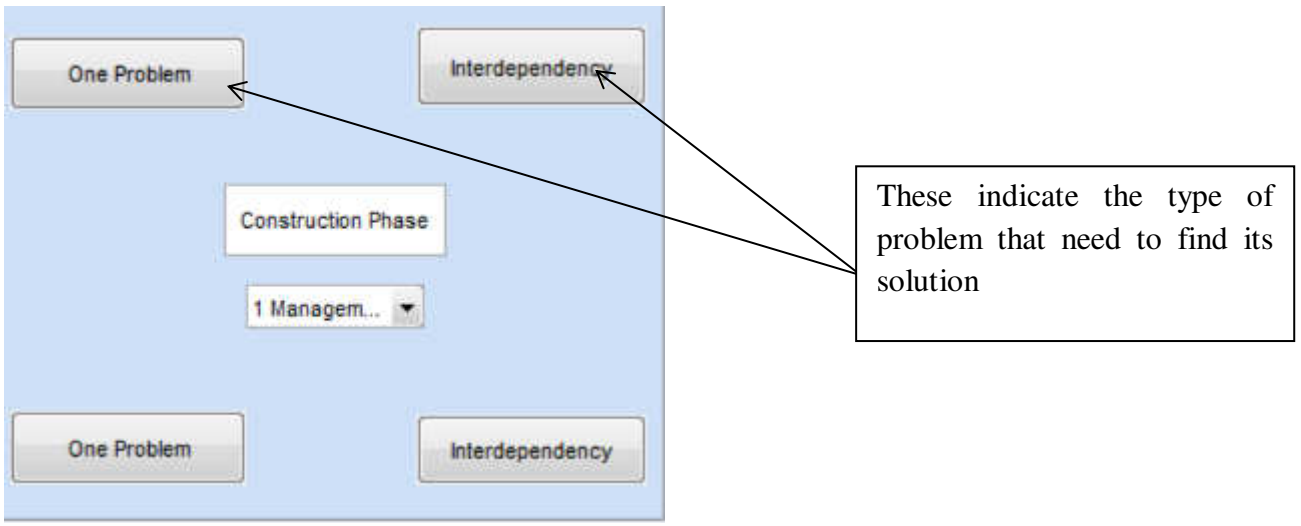


Figure (4-11) Project Problem Type

After pushing each of the push bottom in figure (4.11) the following window will appear in the figure (4.12)

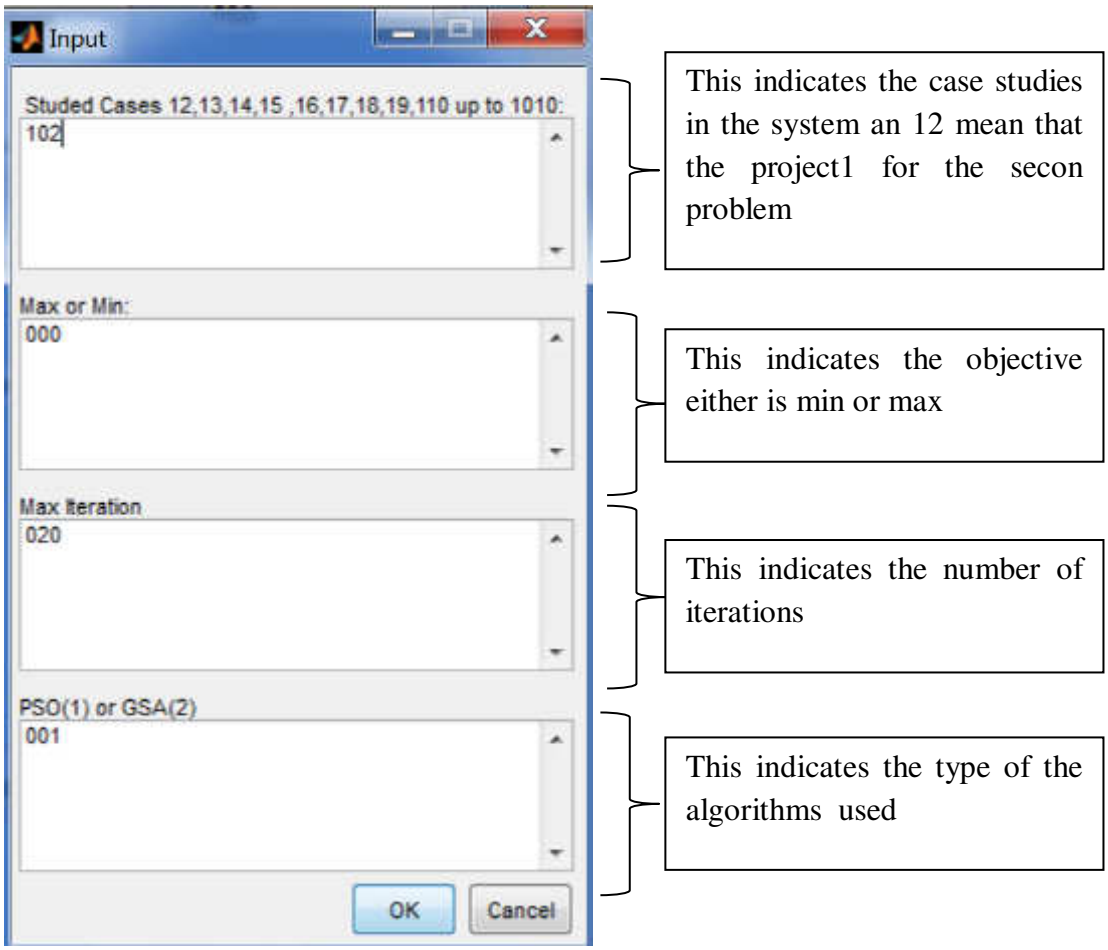


Figure (4-12) Case Study Selection

These figures above show the system as whole and the results of the optimization will be discussed in chapter five.The data of the expert system is shown the electronic appendix.

CHAPTER FIVE

Results and Discussion

Chapter Five

Results and Discussion

5.1 Introduction

In the previous chapter , it was explained how the expert system was built and the parts and elements that combined together to build the system. This chapter will include the results of the heart of the expert system which are the optimization techniques results (PSO and GSA) . The programming language utilized to build the proposed system is MATLAB . The experiments were performed on an Intel Core i7, 64-bit Operating System, 2.20-GHz processor and 4-GB RAM

The results will show the different between different project , different phase in the project and finally between the two techniques.

5.2 Results for One problem

In this section the results of selection the best solution for the problem will be shown and in the two phases (pre-construction and construction) and also by using two techniques. The results of PSO in finding the solution for one problem and for one project is indicate in table (5,1)

Each project , ten problem were taken to show the procedure for the selection of the solution , where each problem have ten solutions.

Table (5.1) PSO for One Problem in the Preconstruction Phase(Project One)

Problem	Xij	z	ci	Si	Sij	Time(days)	Cost (ID)	e	v
1	0.99	0.7722	0.01	0.03	0.02	365	1.1E+09	0.78	0
2	0.99	0.792	0.01	0.03	0.02	365	1.1E+09	0.8	0

3	0.99	0.8712	0.01	0.1	0.04	365	1.1E+09	0.88	0
4	0.99	0.8712	0.01	0.2	0.1	365	1.1E+09	0.88	0
5	0.99	0.891	0.21	0.1	0.015	365	1.1E+09	0.9	0
6	0.99	0.792	0.1	0.34	0.2	365	1.1E+09	0.8	0
7	0.99	0.792	0.001	0.05	0.02	365	1.1E+09	0.8	0
8	0.99	0.8811	0.019	0.04	0.025	365	1.1E+09	0.89	0
9	0.99	0.7722	0.01	0.03	0.02	365	1.1E+09	0.78	0
10	0.99	0.8811	0.069	0.1	0.035	365	1.1E+09	0.89	0

The figure (5.1) show the iteration for finding the best solution whose effectiveness range from 0-1.

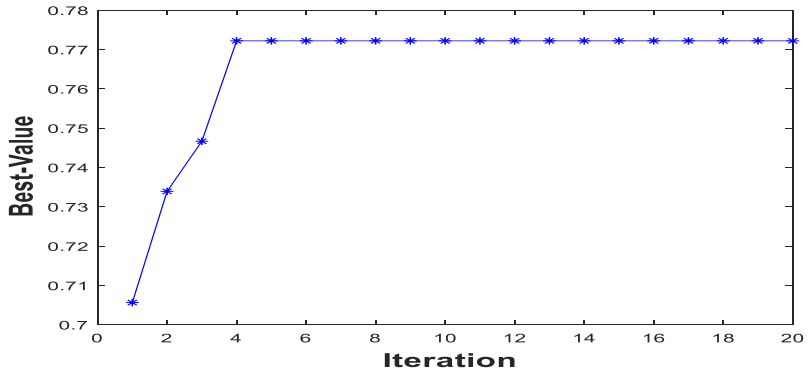


Figure (5.1) PSO for One Problem in the Preconstruction PH.(Project One , Problem 1)

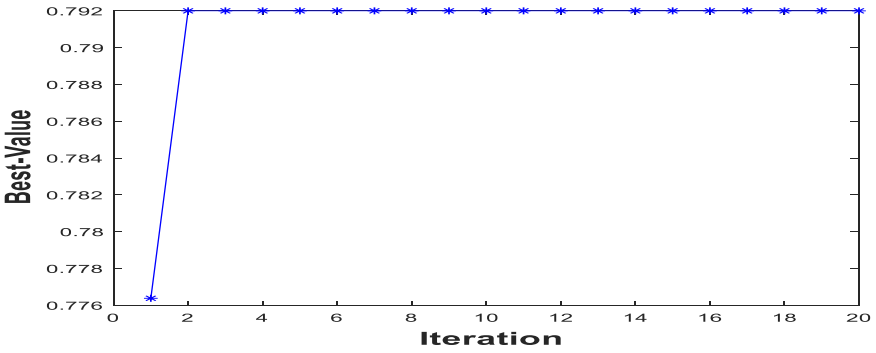


Figure (5.2) PSO for One PR.in the Preconstruction PH.(Project One , PR. 2)

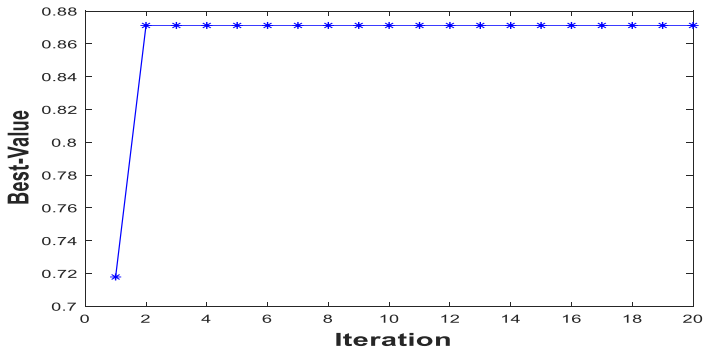


Figure .(5.3) PSO for One PR in the Preconstruction PH. (Project One , PR 3)

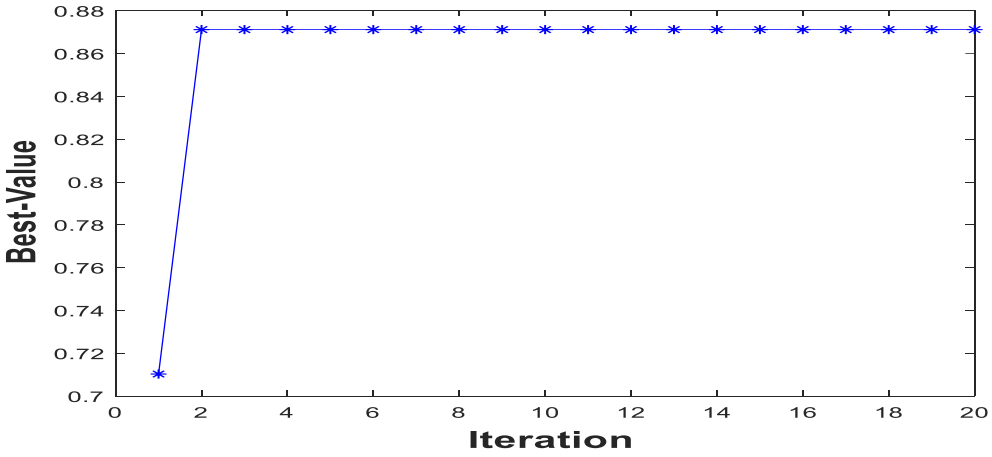


Figure .(5.4) PSO for One PR .in the Preconstruction PH. (Project One , PR. 4)

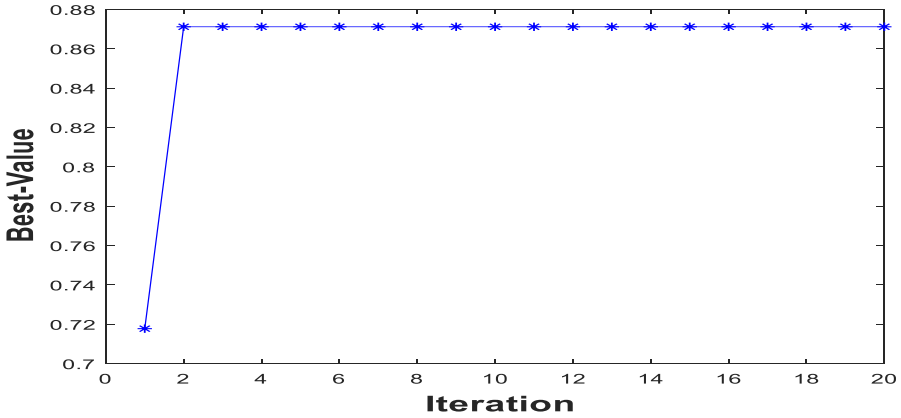


Figure. (5.5) PSO for One PR. in the Preconstruction PH. (Project One , PR. 5)

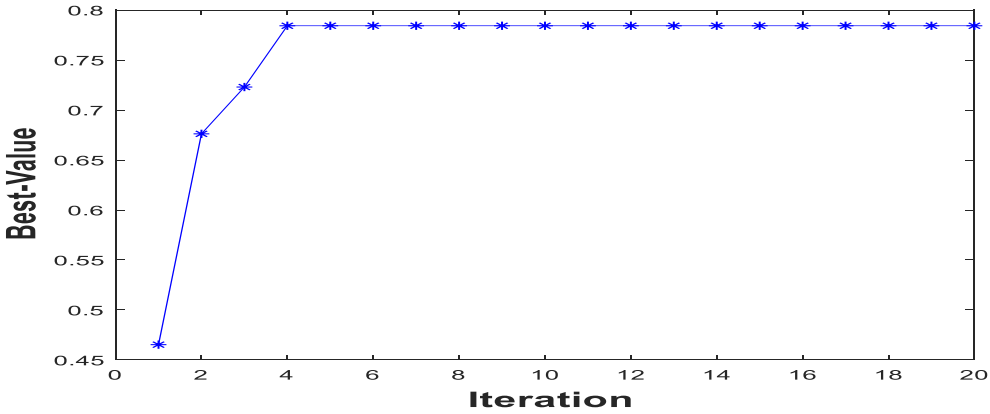


Figure. (5.6) PSO for One PR .in the Preconstruction PH. (Project One , PR .6)

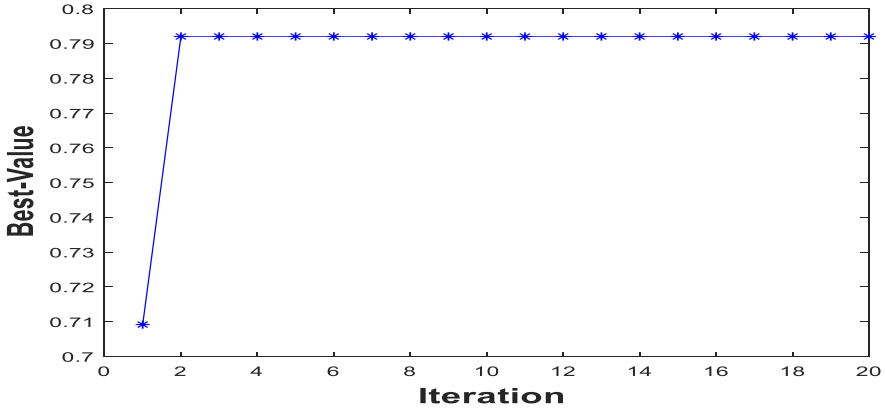


Figure. (5.7) PSO for One PR .in the Preconstruction PH. (Project One , PR .7)

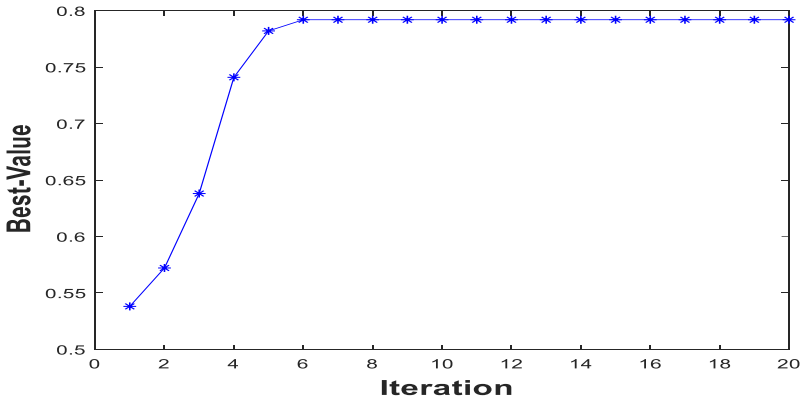


Figure .(5.8) PSO for One PR .in the Preconstruction PH. (Project One , PR .8)

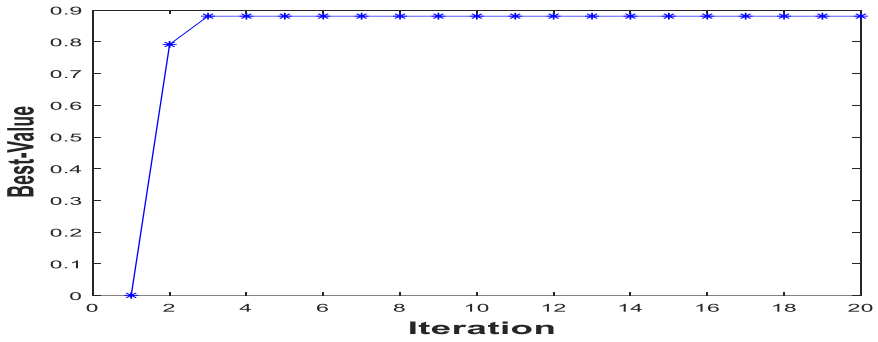


Figure. (5.9) PSO for One PR .in the Preconstruction PH. (Project One , PR .9)

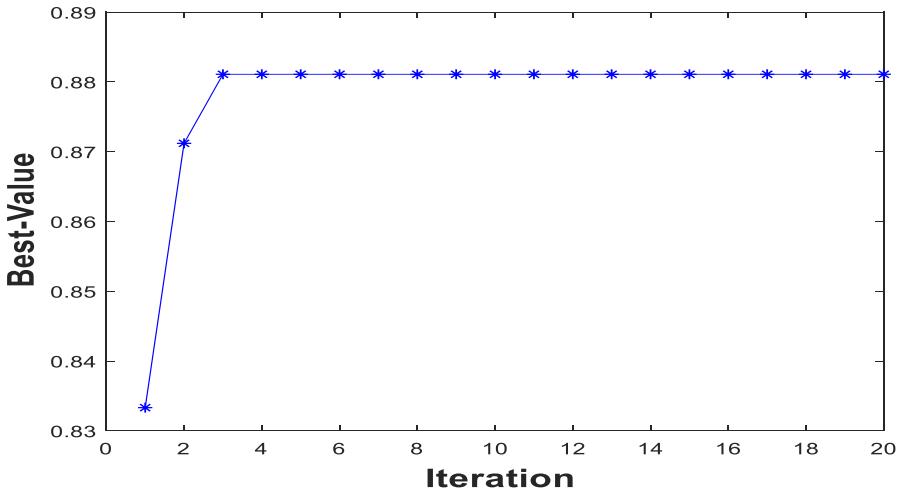


Figure .(5.10) PSO for One PR . in the Preconstruction PH. (Project One , PR .10)

For the most of the problems, it has been notice that the solution is foun in the third iteration.

The results of GSA in finding the solution for one problem and for one project is indicate in table (5,2)

Each project , ten problem were taken to show the procedure for the selection of the solution , where each problem have ten solutions

Table (5.2) GSA for One Problem in the Preconstruction Phase(Project One)

Problem	Xij	z	ci	Si	Sij	time	cost	e	v
1	0.99	0.7722	0.01	0.03	0.02	365	1.1E+09	0.78	1.60E-08
2	0.99	0.792	0.01	0.03	0.02	365	1.1E+09	0.8	2.07E-07
3	0.990005	0.8712	0.01	0.1	0.04	365	1.1E+09	0.88	4.47E-08
4	0.99	0.8712	0.01	0.2	0.1	365	1.1E+09	0.88	6.41E-08
5	0.990381	0.891	0.21	0.1	0.015	365	1.1E+09	0.9	0.000381
6	0.990018	0.792	0.1	0.34	0.2	365	1.1E+09	0.8	0.000131
7	0.99	0.792	0.001	0.05	0.02	365	1.1E+09	0.8	1.28E-08
8	0.99	0.8811	0.019	0.04	0.025	365	1.1E+09	0.89	4.04E-07
9	0.990001	0.7722	0.01	0.03	0.02	365	1.1E+09	0.78	7.31E-06
10	0.990006	0.8712	0.01	0.1	0.02	365	1.1E+09	0.88	6.24E-06

The figure (5.11) show the iteration for finding the best solution whose effectiveness range from 0-1 by using GSA .

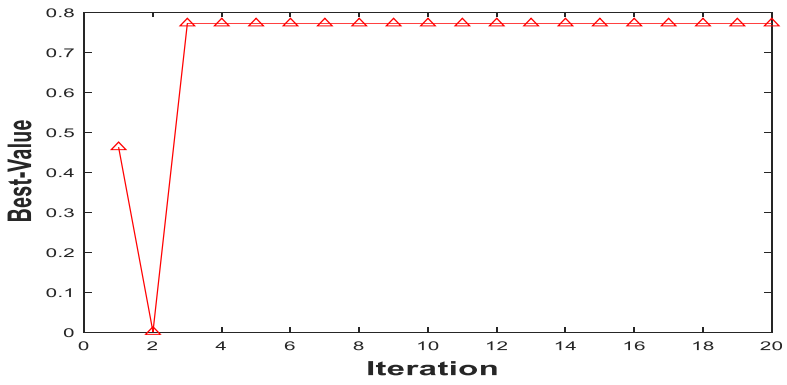


Figure. (5.11) GSA for One PR .in the Preconstruction PH. (Project One , PR .1)

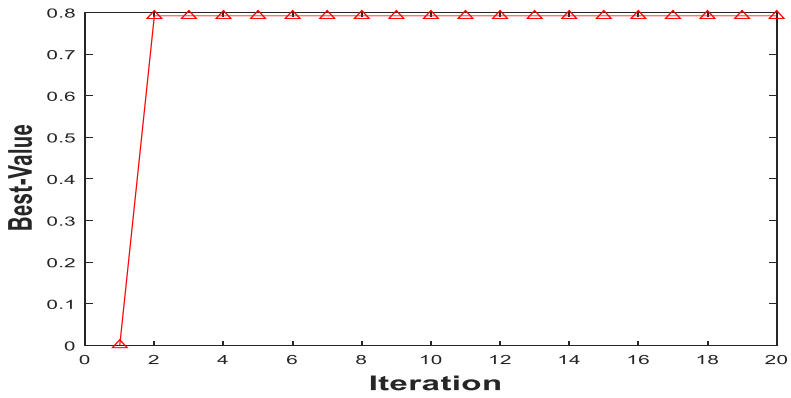


Figure. (5.12) GSA for One PR .in the Preconstruction PH. (Project One , PR .2)

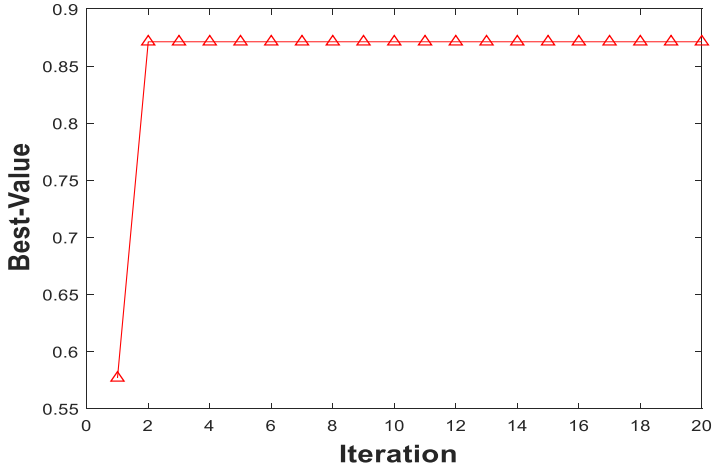


Figure .(5.13) GSA for One PR .in the Preconstruction PH. (Project One , PR .3)

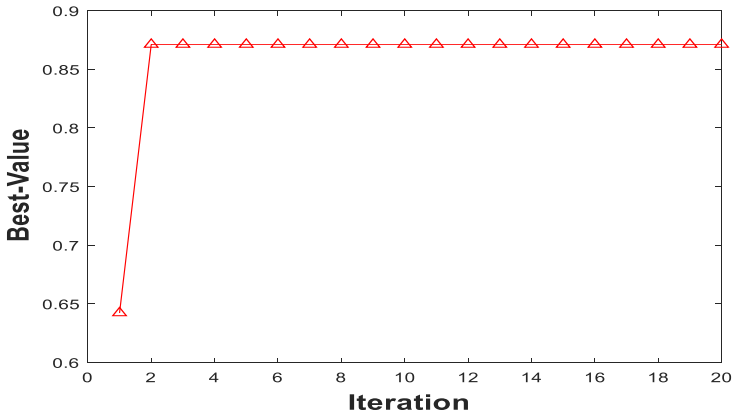


Figure. (5.14) GSA for One PR .in the Preconstruction PH. (Project One , PR .4)

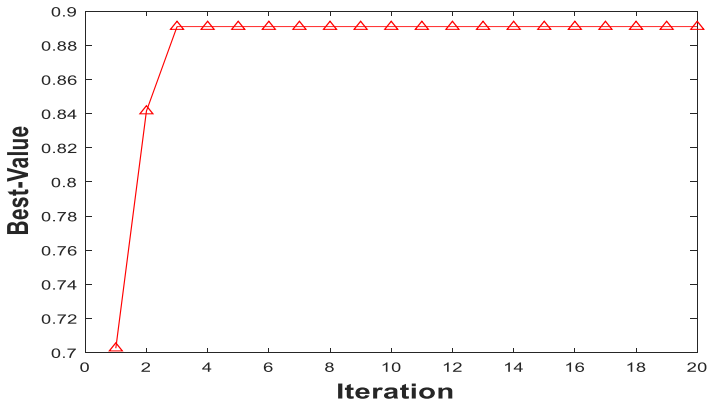


Figure. (5.15) GSA for One PR .in the Preconstruction PH. (Project One , PR .5)

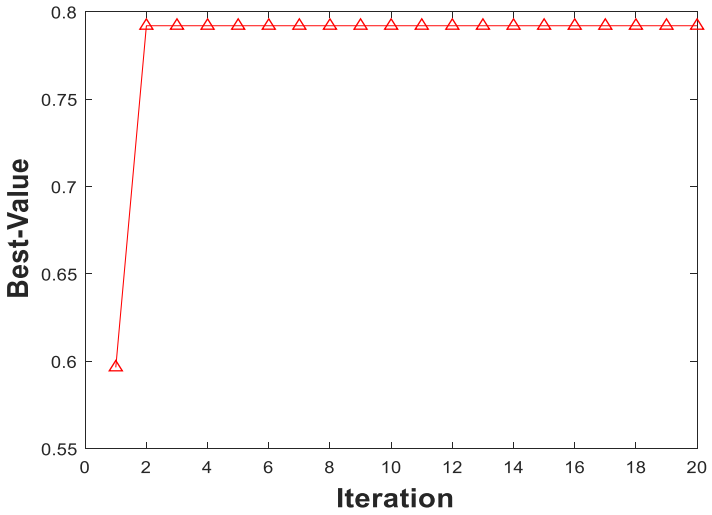


Figure. (5.16) GSA for One PR .in the Preconstruction PH. (Project One , PR .6)

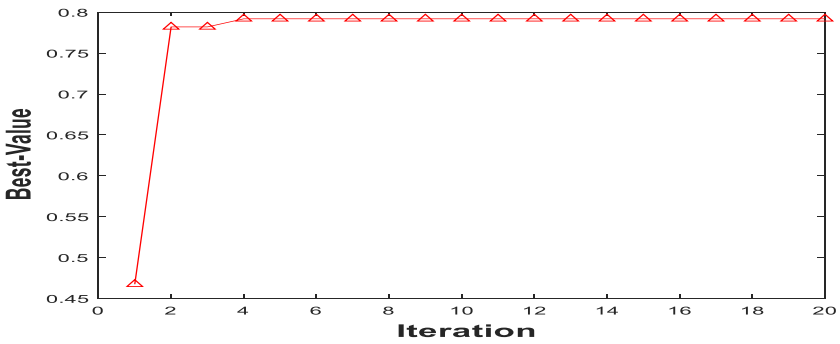


Figure. (5.17) GSA for One PR .in the Preconstruction PH. (Project One , PR .7)

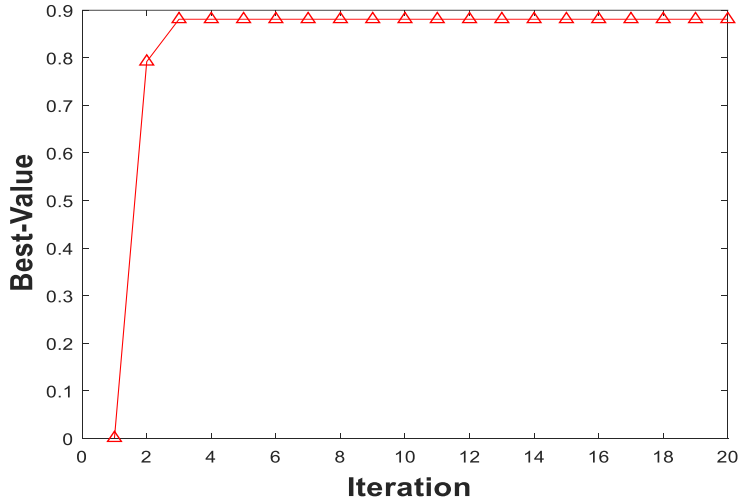


Figure. (5.18) GSA for One PR .in the Preconstruction PH. (Project One , PR .8)

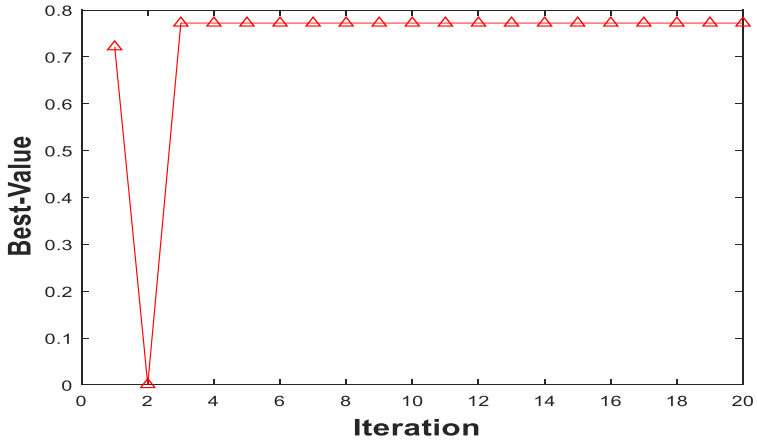


Figure. (5.19) GSA for One PR .in the Preconstruction PH. (Project One , PR .9)

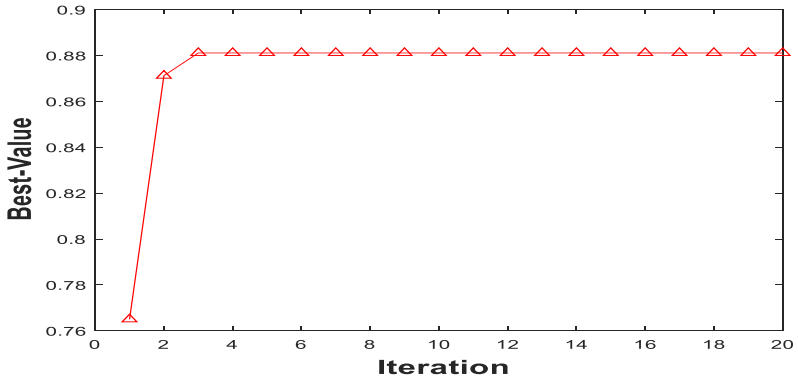


Figure. (5.20) GSA for One PR .in the Preconstruction PH. (Project One , PR .10)

As seen above , the two techniques are effective in finding the best solution in term of velocity and effectiveness , however there are quite different between them in term of the method of searching and in the velocity.

As seen all the velocity of the PSO is zero while the GSA is always more than zero which indicate the PSO is fast and also in the method of searching as seen in problem 8 and 9 the GSA take different way in finding the solution.

The next step is to find the solution in the construction phase using the two techniques as shown on the table (5.3).

Table (5.3) PSO for One Problem in the Construction Phase(Project One)

Problem	Xij	z	ci	Si	Sij	time	cost	e	v
1	0.99	0.8316	0.09	0.1	0.025	365	1.1E+09	0.84	0
2	0.99	0.8316	0.12	0.1	0.05	365	1.1E+09	0.84	0
3	0.99	0.8316	0.02	0.05	0.05	365	1.1E+09	0.84	0
4	0.99	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	0
5	0.99	0.891	0.1	0.2	0.15	365	1.1E+09	0.9	0
6	0.99	0.9108	0.1	0.25	0.15	365	1.1E+09	0.92	0
7	0.99	0.8217	0.017	0.1	0.013	365	1.1E+09	0.83	0
8	0.99	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	0
9	0.99	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	0
10	0.99	0.8415	0.07	0.15	0.13	365	1.1E+09	0.85	0

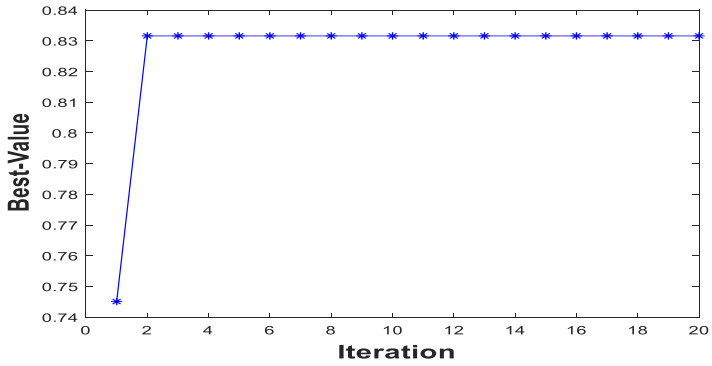


Figure. (5.21) PSO for One PR .in the Construction PH. (Project One , PR .1)

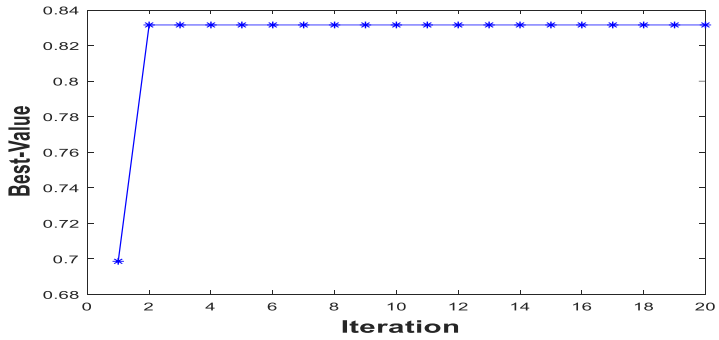


Figure. (5.22) PSO for One PR .in the Construction PH. (Project One , Problem 2)

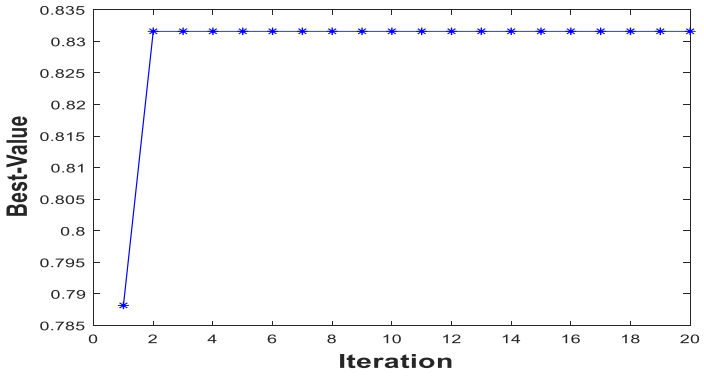


Figure. (5.23) PSO for One PR .in the Construction Phase(Project One , PR .3)

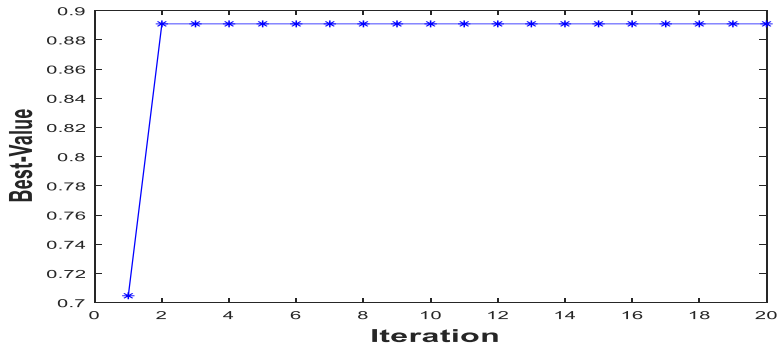


Figure .(5.24) PSO for One PR .in the Construction PH. (Project One , PR .4)

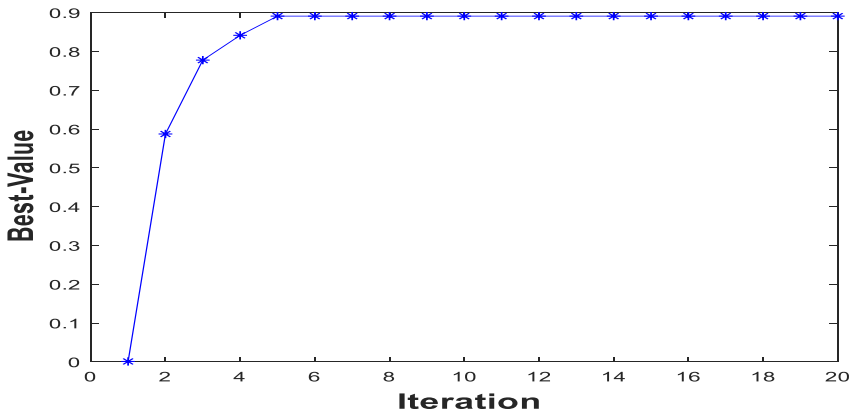


Figure .(5.25) PSO for One PR .in the Construction PH. (Project One , PR .5)

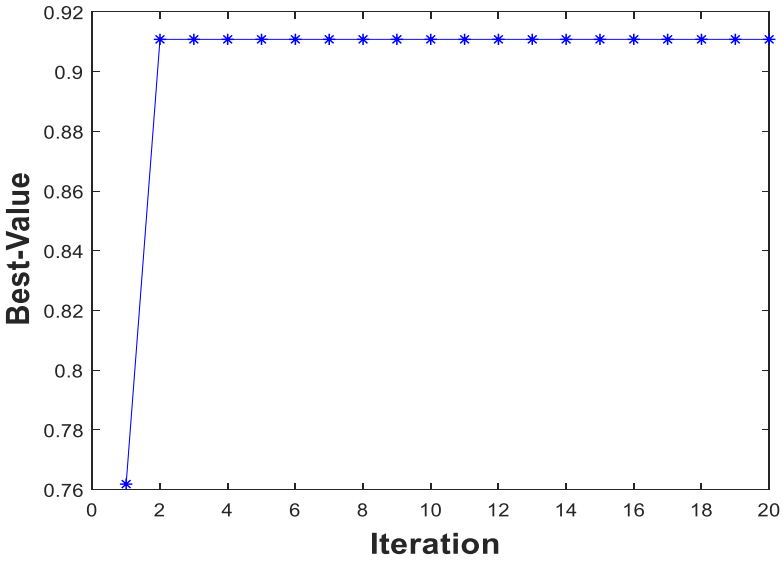


Figure .(5.26) PSO for One PR .in the Construction PH. (Project One , PR .6)

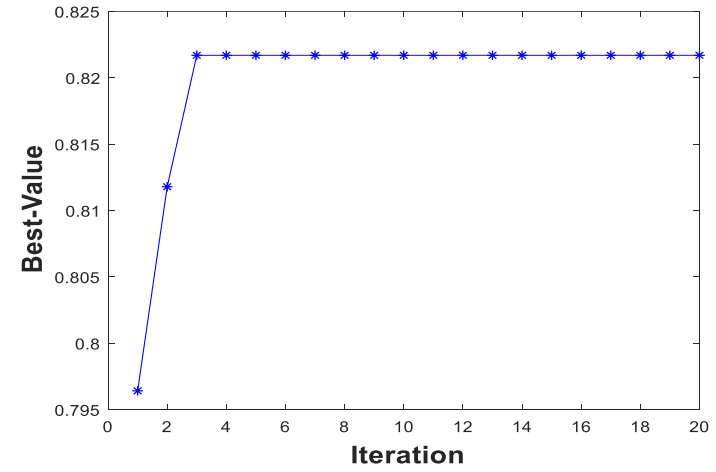


Figure .(5.27) PSO for One PR .in the Construction PH. (Project One , PR .7)

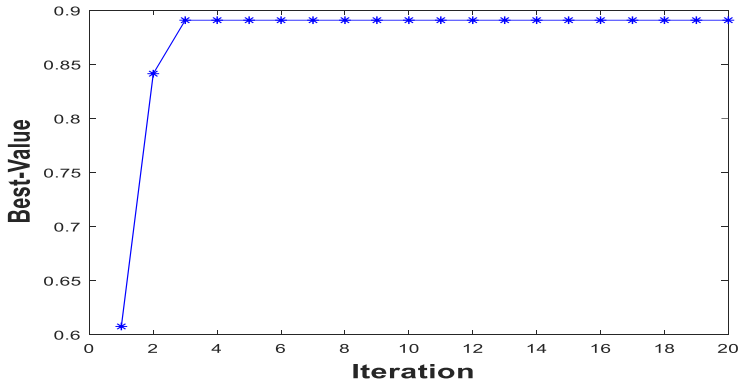


Figure .(5.28) PSO for One PR .in the Construction PH. (Project One , PR .8)

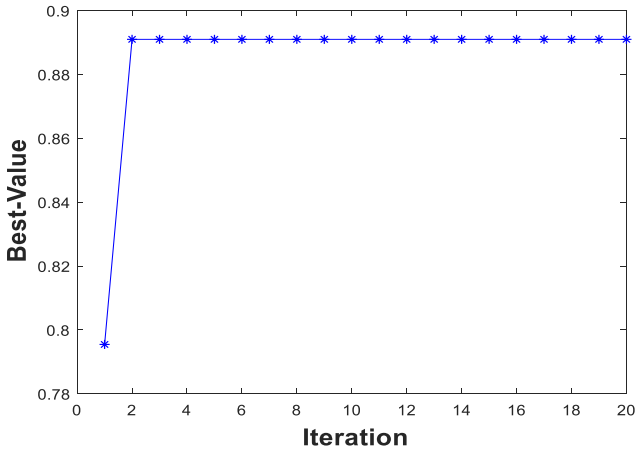


Figure .(5.29) PSO for One PR .in the Construction PH. (Project One , PR .9)

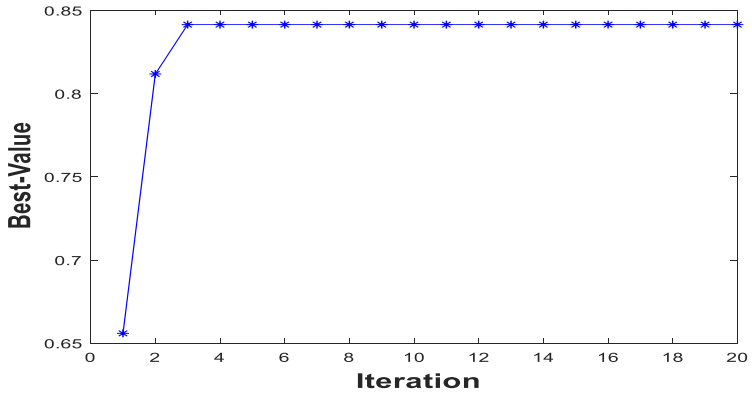


Figure .(5.30) PSO for One PR .in the Construction PH. (Project One , PR .10)

The next step is to find the solution in the construction phase using the two techniques as shown on the table (5.4) by using GSA .

Table (5.4) GSA for One Problem in the Construction Phase(Project One)

Problem	Xij	z	ci	Si	Sij	Time(days)	Cost(ID)	e	v
1	0.99	0.8316	0.09	0.1	0.025	365	1.1E+09	0.84	1.19E-08
2	0.99	0.8316	0.12	0.1	0.05	365	1.1E+09	0.84	1.04E-08
3	0.99	0.8316	0.02	0.05	0.05	365	1.1E+09	0.84	1.08E-08
4	0.990114	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	0.000114
5	0.990001	0.891	0.1	0.2	0.15	365	1.1E+09	0.9	9.29E-07
6	0.99	0.9108	0.1	0.25	0.15	365	1.1E+09	0.92	2.93E-11
7	0.990002	0.8217	0.017	0.1	0.013	365	1.1E+09	0.83	1.65E-05
8	0.99	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	2.46E-09
9	0.990036	0.891	0.01	0.2	0.15	365	1.1E+09	0.9	3.64E-05
10	0.99	0.8415	0.07	0.15	0.13	365	1.1E+09	0.85	3.28E-10

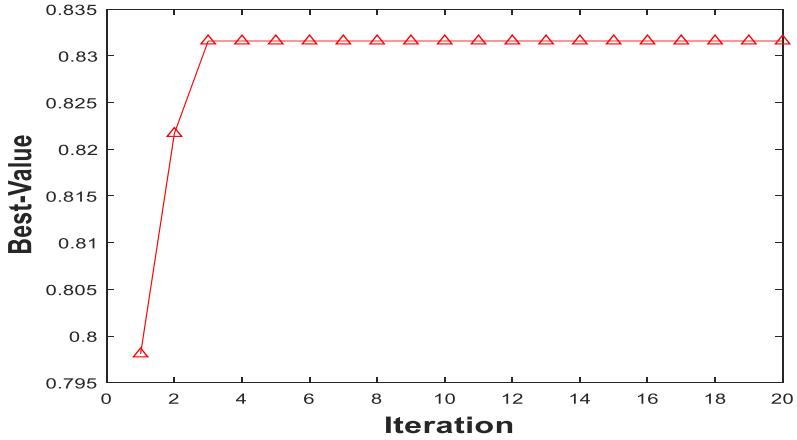


Figure .(5.31) GSA for One PR .in the Construction PH. (Project One , PR .1)

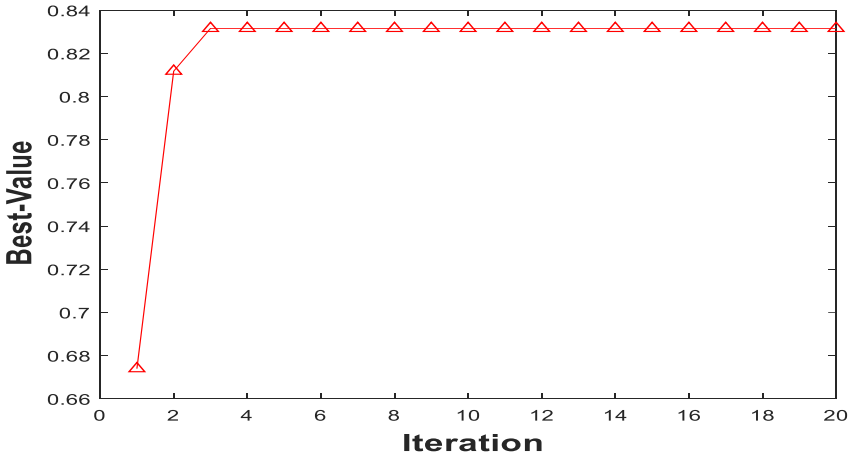


Figure .(5.32) GSA for One PR .in the Construction PH. (Project One , PR .2)

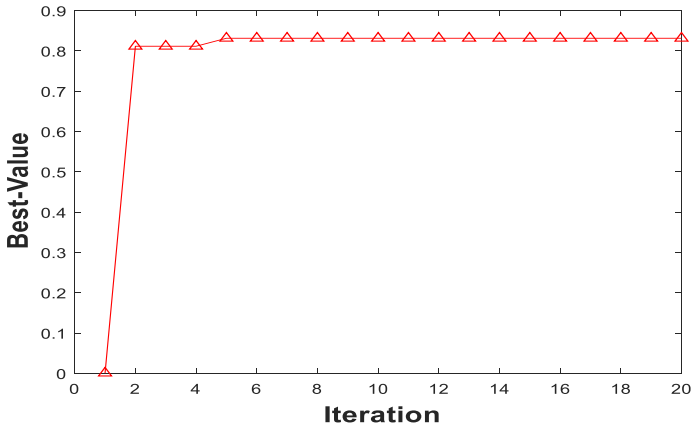


Figure .(5.33) GSA for One PR .in the Construction PH. (Project One , PR .3)

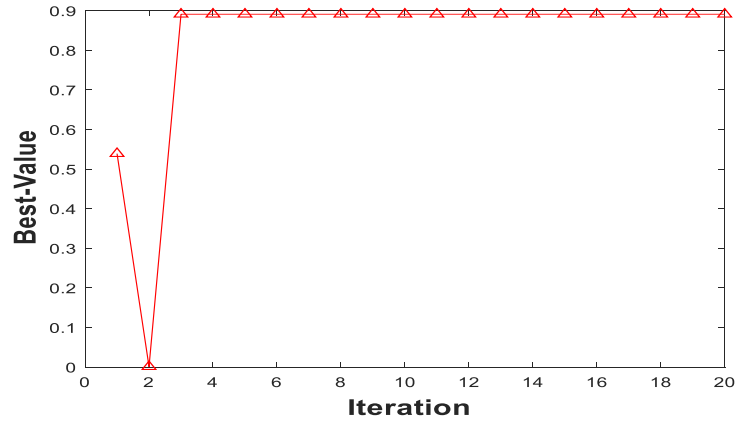


Figure .(5.34) GSA for One PR .in the Construction PH. (Project One , PR .4)

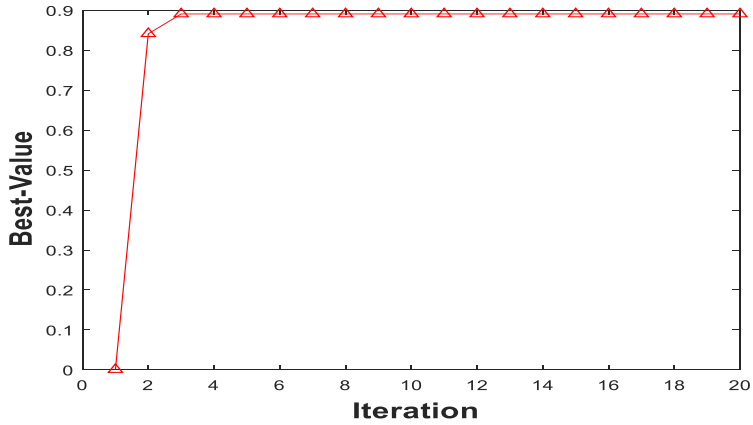


Figure. (5.35) GSA for One PR .in the Construction PH. (Project One , PR .5)

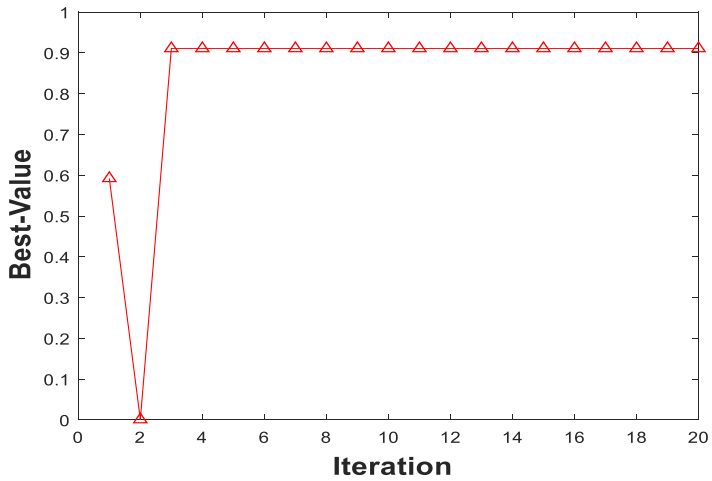


Figure .(5.36) GSA for One PR .in the Construction PH. (Project One , PR .6)

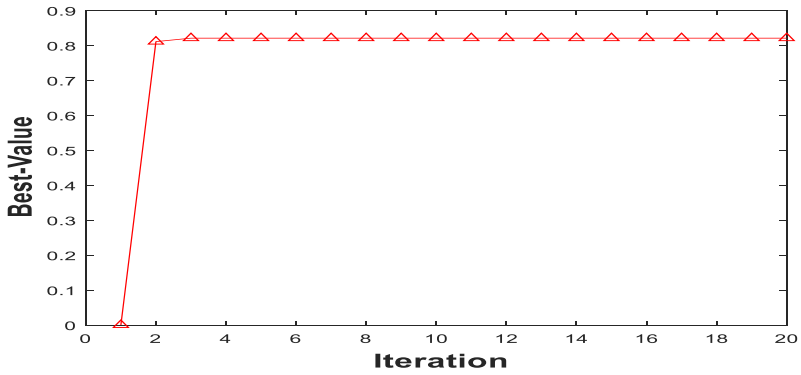


Figure. (5.37) GSA for One PR .in the Construction PH. (Project One , PR .7)

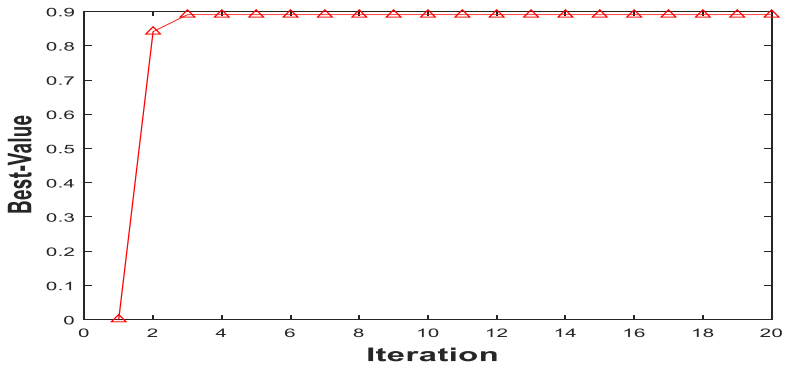


Figure. (5.38) GSA for One PR .in the Construction PH. (Project One , PR .8)

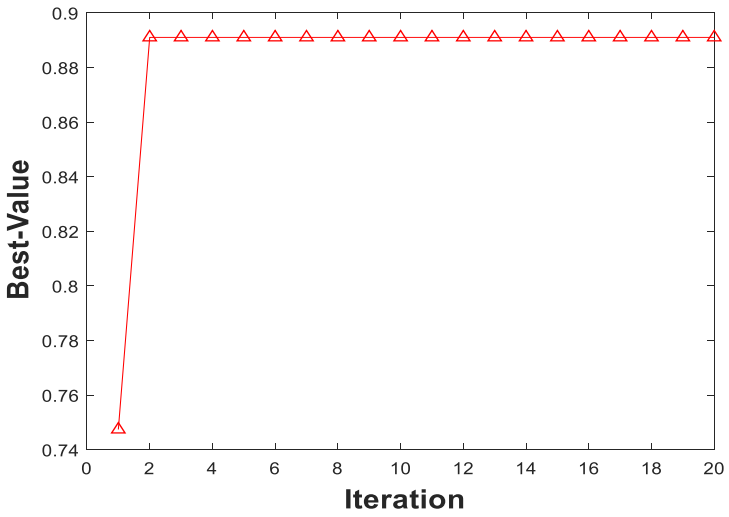


Figure .(5.39) GSA for One PR .in the Construction PH. (Project One , PR .9)

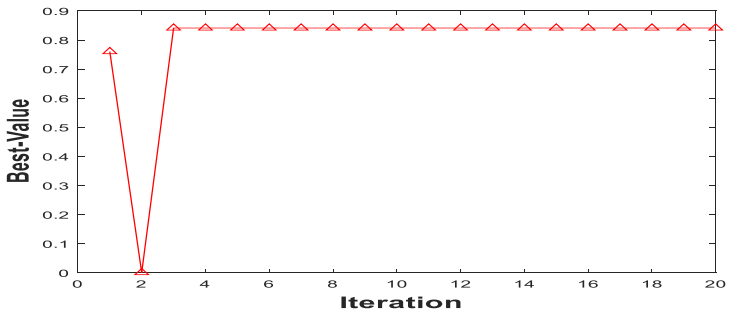


Figure .(5.40) GSA for One PR .in the Construction PH. (Project One , PR .10)

As seen above the same different appear between PSO and GSA in the velocity and in the method of searching , also the different between the problem pre and during construction seem to be very clear as the parameters have different values in spit that the budget and time are the same.

5.3 Results for the Interdependency

In this section the interdependency between two problem is calculated in order to know which problem has the greater effect on the other and for the two phases using two techniques. The result of the interdependency for the pre-construction by using PSO as shown in the table (5.5)

Table (5.5) PSO for Interdependency in the Pre-Construction Phase(Project One)

problem	z	xij	tha	lmda	nf	tao	Dj	Di	wj	v
1.2	0.891	0.990001	0.010001	0.53485	0.010001	0.502513	5.00E-07	9.95E-07	1	1.70E-05
1.3	0.891001	0.990001	0.443174	0.552126	0.251424	0.567938	0.08	0.14086	1	0.003839
1.4	0.891001	0.990001	0.2835	0.71647	0.479893	0.502513	5.00E-07	9.95E-07	1	0.000487
1.5	0.891	0.990001	0.404891	0.670826	0.156737	0.523392	5.00E-	9.55E-07	1	0

							07			
2.1	0.9702	0.990001	0.583358	0.669248	0.990001	1.246471	5.00E-07	4.01E-07	1	0.001872
2.3	0.93	0.946928	0.674535	0.983106	0.765017	1.519137	0.0165	0.010861	1	0
2.4	0.9702	0.990001	0.623623	0.49123	0.010001	0.502513	0.05	0.0995	1	0.006957
2.5	0.9702	0.990001	0.964595	0.990001	0.990001	1	0.0165	0.000165	1	6.04E-07
3.1	0.967911	0.987665	0.510789	0.866043	0.078818	0.508821	5.00E-07	9.83E-07	1	7.87E-05
3.2	0.9702	0.990001	0.504084	0.010001	0.424556	4.864892	5.00E-07	1.03E-07	1	0.000205
3.4	0.9702	0.990001	0.583358	0.669248	0.990001	1.246471	5.00E-07	4.01E-07	1	0.00016
3.5	0.967671	0.987421	0.028391	0.530824	0.085799	0.618452	0.083	0.134206	1	1.39E-06
4.1	0.9702	0.990001	0.990001	0.990001	0.463808	0.568066	0.0165	0.029046	1	0.00E+00
4.2	0.967671	0.987421	0.028391	0.530824	0.085799	0.618452	0.0165	0.026068	1	2.89E-05
4.3	0.9702	0.990001	0.623623	0.49123	0.010001	0.502513	0.0165	0.032835	1	8.10E-06
4.5	0.9702	0.990001	0.990001	0.691863	0.010001	0.664394	5.00E-07	7.53E-07	1	0.00E+00
5.1	0.891	0.990001	0.010001	0.097888	0.010001	0.502513	5.00E-07	9.95E-07	1	0.00E+00
5.2	0.891	0.990001	0.186701	0.929889	0.010001	0.502513	0.05	0.0995	1	6.08E-06
5.3	0.891	0.990001	0.990001	0.990001	0.071149	100	0.0165	0.000165	1	0.00E+00
5.4	0.891	0.990001	0.010001	0.183033	0.761051	100	0.0165	0.000165	1	0.00E+00

As it can see the effect of the problem two on the one effect of problem two is better which means that problem one requires quick solution.

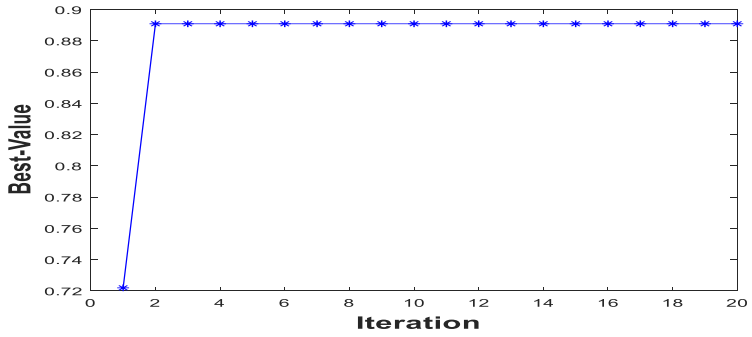


Figure. (5.41) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 1.2)

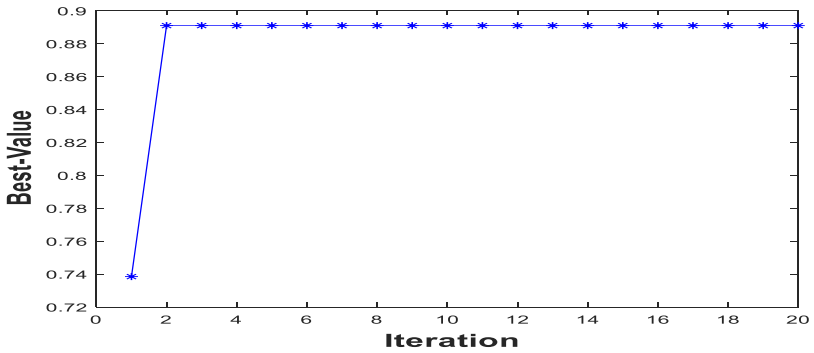


Figure. (5.42) PSO for Interdependency in the Pre-Co Ph. .(Project One , Problem 1.3)

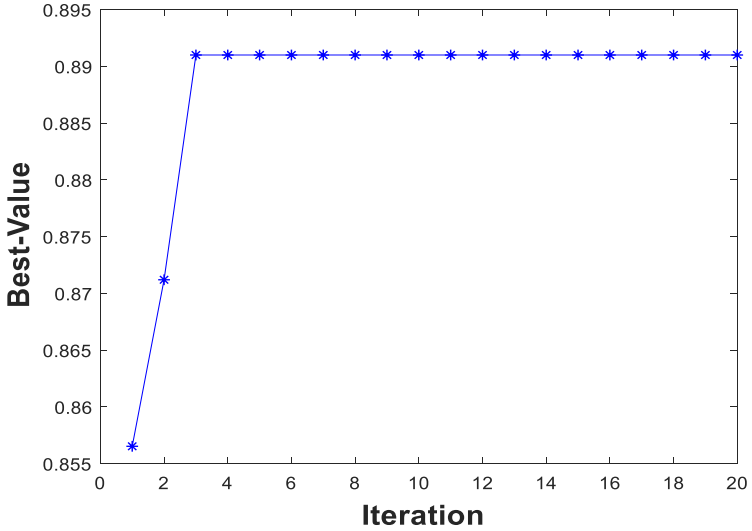


Figure .(5.43) PSO for Interdependency in the Pre-Co Ph. .(Project One , Problem 1.4)

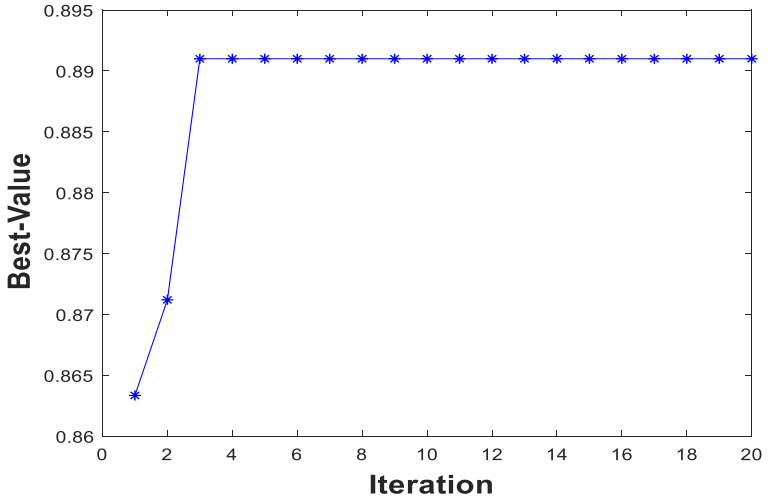


Figure .(5.44) PSO for Interdependency in the Pre-Co Ph. .(Project One , Problem 1.5)

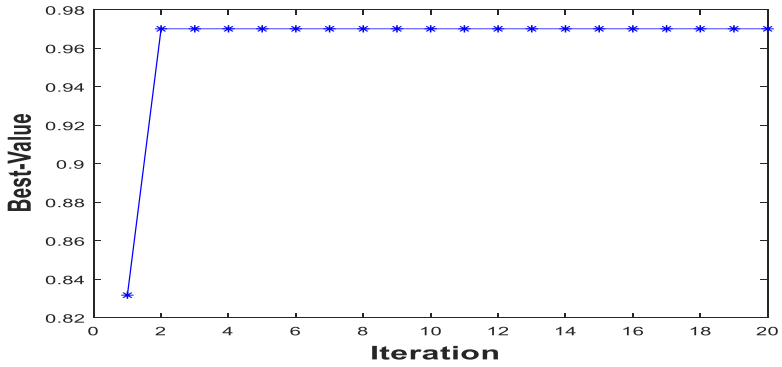


Figure. (5.45) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 2.1)

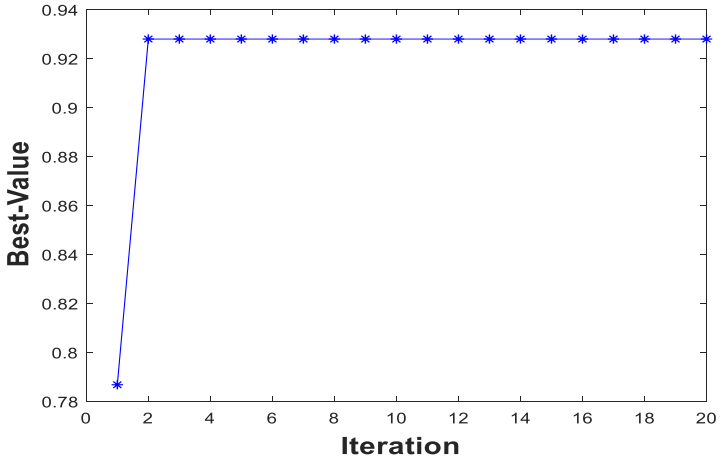


Figure .(5.46) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 2.3)

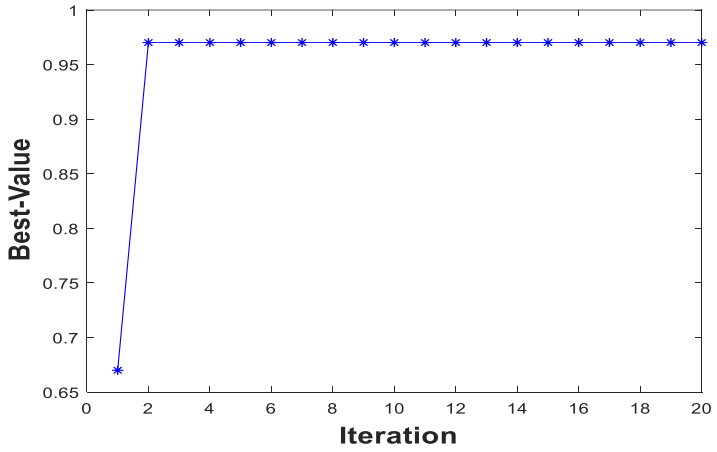


Figure. (5.47) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 2.4)

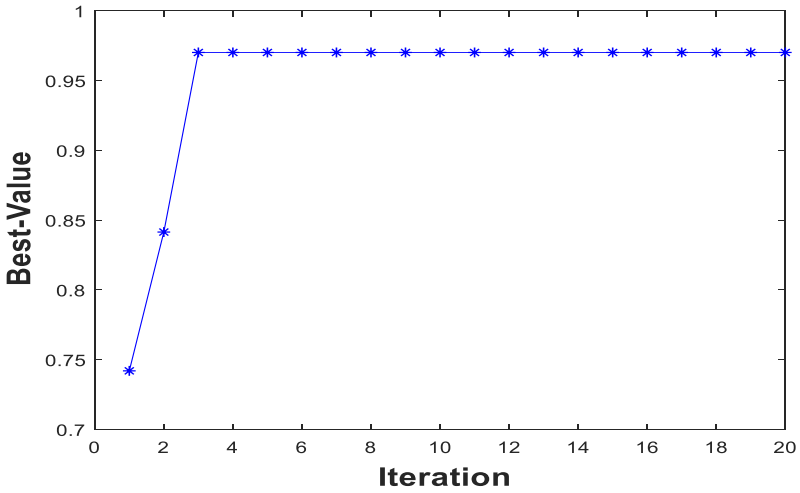


Figure. (5.48) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 2.5)

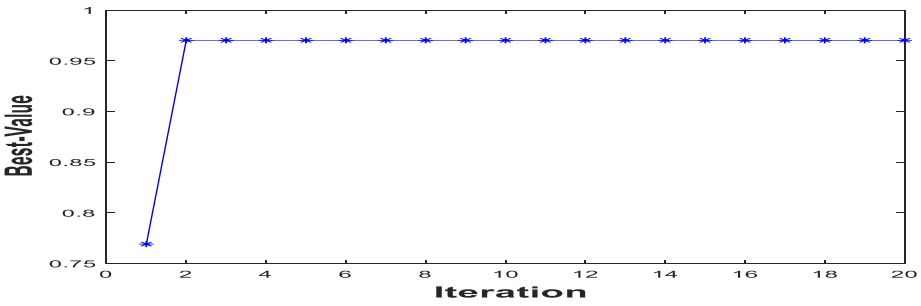


Figure .(5.49) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 3.1)

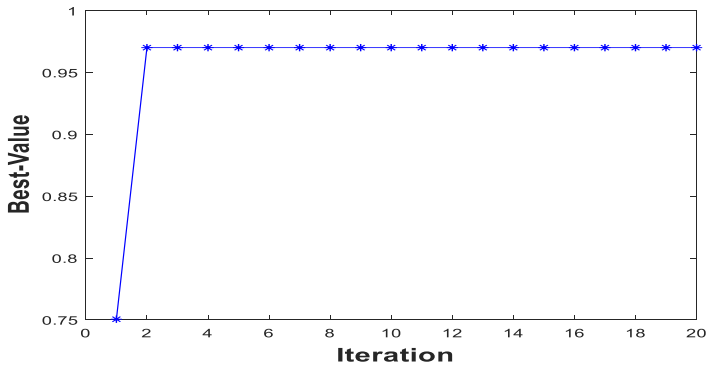


Figure .(5.50) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 3.2)

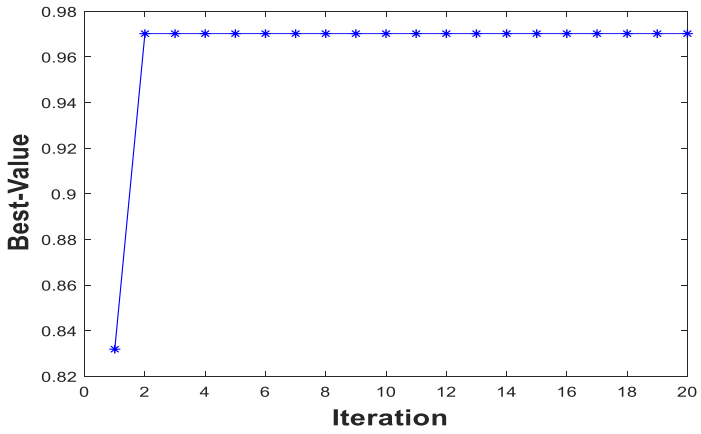


Figure (5.51) PSO for Interdependency in the Pre-Construction Phase(Project One , Problem 3.4)

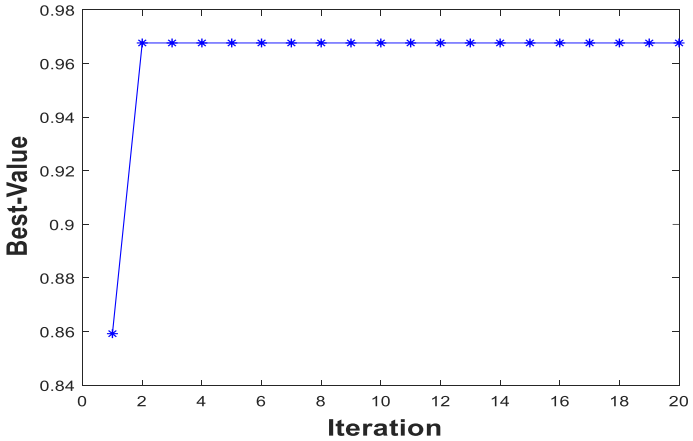


Figure .(5.52) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 3.5)

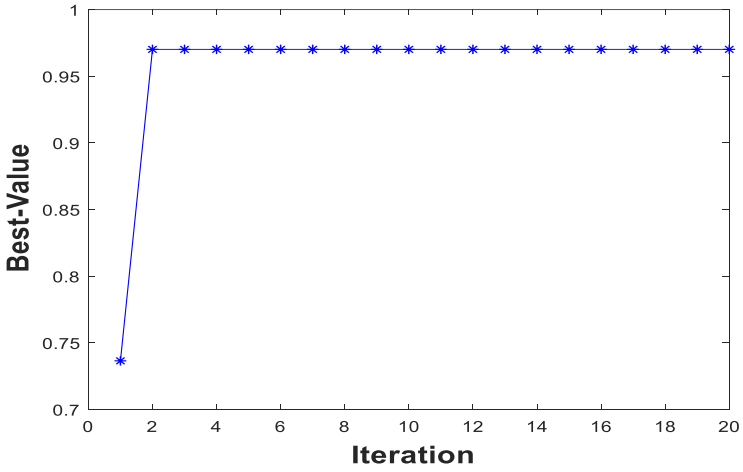


Figure (5.53) PSO for Interdependency in the Pre-Co Ph. .(Project One , Problem 4.1)

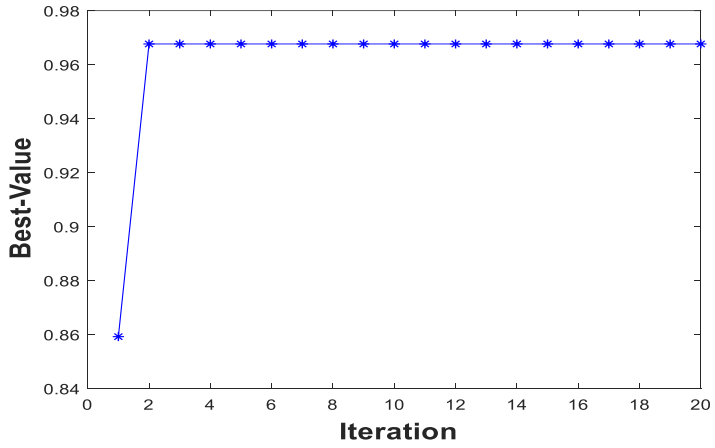


Figure (5.54) PSO for Interdependency in the Pre-Construction Phase(Project One , Problem 4.2)

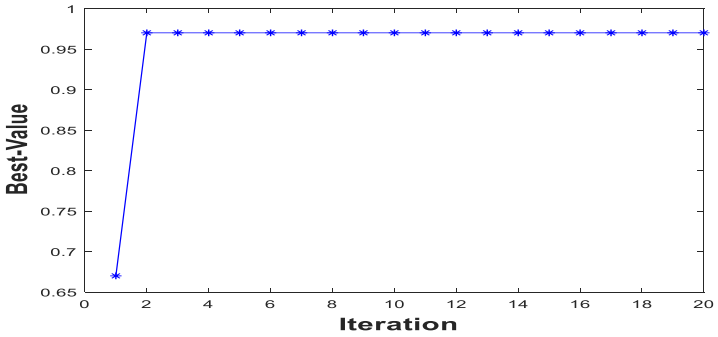


Figure. (5.55) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 4.3)

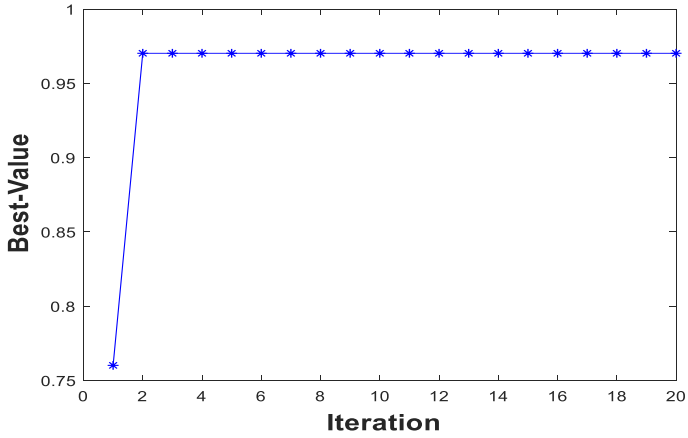


Figure .(5.56) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 4.5)

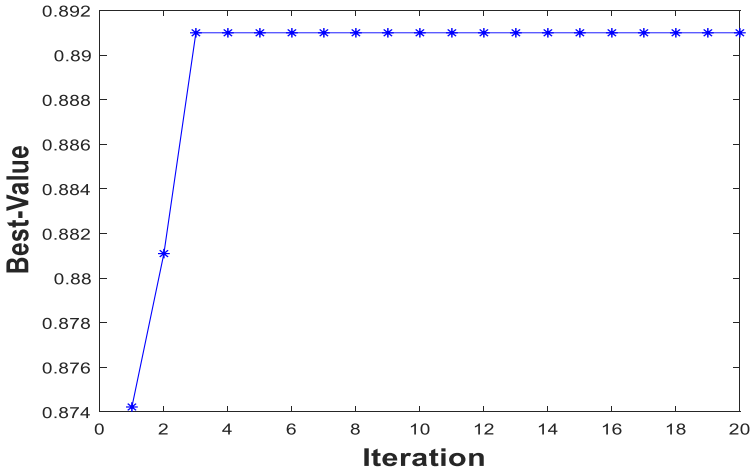


Figure. (5.57) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 5.1)

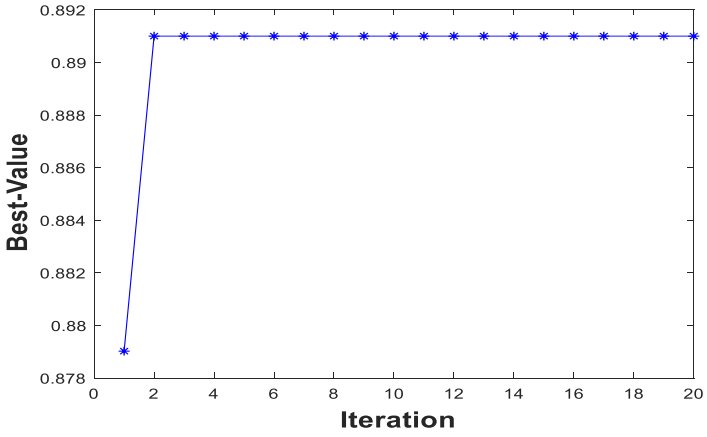


Figure .(5.58) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 5.2)

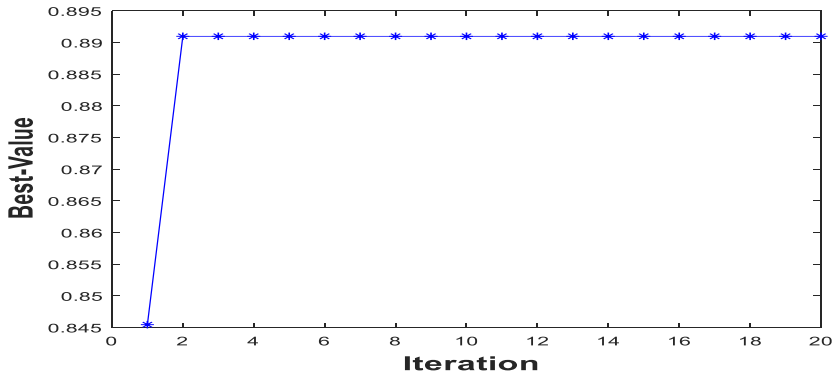


Figure. (5.59) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 5.3)

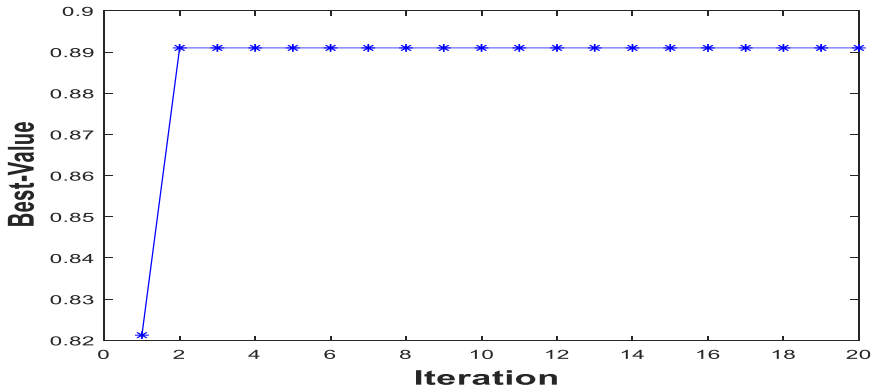


Figure. (5.60) PSO for Interdependency in the Pre-Co Ph. (Project One , Problem 5.4)

The result of the interdependency for the pre-construction by using GSA as shown in the table (5.6)

Table (5.6) GSA for Interdependency in the Pre-Construction Phase(Project One)

problem	z	xij	tha	lmda	nf	tao	Dj	Di	wj	v
1.2	0.891	0.990017	0.922062	0.788915	0.176459	0.898687	5.00E-07	5.56E-07	1	0.00E+00
1.3	0.891	0.990001	0.009995	0.50858	0.435298	0.615771	0.08	0.129919	1	2.40E-06
1.4	0.891	0.81987	0.599967	0.410845	0.117938	1.266863	5.00E-07	3.95E-07	1	3.75E-07
1.5	0.891	0.990001	0.086533	0.979156	0.284545	9.272821	0.1	0.010784	1	3.60E-06
2.1	0.970	0.990	0.526	0.010	0.076	1.401	5.00	3.57E	1	1.32E

	2	001	613	001	343	666	E-07	-07		-10
2.3	0.9702	0.990001	0.057194	0.201604	0.385883	1.177186	0.0165	0.014016	1	5.06E-10
2.4	0.9702	0.990001	0.990001	0.267178	0.315995	64.76473	0.05	0.000772	1	5.06E-09
2.5	0.9702	0.990001	0.416381	0.010001	0.024187	1.469083	0.0165	0.011231	1	1.55E-10
3.1	0.9702	0.990001	0.686326	0.010001	0.786274	10.37347	5.00E-07	4.82E-08	1	6.77E-10
3.2	0.9702	0.990001	0.786588	0.064395	0.029233	1.718143	5.00E-07	2.91E-07	1	2.39E-09
3.4	0.9702	0.64161	-0.10063	0.231434	0.937692	1.128248	5.00E-07	4.43E-07	1	2.75E-09
3.5	0.9702	0.997901	0.529259	1.110646	0.386886	100	0.083	0.00083	1	1.43E-09
4.1	0.9702	0.956518	0.434425	-0.30532	0.43613	0.833227	0.0165	0.019803	1	9.94E-10
4.2	0.9702	0.990002	0.32784	0.941054	0.844166	0.502513	0.0165	0.032835	1	5.00E-09
4.3	0.970201	0.990001	0.990001	0.010001	0.842556	1.086204	0.0165	0.015191	1	7.87E-10
4.5	0.8305	0.553133	0.673897	0.868927	4.932256	0.581495	5.00E-07	8.60E-07	1	0.00E+00
5.1	0.891	0.990003	0.206975	0.944783	0.55718	0.502766	5.00E-07	9.94E-07	1	9.11E-07
5.2	0.891	0.697464	0.907494	2.200307	0.210822	0.663101	0.05	0.075403	1	1.09E-07
5.3	0.891	0.990001	0.874081	0.010001	0.755619	0.502674	0.0165	0.032824	1	0.00E+00
5.4	0.891	0.990001	0.718886	0.728283	0.759379	0.850578	0.0165	0.019399	1	3.58E-10

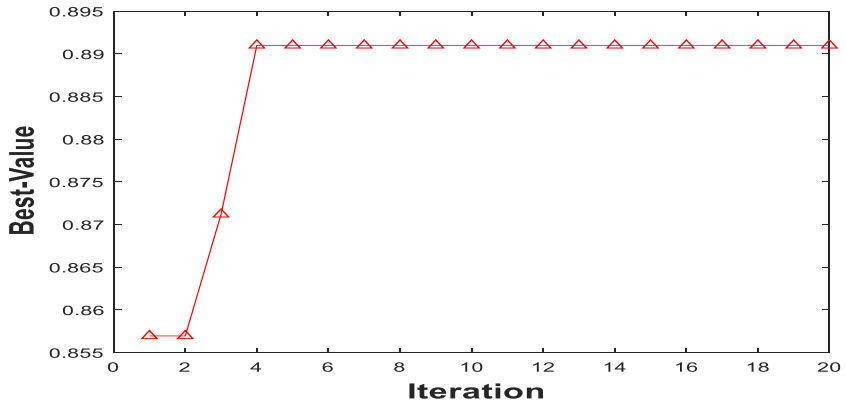


Figure .(5.61) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 1.2)

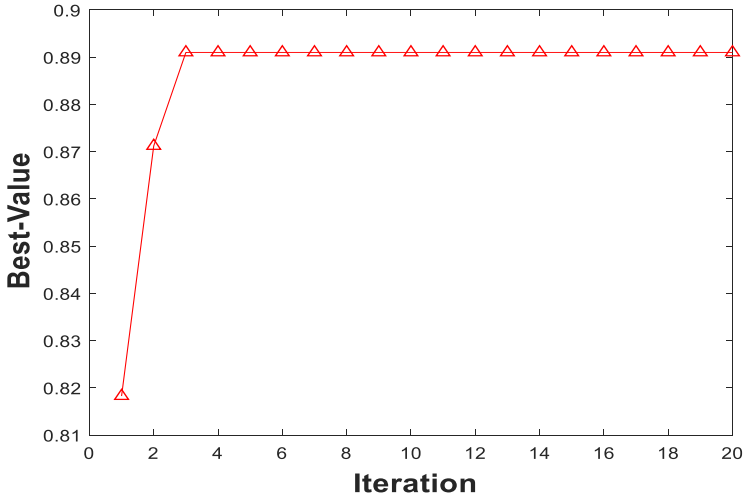


Figure .(5.62) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 1.3)

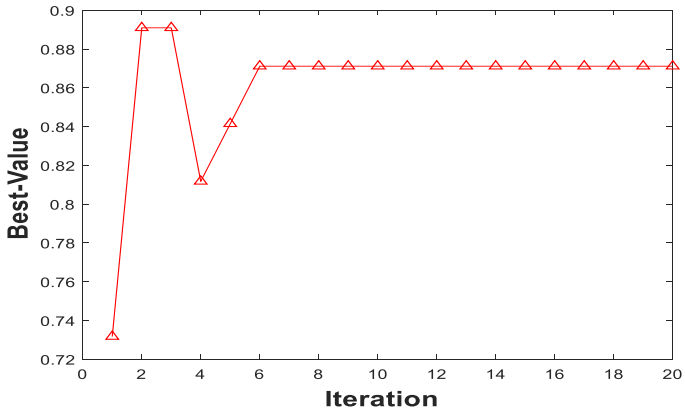


Figure (5.63) PSO for Interdependency in the Pre-Co Ph. ز(Project One , Problem 1.4)

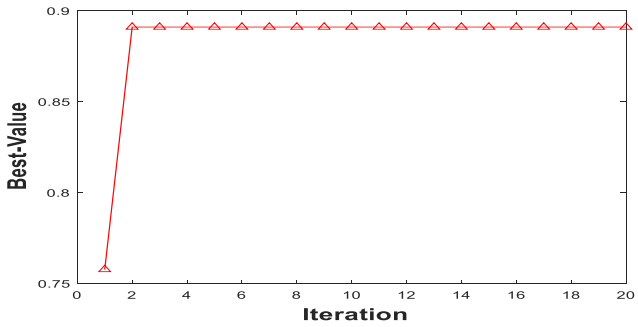


Figure. (5.64) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 1.5)

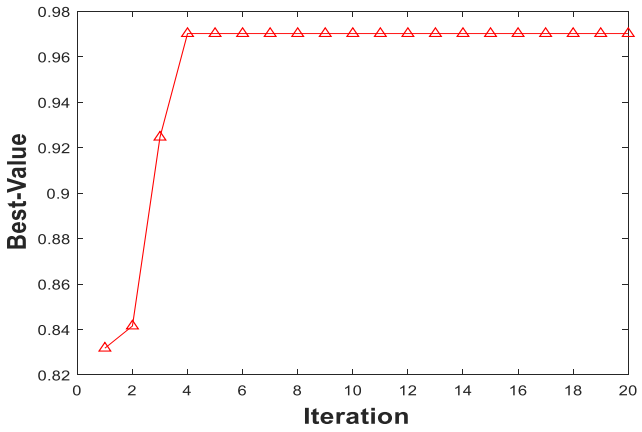


Figure .(5.65) GSA for Interdependency in the Pre-Co Ph. .(Project One , Problem 2.1)

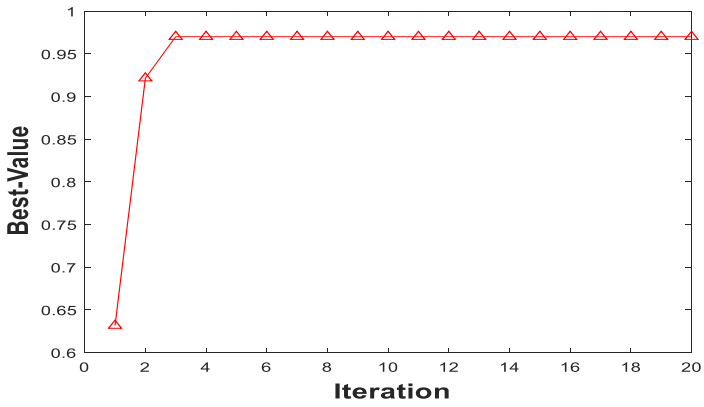


Figure. (5.66) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 2.3)

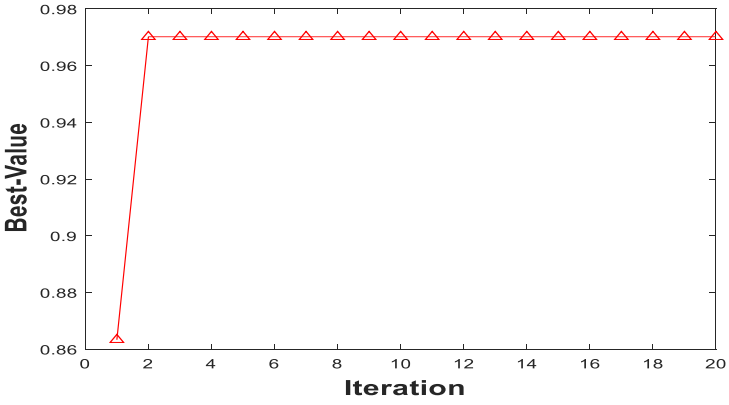


Figure .(5.67) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 2.4)

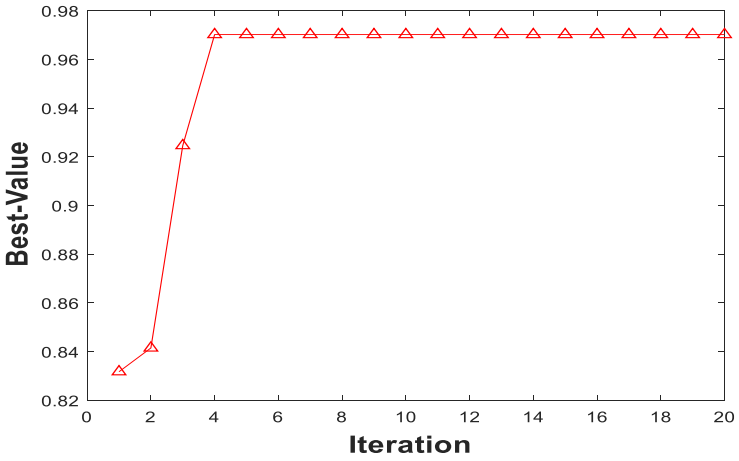


Figure .(5.68) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 2.5)

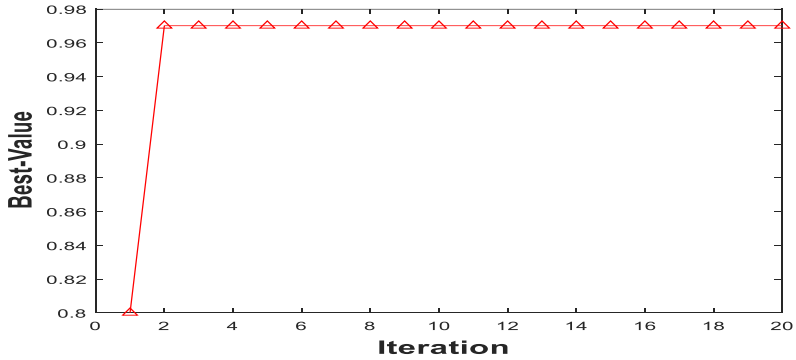


Figure .(5.69) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 3.1)

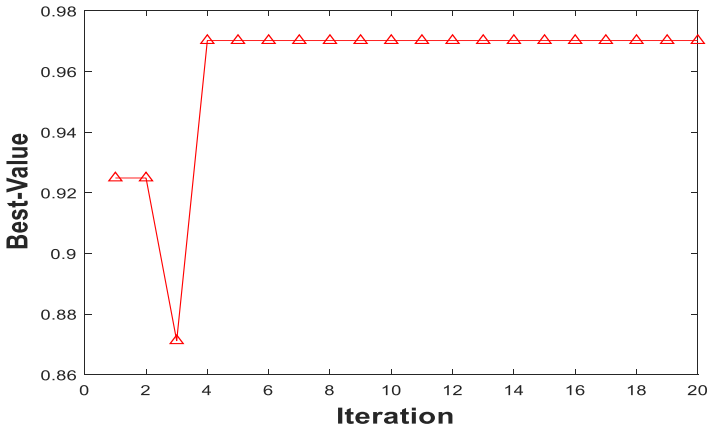


Figure .(5.70) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 3.2)

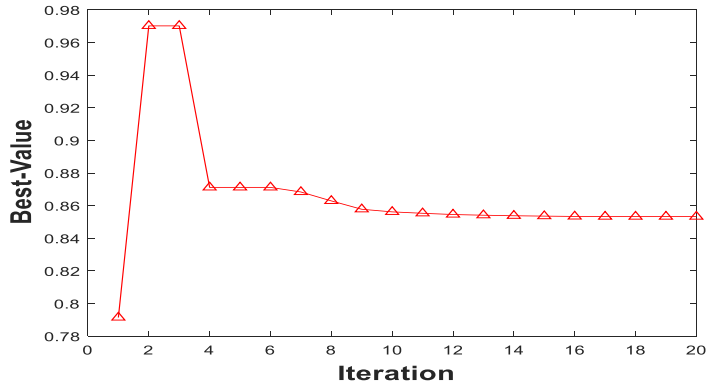


Figure .(5.71) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 3.4)

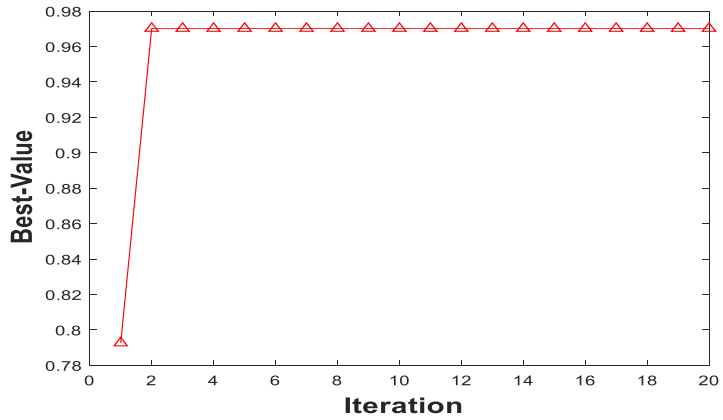


Figure .(5.72) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 3.5)

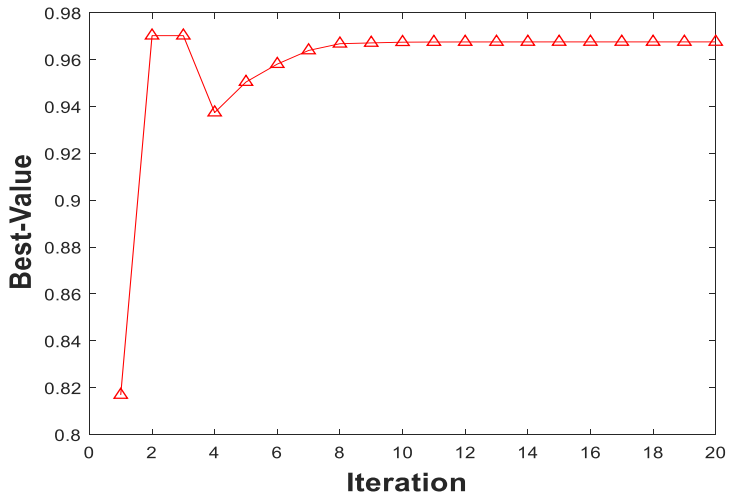


Figure. (5.73) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 4.1)

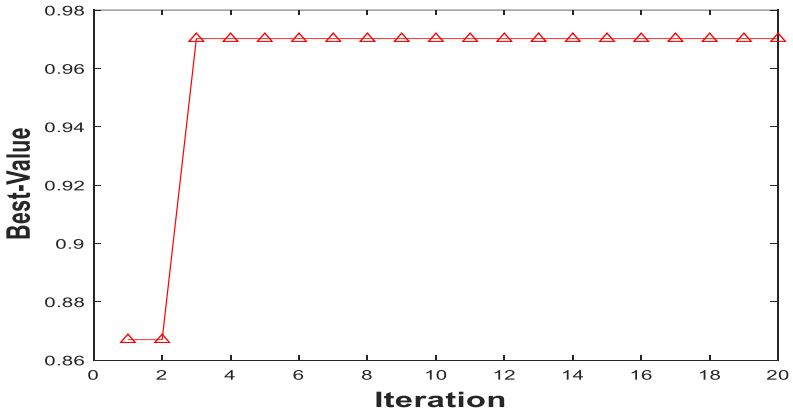


Figure .(5.74) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 4.2)

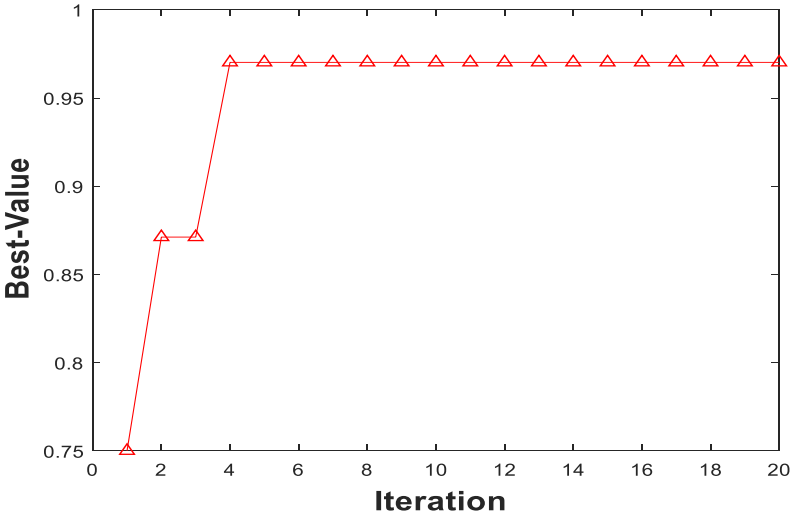


Figure. (5.75) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 4.3)

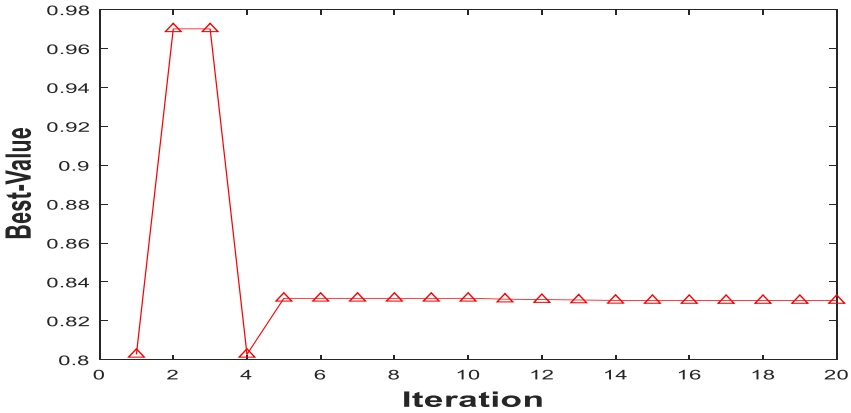


Figure. (5.76) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 4.5)

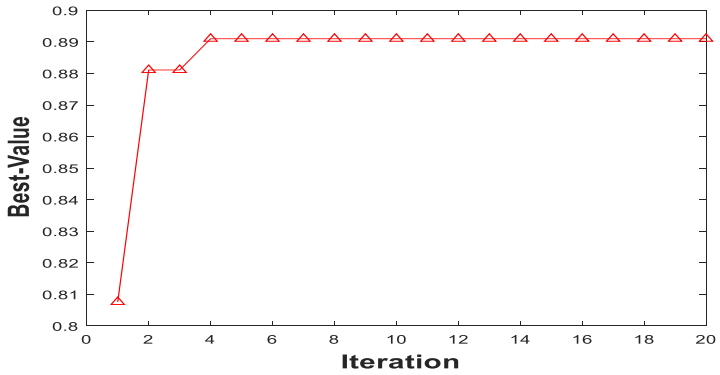


Figure. (5.77) GSA for Interdependency in the Pre-Co Ph. .(Project One , Problem 5.1)

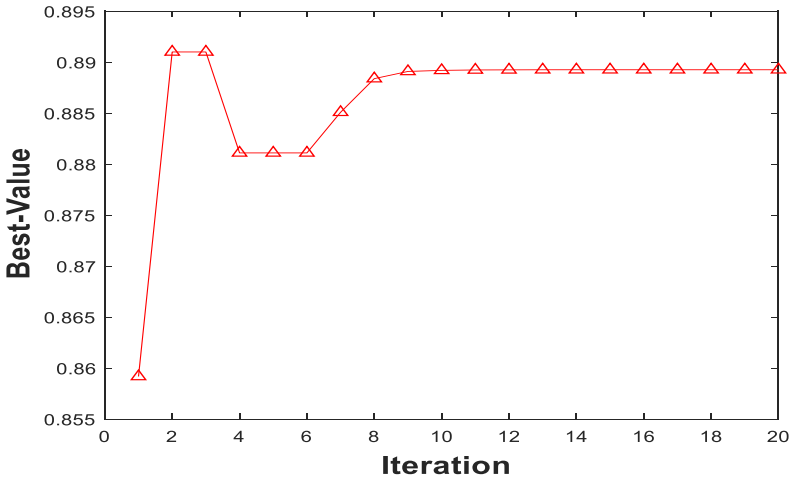


Figure .(5.78) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 5.2)

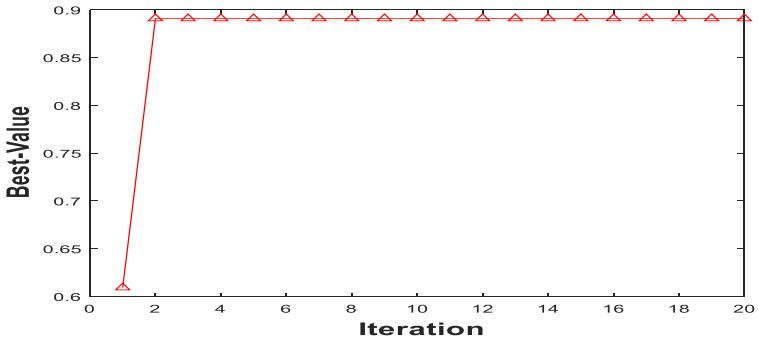


Figure. (5.79) GSA for Interdependency in the Pre-Co Ph. (Project One , Problem 5.3)

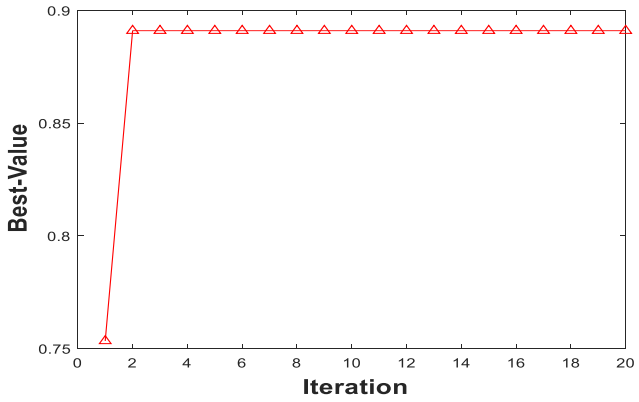


Figure .(5.80) GSA for Interdependency in the Pre-Co Ph. .(Project One , Problem 5.4)

PSO technique also shows better results as the GSA variables has some negative values and the method of searching seem to have winding way to find the interdependency between the two problem.

The results of the interdependency between two problem in the construction phase as by using PSO is shown in the table (5.7):

Table (5.7) PSO for Interdependency in the Construction Phase(Project One)

problem	z	xij	tha	lmda	nf	tao	Dj	Di	wj	v
1.2	0.861301	0.990001	0.990001	0.010001	0.010001	100	5.00E-07	5.00E-09	1	0
1.3	0.861301	0.990001	0.010001	0.010001	0.990001	0.626363	0.08	0.127722	1	0
2.1	0.871201	0.990001	0.893624	0.364161	0.815136	6.926421	5.00E-07	7.22E-08	1	0
2.3	0.871201	0.990001	0.990001	0.220145	0.41776	1.859264	0.0165	0.00907	1	0
3.1	0.871201	0.990001	0.010001	0.960172	0.701381	0.549202	0.0165	0.030044	1	0
3.2	0.871201	0.990001	0.990001	0.010001	0.814334	100	5.00E-07	5.00E-09	1	0

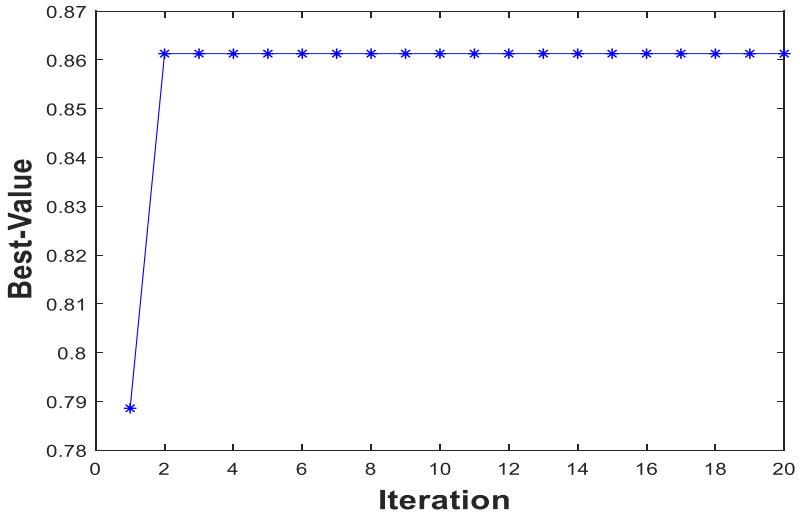


Figure (5.81) PSO for Interdependency in the Construction Phase(Project One , Problem 1.2)

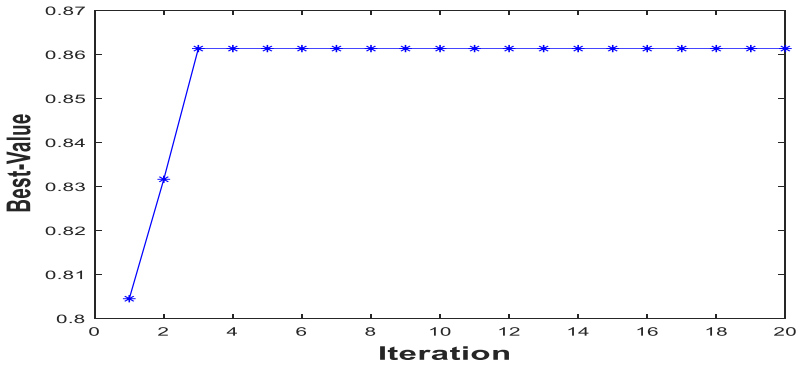


Figure (5.82) PSO for Interdependency in the Construction Phase(Project One , Problem 1.3)

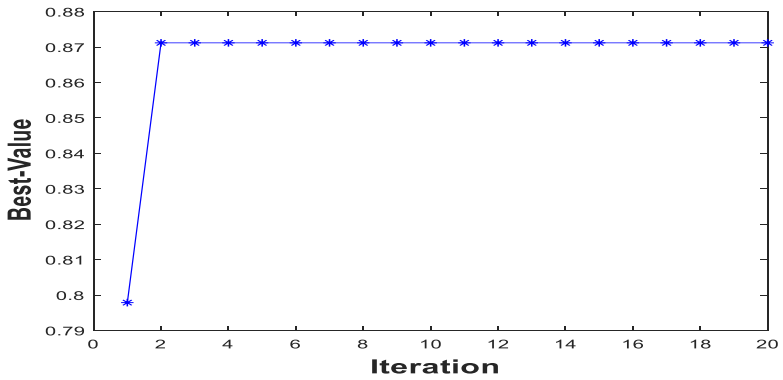


Figure (5.83) PSO for Interdependency in the Construction Phase(Project One , Problem 2.1)

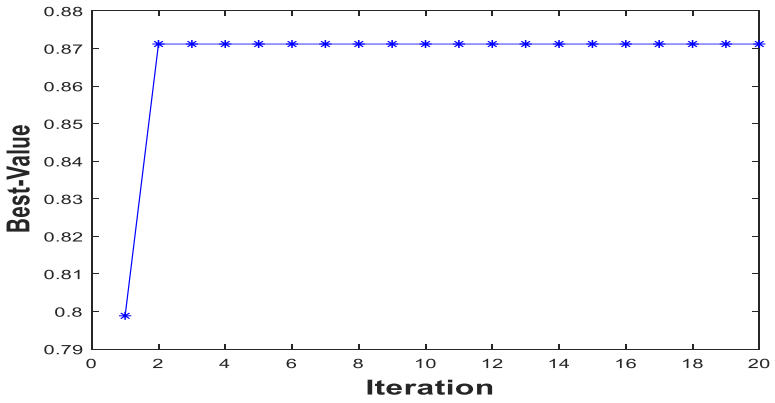


Figure (5.84) PSO for Interdependency in the Construction Phase(Project One , Problem 2.3)

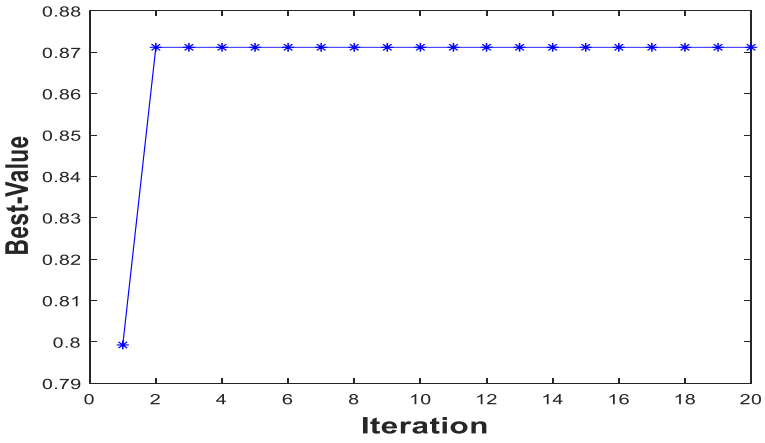


Figure (5.85) PSO for Interdependency in the Construction Phase(Project One , Problem 3.1)

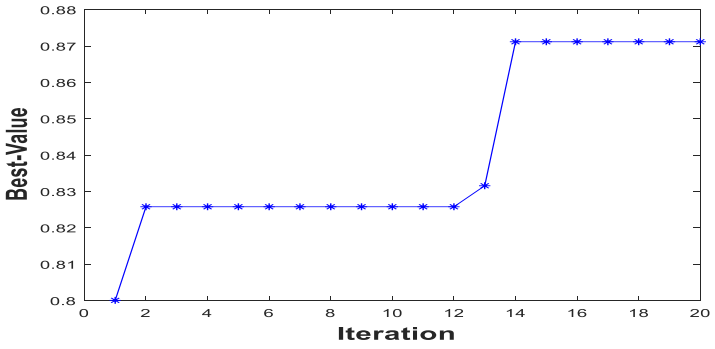


Figure (5.86) PSO for Interdependency in the Construction Phase(Project One , Problem 3.2)

The results show that the effect on the problem one on two is slightly different from the two on one which mean that both require

solution and it's the same apply on the problem two and three which indicate that the construction phase is very critical and require great attention.

The results of the interdependency between two problem in the construction phase as by using GSA is shown in the table (5.8):

Table (5.8) GSA for Interdependency in the Construction Phase(Project One)

problem	z	xij	tha	lmda	nf	tao	Dj	Di	wj	v
1.2	0.861301	0.990001	0.61632	0.278833	0.074063	1.538231	5.00E-07	3.25E-07	1	5.02E-08
1.3	0.861301	0.7258	0.538366	0.168309	1.280901	99.89853	0.08	0.000801	1	3.54E-07
2.1	0.871201	0.990001	0.977446	0.01	0.778543	78.30838	5.00E-07	6.39E-09	1	1.42E-07
2.3	0.871201	0.990001	0.010003	0.990001	0.604447	100	0.01 65	0.000165	1	4.67E-09
3.1	0.871201	0.990001	0.01	0.010001	0.65618	0.592491	5.00E-07	8.44E-07	1	8.21E-06
3.2	0.871201	0.990001	0.744251	0.383943	0.032543	0.502513	5.00E-07	9.95E-07	1	1.90E-08

The different between PSO and GSA is in velocity and also in the method of searching.

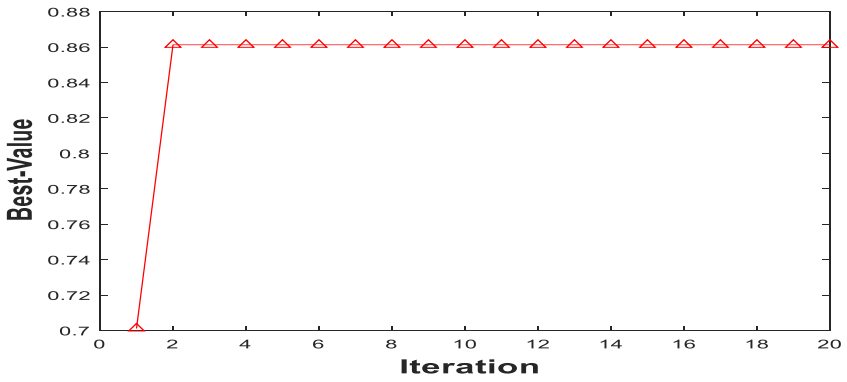


Figure (5.87) GSA for Interdependency in the Construction Phase(Project One , Problem 1.2)

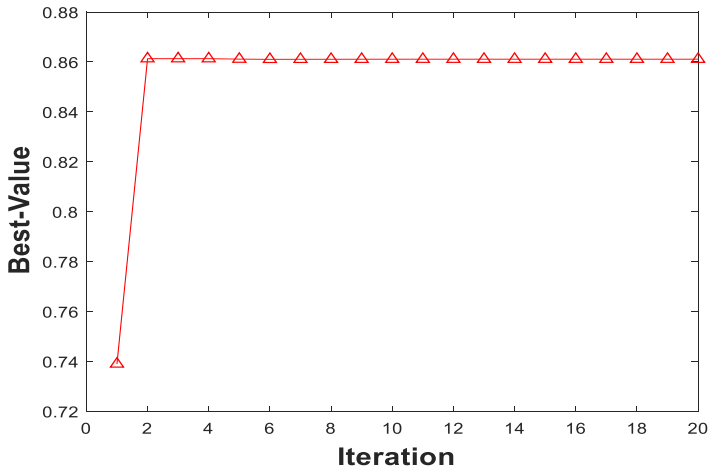


Figure (5.88) GSA for Interdependency in the Construction Phase(Project One , Problem 1.3)

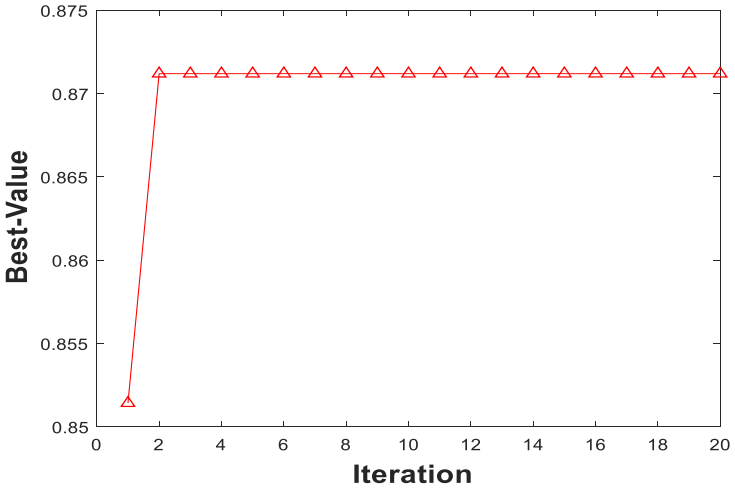


Figure (5.89) GSA for Interdependency in the Construction Phase(Project One , Problem 2.1)

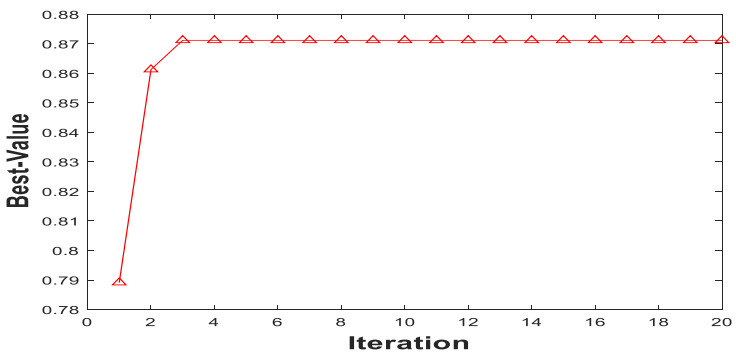


Figure (5.90) GSA for Interdependency in the Construction Phase(Project One , Problem 2.3)

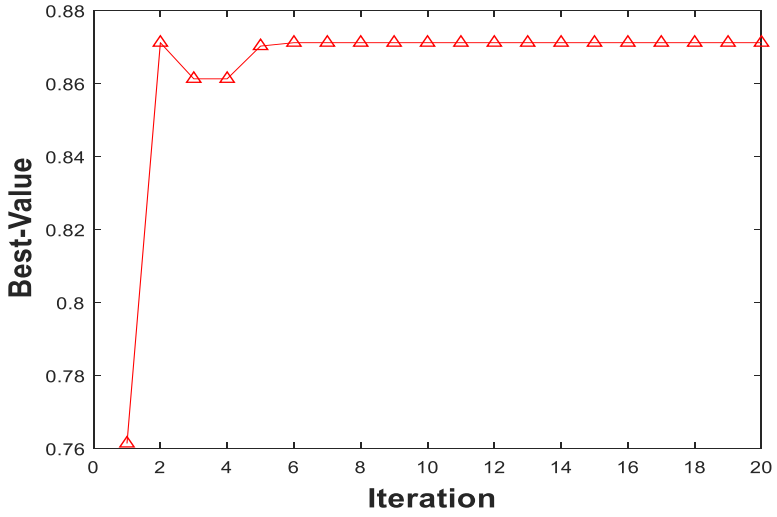


Figure (5.91) GSA for Interdependency in the Construction Phase(Project One , Problem 3.1)

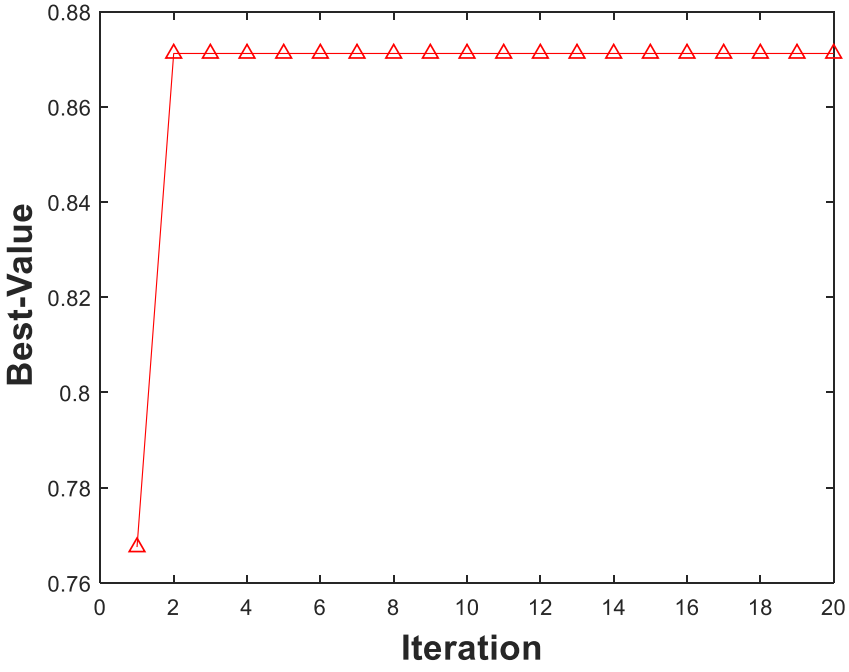


Figure (5.92) GSA for Interdependency in the Construction Phase(Project One , Problem 3.2)

There are two other projects are shown the appendix F and G.

CHAPTER SIX

Conclusions and Recommendations

Chapter Six

Conclusions and Recommendations

6.1 Introduction

This chapter offers a summary of the main conclusions of the theoretical and field study conducted by the researcher, as well as the results of the expert system and the two techniques. Depending on these conclusions, different suggestions for future studies are set forward.

6.2 Conclusions

Based on the work of the research, the following conclusions can be drawn:

1- The problems in the pre-construction phase are more than the construction phase but less impact.
2- The construction phase considers risky and has an impact of about 25% on cost and 20% on time.
3- The interdependency between problem quite equal in the construction problems rather than pre-construction problems.
4- Expert System is a computer program that is intelligent for finding the solution of the complex problems equal to the human expert level of a by using assignment specific information and inference techniques.
5- The expert system is considered an excellent tool in the decision making that requires a complex procedure.
6- Designing the expert system is depending on the configuration of knowledge and the need for construction projects. This system is designed to provide a database for ant previously problems that have been occurred in the projects.

7- The expert system can also be used to find the solutions for the new problems than happen in the project, thus its work forward and backward chaining.

8- PSO algorithm shows operative method in determining the greatest solution in term of speed and method of searching.

9- GSA is also operative method in determining the greatest solution and it requires more time.

10- All the velocity of the PSO is zero while the GSA is always more than zero which indicate the PSO is fast and also in the method of searching as seen in problem 7 and 9 the GSA take different way in finding the solution.

13-PSO technique also shows better results as the GSA variables have some negative value and the method of searching seem to have a winding way to find the interdependency between the two problems.

6.3 Recommendations

1- Conducting educational and training courses to implement an expert system in construction projects.

2- Using the expert system in different problems and in a different phase.

4- Use different techniques in the expert system and compare the results.

5- Study another constraints of the projects like quality or scope of the projects by using the design expert system.

4- Using simulation techniques in the planning of the project and putting the worst of the possibilities for taking precautionary precautions to face the uncertainty.

5- Use modern techniques in risk analysis to reduce uncertainty and reduce risks.

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Appendix A
Summary of findings from literature

Table(1) Summary of findings from literature

S/No	Source	Country	Challenges of cost control
1	(Kirun and Varghese, 2015)	India	Improper planning and scheduling, ineffective planning, reworks due to errors, due to defective work, wastage of materials, design changes, additional works, currency value, fluctuation in material cost and increase in interest rate
2	(Sanni & Hashim, 2013)	Nigeria	Improper contract document, engagement of inexperience staff, unstable market condition, complexity of the project, unstable government regulations, choice of procurement method, lack of research and innovation, price and design risk, quality factors of cost information, non-provision of training of young professionals, inadequate access to software packages, non-clarity of exclusions, and ineffectiveness of professional bodies
3	(Ademola, 2012)	South Africa	Lack of knowledge on the use of available tools and technology, Abandonment of complicated strategies
4	(Song, 2014)	China	Using obsolete methods and concepts Over emphasizing results, and ignoring the process of PCC Lacking PCC processes and systems suitable to the enterprise Lack of consistency in cost management by managers Serious decision failure, exorbitant marketing expenses.

5	(Charoenngan & Sriprasert, 2001)	Thailand	Difficulty in monitoring different sources of day-to-day cost data

Appendix B

Identified Project cost and Time Control Inhibiting Factors and Classification

Table (1) Identified Project cost and time control inhibiting factors and classification

Factors	Sources
Inflation of prices	Arditi et al (1985), kaming et al (1997), Aibinu and Jagboro (2002), Kuruooglu and Ergen (2000), Ogunlana et al (1996), Frimpong et al (2003)
Fluctuation of currency/exchange rate	Dlakwa and Cuplin (1990), Sonuga (2002), Aibinu and Jagboro (2002), Mansfield et al (1994) Arditi et al (1985), Baloi and Price (2003)
Unstable government policies	Sonuga (2002), Faniran (1999), Iyer and Jha (2005), Kuruooglu and Ergen (2000), Baloi and Price (2003)
Weak regulation and control	Koushki et al (2005), Arditi et al (1985), Kartam et al (2000)
Unpredictable weather Conditions	Kaming et al (1997), Koushki et al (2005), Iyer and Jha (2005), Al-Momani AH (2000), Frimpong et al (2003), Yogeswaran et al (1998)
Dependency on imported Materials	Manfield et al (1994), Sonuga (2002), Arditi et al (1985), Frimpong et al (2003)
Low skilled manpower	Dlakwa and Cuplin (1990), Kaming et al (1997), Kuruooglu and Ergen (2000), Assaf et al (1995), Koushki et al (2005) ,Kumaraswamy and Chan (1998), Arditi et al (1985), Kartam et al (2000)
Risk and uncertainty associated with projects	Egbu (1998), Flyvbjerg et al (2003), Baloi and Price (2003)

Unstable interest rate	Mansfield et al (1994), Dlakwa and Cuplin (1990)
Lack of proper training and experience of PM	Iyer and Jha (2005), Kuruooglu and Ergen (2000), Assaf et al (1995), Arditi et al (1985), Kartam et al (2000), Frimpong et al (2003)
Lack of appropriate software	Lee et al (2005), Iyer and Jha (2005)
Inaccurate evaluation of projects time/duration	Dlakwa and Cuplin (1990), Kaming et al (1997), Assaf et al (1995), Chang (2002), Mansfield et al (1994), Kumaraswamy and Chan (1998), Ogunlana et al (1996), Frimpong et al (2003)
Non-performance of subcontractors and nominated	Manfield et al (1994), (Kumaraswamy and Chan (1998), Yogeswaran et al (1998)

Appendix C
Construction Problems

Table (1) construction problems

Solutions	Problems	Ci	Sj	Sij	E
Good Preparation	Type of labor required, Type and number of supervisory and labor required	0.09	0.1	0.022	0.82
Documentation and Tracking		0.09	0.1	0.021	0.83
Leadership		0.09	0.1	0.025	0.84
using Skills worker		0.01	0.1	0.021	0.82
Sufficient and Consistent Efforts and Resources		0.01	0.1	0.02	0.77
Define Parameters and Enforce Them		0.075	0.1	0.02	0.84
Communication at Every Level of Management		0.078	0.1	0.082	0.87
Project Warning Signs		0.059	0.1	0.02	0.8
Supervision		0.072	0.1	0.012	0.82
establish stratigic alignment		0.01	0.1	0.09	0.75
Management expertise	The projects' stakeholders	0.11	0.1	0.09	0.82
Documentation and Tracking		0.1	0.1	0.08	0.81
Leadership		0.12	0.1	0.05	0.84
using Skills worker		0.1	0.1	0.01	0.82
Sufficient and Consistent Efforts and Resources		0.1	0.1	0.02	0.78
Planning and execution guideline		0.15	0.1	0.02	0.88
Communication at Every Level of Management		0.18	0.1	0.02	0.87
Project Warning Signs		0.19	0.1	0.07	0.8
Supervision		0.12	0.1	0.06	0.82
establish strategic		0.1	0.1	0.09	0.77

alignment					
Management expertise	The client financial capacity	0.01	0.05	0.09	0.82
Documentation and Tracking		0.01	0.05	0.08	0.81
Client engagement and control		0.02	0.05	0.05	0.84
using Skills worker		0.01	0.05	0.01	0.82
Sufficient and Consistent Efforts and Resources		0.01	0.05	0.02	0.78
Collaborative working		0.04	0.05	0.02	0.88
Communication at Every Level of Management		0.02	0.05	0.02	0.87
Design management plan		0.03	0.05	0.07	0.8
Supervision		0.02	0.05	0.06	0.82
Design manager		0.01	0.05	0.09	0.77
DETAILED ESTIMATE	. Clearness of the work and specifications	0.01	0.2	0.12	0.82
select Project team's experience in the construction type		0.017	0.2	0.13	0.85
BIM		0.01	0.2	0.15	0.9
provide sufficient details for estimators		0.011	0.2	0.12	0.85
defined scope		0.01	0.2	0.15	0.88
Design contingency accounts		0.015	0.2	0.18	0.78
apply escalation up to the mid-point of construction		0.018	0.2	0.11	0.75
Acquire training and skilling		0.019	0.2	0.18	0.89
Perform detailed risk analysis		0.002	0.2	0.11	0.8
make alternative estimation		0.01	0.2	0.14	0.87

approaches.					
DETAILED ESTIMATE	Original price estimated by the client	0.1	0.2	0.12	0.82
select Project team's experience in the construction type		0.17	0.2	0.13	0.85
BIM		0.1	0.2	0.15	0.9
provide sufficient details for estimators		0.11	0.2	0.12	0.85
defined scope		0.1	0.2	0.15	0.88
Design contingency accounts		0.15	0.2	0.18	0.78
apply escalation up to the mid-point of construction		0.18	0.2	0.11	0.75
Acquire training and skilling		0.19	0.2	0.18	0.89
Perform detailed risk analysis		0.12	0.2	0.11	0.8
make alternative estimation approaches.		0.1	0.2	0.14	0.87
Accommodating	. Ability of doing the job	0.1	0.25	0.12	0.82
select Project team's experience in the construction type		0.17	0.25	0.13	0.85
BIM		0.1	0.25	0.15	0.92
provide sufficient details for estimators		0.11	0.25	0.12	0.85
defined scope		0.1	0.25	0.15	0.88
Design contingency accounts		0.15	0.25	0.18	0.78
apply escalation up to the mid-point of construction		0.18	0.25	0.11	0.75
Acquire training and skilling		0.19	0.25	0.18	0.89

Perform detailed risk analysis		0.12	0.25	0.11	0.8
make alternative estimation approaches.		0.1	0.25	0.14	0.87
Data for preparing for schedules and network diagrams	Availability of qualified human resources	0.01	0.10	0.012	0.8
defined, agreed upon escalation matrix with escalation contact points		0.017	0.10	0.013	0.83
Ensure that the project stakeholders are well aware of the escalation process		0.01	0.10	0.015	0.82
analyze the situation with data points		0.02	0.10	0.09	0.85
Service Level Agreements (SLAs) of the other party for responding		0.03	0.10	0.05	0.88
Avoid the Cry-Wolf scenario		0.04	0.10	0.08	0.88
apply escalation up to the mid-point of construction		0.018	0.10	0.01	0.75
Escalate only to the right stakeholders and do not involve all in the issue		0.019	0.10	0.08	0.89
Escalate by giving background, highlight correct data, severity of the situation		0.02	0.10	0.01	0.8
Document escalation with data points, and mark all		0.01	0.10	0.04	0.87

necessary actions with action-owners					
DETAILED ESTIMATE	Reliability level of subcontractors	0.01	0.20	0.12	0.82
select Project team's experience in the construction type		0.017	0.20	0.13	0.85
BIM		0.01	0.20	0.15	0.9
provide sufficient details for estimators		0.011	0.20	0.12	0.85
defined scope		0.02	0.20	0.15	0.88
Design contingency accounts		0.04	0.20	0.18	0.78
apply escalation up to the mid-point of construction		0.03	0.20	0.11	0.75
Acquire training and skilling		0.02	0.20	0.18	0.89
Perform detailed risk analysis		0.02	0.20	0.11	0.8
make alternative estimation approaches.	. Familiarity with site condition	0.01	0.20	0.14	0.87
cost accounting system		0.01	0.20	0.12	0.82
select Project team's experience in the construction type		0.017	0.20	0.13	0.85
BIM		0.01	0.20	0.15	0.9
provide sufficient details for estimators		0.011	0.20	0.12	0.85
cost report		0.02	0.20	0.15	0.88
Design contingency accounts		0.04	0.20	0.18	0.78
apply escalation up to the mid-point of construction		0.03	0.20	0.11	0.75
Acquire training		0.02	0.20	0.18	0.89

and skilling					
Perform detailed risk analysis		0.02	0.20	0.11	0.8
make alternative estimation approaches.		0.01	0.20	0.14	0.87
Weak Performance Management	Availability of equipment and materials, Availability of required equipment, Type of equipment required	0.01	0.15	0.12	0.82
manage Connection Gaps		0.07	0.15	0.13	0.85
Willingness to continuously learn		0.01	0.15	0.11	0.74
Train for Decision-making		0.011	0.15	0.12	0.85
Active listening		0.02	0.15	0.11	0.88
Negotiation and diplomacy		0.04	0.15	0.12	0.78
Brainstorm Alternatives		0.03	0.15	0.11	0.75
Acquire training and skilling		0.02	0.15	0.13	0.89
Perform detailed risk analysis		0.02	0.15	0.11	0.8
make alternative training approaches.		0.01	0.15	0.14	0.87
Weak Performance Management	Quality of available labour,. Availability of labour	0.01	0.12	0.12	0.82
manage Connection Gaps		0.07	0.12	0.13	0.85
Willingness to continuously learn		0.01	0.12	0.11	0.74
Train for Decision-making		0.011	0.12	0.12	0.85
Active listening		0.02	0.12	0.11	0.88
Negotiation and diplomacy		0.04	0.12	0.12	0.78

Brainstorm Alternatives		0.03	0.12	0.11	0.75
Acquire training and skilling		0.02	0.12	0.13	0.89
Perform detailed risk analysis		0.02	0.12	0.11	0.8
make alternative training approaches.		0.01	0.12	0.14	0.87
Weak Performance Management	Lack of project-stipulated data	0.01	0.15	0.12	0.82
manage Connection Gaps		0.07	0.15	0.13	0.85
Willingness to continuously learn		0.01	0.15	0.11	0.74
Train for Decision-making		0.011	0.15	0.12	0.85
Active listening		0.02	0.15	0.11	0.88
Negotiation and diplomacy		0.04	0.15	0.12	0.78
Brainstorm Alternatives		0.03	0.15	0.11	0.75
Acquire training and skilling		0.02	0.15	0.13	0.89
Perform detailed risk analysis		0.02	0.15	0.11	0.8
make alternative training approaches.		0.01	0.15	0.14	0.9
Weak Performance Management	Vague and deficient drawings and specifications	0.01	0.20	0.12	0.82
manage Connection Gaps		0.07	0.20	0.13	0.85
Willingness to continuously learn		0.01	0.20	0.11	0.74
Train for Decision-making		0.011	0.20	0.12	0.85
Active listening		0.02	0.20	0.11	0.88
Negotiation and diplomacy		0.04	0.20	0.12	0.78
Brainstorm		0.03	0.20	0.11	0.92

Alternatives					
Acquire training and skilling		0.02	0.20	0.13	0.89
Perform detailed risk analysis		0.02	0.20	0.11	0.8
make alternative training approaches.		0.01	0.20	0.14	0.9
Establishment of safety organization	Uncooperative managers and slow decision-making	0.01	0.1	0.02	0.82
Safety inputs storage		0.07	0.1	0.03	0.85
Establishment of safety regulations		0.01	0.1	0.01	0.9
Train for Decision-making		0.011	0.1	0.02	0.85
Establishment of reward and punishment rules		0.02	0.1	0.08	0.88
Produce a site policy that includes and conditions, procedures, guidance notes and codes of practice		0.04	0.1	0.07	0.78
Set up the site organization for the management of health and safety		0.03	0.1	0.08	0.89
Acquire training and skilling		0.02	0.1	0.03	0.89
Manage health and safety on site by coordinating activities,		0.02	0.1	0.01	0.8
make alternative training approaches.		0.01	0.1	0.04	0.9
Document Management	Adversarial relationship between consultant and	0.01	0.1	0.02	0.8

	contractor				
using modern management		0.017	0.1	0.023	0.85
proper schedule		0.01	0.1	0.015	0.9
High Insurance Costs		0.011	0.1	0.022	0.85
defined scope		0.01	0.1	0.025	0.88
Design contingency accounts		0.015	0.1	0.018	0.78
apply escalation up to the mid-point of construction		0.018	0.1	0.01	0.75
Acquire training and skilling		0.019	0.1	0.028	0.92
Perform detailed risk analysis		0.002	0.1	0.01	0.8
make alternative estimation approaches.		0.01	0.1	0.024	0.87
Good Preparation	Inadequate identification and representation of needs and requirements during the development process	0.09	0.1	0.022	0.82
Documentation and Tracking		0.09	0.1	0.021	0.83
Leadership		0.09	0.1	0.025	0.84
using Skills worker		0.01	0.1	0.021	0.82
Sufficient and Consistent Efforts and Resources		0.01	0.1	0.02	0.77
Define Parameters and Enforce Them		0.075	0.1	0.02	0.84
Communication at Every Level of Management		0.078	0.1	0.082	0.87
Project Warning Signs		0.059	0.1	0.02	0.8
Supervision		0.072	0.1	0.012	0.82
establish strategic alignment		0.01	0.1	0.09	0.75

Management expertise	Misunderstanding and misinterpretation of client needs and requirements	0.11	0.1	0.09	0.82
Documentation and Tracking		0.1	0.1	0.08	0.81
Leadership		0.12	0.1	0.05	0.84
using Skills worker		0.1	0.1	0.01	0.82
Sufficient and Consistent Efforts and Resources		0.1	0.1	0.02	0.78
Planning and execution guideline		0.15	0.1	0.02	0.88
Communication at Every Level of Management		0.18	0.1	0.02	0.87
Project Warning Signs		0.19	0.1	0.07	0.8
Supervision		0.12	0.1	0.06	0.82
establish strategic alignment		0.1	0.1	0.09	0.77
Document Management	Lack of documentation on changes, and feedback	0.01	0.1	0.02	0.8
using modern management		0.017	0.1	0.023	0.85
proper schedule		0.01	0.1	0.015	0.9
High Insurance Costs		0.011	0.1	0.022	0.85
defined scope		0.01	0.1	0.025	0.88
Design contingency accounts		0.015	0.1	0.018	0.78
apply escalation up to the mid-point of construction		0.018	0.1	0.01	0.75
Acquire training and skilling		0.019	0.1	0.028	0.92
Perform detailed risk analysis		0.002	0.1	0.01	0.8
make alternative estimation approaches.		0.01	0.1	0.024	0.87

DETAILED ESTIMATE	Requirements are difficult to identify	0.01	0.2	0.12	0.82
select Project team's experience in the construction type		0.017	0.2	0.13	0.85
BIM		0.01	0.2	0.15	0.9
provide sufficient details for estimators		0.011	0.2	0.12	0.85
defined scope		0.01	0.2	0.15	0.88
Design contingency accounts		0.015	0.2	0.18	0.78
apply escalation up to the mid-point of construction		0.018	0.2	0.11	0.75
Acquire training and skilling		0.019	0.2	0.18	0.89
Perform detailed risk analysis		0.002	0.2	0.11	0.8
make alternative estimation approaches.		0.01	0.2	0.14	0.87
Prediction Sales	Lack of end-users' involvement	0.009	0.01	0.0022	0.82
Make Study Cost of Goods Sold		0.0019	0.01	0.0021	0.83
Control Cash flow		0.0019	0.01	0.0025	0.84
using Skills worker		0.0011	0.01	0.0021	0.82
Sufficient and Consistent Efforts and Resources		0.0001	0.01	0.002	0.77
Control Fluctuations/Pricing Mechanism		0.0075	0.01	0.002	0.84
provide incentive for the addition technology expert		0.0078	0.01	0.0082	0.87
Control Cash inflows		0.0059	0.01	0.002	0.8
Supervision		0.0072	0.01	0.0012	0.82

establish strategic alignment		0.001	0.01	0.009	0.75

Appendix D
Pre-construction Parameters

Table (D) Pre-construction Parameters

E	Sij	Sj	c	Problems
0.78	0.02	0.03	0.01	1
0.7	0.023	0.03	0.017	1
0.77	0.015	0.03	0.01	1
0.75	0.022	0.03	0.011	1
0.8	0.025	0.03	0.01	1
0.74	0.018	0.03	0.015	1
0.85	0.01	0.03	0.018	1
0.88	0.028	0.03	0.019	1
0.82	0.01	0.03	0.002	1
0.9	0.024	0.03	0.01	1
0.8	0.02	0.03	0.01	2
0.79	0.025	0.03	0.018	2
0.77	0.016	0.03	0.01	2
0.74	0.025	0.03	0.011	2
0.8	0.025	0.03	0.01	2
0.84	0.018	0.03	0.015	2
0.85	0.01	0.03	0.018	2
0.98	0.028	0.03	0.019	2
0.82	0.01	0.03	0.002	2
0.9	0.026	0.03	0.01	2
0.88	0.04	0.1	0.01	3
0.79	0.02	0.1	0.018	3
0.77	0.01	0.1	0.01	3
0.74	0.025	0.1	0.011	3
0.82	0.06	0.1	0.01	3
0.84	0.07	0.1	0.015	3
0.85	0.08	0.1	0.018	3
0.98	0.028	0.1	0.019	3
0.82	0.01	0.1	0.002	3
0.7	0.09	0.1	0.01	3
0.88	0.1	0.2	0.01	4
0.78	0.15	0.2	0.03	4
0.77	0.18	0.2	0.5	4
0.74	0.025	0.2	0.011	4
0.82	0.06	0.2	0.01	4
0.84	0.07	0.2	0.015	4
0.85	0.08	0.2	0.018	4
0.98	0.028	0.2	0.019	4
0.78	0.18	0.2	0.09	4

0.7	0.09	0.2	0.01	4
0.8	0.02	0.1	0.1	5
0.85	0.023	0.1	0.17	5
0.9	0.015	0.1	0.21	5
0.85	0.022	0.1	0.11	5
0.88	0.025	0.1	0.21	5
0.78	0.018	0.1	0.15	5
0.75	0.01	0.1	0.18	5
0.89	0.028	0.1	0.19	5
0.8	0.01	0.1	0.2	5
0.77	0.02	0.1	0.1	5
0.8	0.2	0.34	0.1	6
0.79	0.21	0.34	0.18	6
0.77	0.25	0.34	0.19	6
0.74	0.1	0.34	0.011	6
0.82	0.12	0.34	0.01	6
0.84	0.17	0.34	0.15	6
0.87	0.28	0.34	0.18	6
0.98	0.24	0.34	0.19	6
0.82	0.1	0.34	0.02	6
0.7	0.29	0.34	0.01	6
0.8	0.02	0.05	0.001	7
0.79	0.0021	0.05	0.0018	7
0.79	0.025	0.05	0.0019	7
0.74	0.01	0.05	0.0011	7
0.79	0.012	0.05	0.001	7
0.84	0.017	0.05	0.015	7
0.87	0.028	0.05	0.018	7
0.98	0.024	0.05	0.019	7
0.82	0.01	0.05	0.002	7
0.7	0.029	0.05	0.001	7
0.8	0.02	0.04	0.01	8
0.79	0.0021	0.04	0.018	8
0.89	0.025	0.04	0.019	8
0.74	0.01	0.04	0.011	8
0.79	0.012	0.04	0.01	8
0.84	0.017	0.04	0.15	8
0.87	0.028	0.04	0.18	8
0.98	0.024	0.04	0.19	8
0.82	0.01	0.04	0.02	8
0.7	0.029	0.04	0.01	8

0.78	0.02	0.03	0.01	9
0.7	0.023	0.03	0.017	9
0.77	0.015	0.03	0.01	9
0.75	0.022	0.03	0.011	9
0.8	0.025	0.03	0.01	9
0.74	0.018	0.03	0.015	9
0.85	0.01	0.03	0.018	9
0.88	0.028	0.03	0.019	9
0.82	0.01	0.03	0.002	9
0.9	0.024	0.03	0.01	9
0.88	0.02	0.1	0.01	10
0.8	0.021	0.1	0.018	10
0.89	0.035	0.1	0.069	10
0.74	0.01	0.1	0.071	10
0.79	0.052	0.1	0.01	10
0.84	0.077	0.1	0.65	10
0.87	0.088	0.1	0.78	10
0.8	0.074	0.1	0.39	10
0.82	0.01	0.1	0.82	10
0.7	0.059	0.1	0.01	10
0.8	0.2	0.25	0.015	11
0.89	0.21	0.25	0.018	11
0.82	0.15	0.25	0.069	11
0.78	0.1	0.25	0.071	11
0.79	0.12	0.25	0.09	11
0.8	0.17	0.25	0.65	11
0.73	0.18	0.25	0.08	11
0.8	0.14	0.25	0.039	11
0.8	0.11	0.25	0.072	11
0.73	0.19	0.25	0.01	11
0.8	0.02	0.1	0.01	12
0.82	0.051	0.1	0.019	12
0.86	0.045	0.1	0.069	12
0.72	0.01	0.1	0.081	12
0.77	0.062	0.1	0.01	12
0.84	0.07	0.1	0.075	12
0.87	0.08	0.1	0.078	12
0.8	0.04	0.1	0.059	12
0.82	0.01	0.1	0.072	12
0.7	0.09	0.1	0.01	12
0.88	0.02	0.1	0.01	13

0.89	0.021	0.1	0.018	13
0.82	0.035	0.1	0.069	13
0.74	0.01	0.1	0.071	13
0.8	0.052	0.1	0.01	13
0.83	0.077	0.1	0.065	13
0.87	0.088	0.1	0.078	13
0.82	0.074	0.1	0.039	13
0.82	0.01	0.1	0.082	13
0.77	0.059	0.1	0.01	13
0.87	0.02	0.1	0.01	14
0.85	0.021	0.1	0.018	14
0.82	0.035	0.1	0.069	14
0.74	0.01	0.1	0.071	14
0.8	0.052	0.1	0.01	14
0.84	0.077	0.1	0.065	14
0.87	0.088	0.1	0.078	14
0.82	0.074	0.1	0.039	14
0.82	0.01	0.1	0.082	14
0.79	0.059	0.1	0.01	14
0.82	0.022	0.03	0.01	15
0.83	0.021	0.03	0.019	15
0.84	0.025	0.03	0.019	15
0.82	0.021	0.03	0.011	15
0.77	0.02	0.03	0.01	15
0.84	0.02	0.03	0.075	15
0.87	0.082	0.03	0.078	15
0.8	0.02	0.03	0.059	15
0.82	0.012	0.03	0.072	15
0.75	0.09	0.03	0.01	15
0.82	0.0022	0.01	0.009	`16
0.83	0.0021	0.01	0.0019	`16
0.84	0.0025	0.01	0.0019	`16
0.82	0.0021	0.01	0.0011	`16
0.77	0.002	0.01	0.0001	`16
0.84	0.002	0.01	0.0075	`16
0.87	0.0082	0.01	0.0078	`16
0.8	0.002	0.01	0.0059	`16
0.82	0.0012	0.01	0.0072	`16
0.75	0.009	0.01	0.001	17
0.89	0.002	0.01	0.0091	17
0.88	0.0021	0.01	0.0018	17

0.82	0.0035	0.01	0.069	17
0.74	0.0031	0.01	0.071	17
0.8	0.0052	0.01	0.01	17
0.84	0.0077	0.01	0.065	17
0.87	0.0088	0.01	0.078	17
0.84	0.0074	0.01	0.039	17
0.82	0.0071	0.01	0.082	18
0.77	0.0059	0.01	0.01	18
0.77	0.012	0.02	0.0089	18
0.82	0.0091	0.02	0.0018	18
0.83	0.0081	0.02	0.0069	18
0.84	0.01	0.02	0.0071	18
0.81	0.019	0.02	0.0071	18
0.82	0.018	0.02	0.0065	18
0.83	0.018	0.02	0.0078	18
0.82	0.014	0.02	0.0069	18
0.82	0.011	0.02	0.0082	19
0.8	0.019	0.02	0.0091	19
0.87	0.12	0.2	0.1	19
0.82	0.191	0.2	0.18	19
0.73	0.181	0.2	0.069	19
0.89	0.11	0.2	0.19	19
0.82	0.19	0.2	0.171	19
0.82	0.18	0.2	0.165	19
0.83	0.18	0.2	0.178	19
0.82	0.14	0.2	0.169	19
0.82	0.11	0.2	0.182	20
0.82	0.19	0.2	0.191	20
0.8	0.14	0.21	0.01	20
0.89	0.12	0.21	0.018	20
0.87	0.11	0.21	0.01	20
0.84	0.15	0.21	0.011	20
0.83	0.16	0.21	0.01	20
0.84	0.17	0.21	0.015	20
0.85	0.18	0.21	0.018	20
0.98	0.18	0.21	0.019	20
0.82	0.11	0.21	0.002	20
0.78	0.19	0.21	0.01	21
0.88	0.14	0.2	0.11	21
0.89	0.12	0.2	0.18	21
0.85	0.11	0.2	0.17	21

0.84	0.15	0.2	0.11	21
0.83	0.16	0.2	0.19	21
0.84	0.17	0.2	0.15	21
0.85	0.18	0.2	0.18	21
0.8	0.18	0.2	0.19	21
0.82	0.11	0.2	0.2	21
0.78	0.19	0.2	0.1	22
0.88	0.14	0.2	0.11	22
0.89	0.12	0.2	0.18	22
0.85	0.11	0.2	0.17	22
0.84	0.15	0.2	0.11	22
0.83	0.16	0.2	0.19	22
0.84	0.17	0.2	0.15	22
0.85	0.18	0.2	0.18	22
0.8	0.18	0.2	0.19	22
0.82	0.11	0.2	0.2	22
0.78	0.19	0.2	0.1	23
0.88	0.09	0.1	0.11	23
0.89	0.08	0.1	0.09	23
0.88	0.07	0.1	0.12	23
0.84	0.09	0.1	0.11	23
0.83	0.06	0.1	0.09	23
0.84	0.07	0.1	0.05	23
0.85	0.08	0.1	0.08	23
0.8	0.08	0.1	0.09	23
0.82	0.09	0.1	0.1	23
0.78	0.09	0.1	0.1	24
0.82	0.12	0.2	0.01	24
0.85	0.13	0.2	0.017	24
0.9	0.15	0.2	0.01	24
0.85	0.12	0.2	0.011	24
0.88	0.15	0.2	0.01	24
0.78	0.18	0.2	0.015	24
0.75	0.11	0.2	0.018	24
0.89	0.18	0.2	0.019	24
0.8	0.11	0.2	0.002	24
0.87	0.14	0.2	0.01	25
0.85	0.12	0.3	0.1	25
0.82	0.2	0.3	0.17	25
0.88	0.23	0.3	0.1	25
0.85	0.2	0.3	0.11	25

0.85	0.15	0.3	0.1	25
0.79	0.23	0.3	0.15	25
0.75	0.19	0.3	0.18	25
0.89	0.18	0.3	0.19	25
0.82	0.21	0.3	0.12	25
0.87	0.19	0.3	0.11	26
0.88	0.02	0.35	0.01	26
0.78	0.023	0.35	0.07	26
0.82	0.015	0.35	0.09	26
0.85	0.022	0.35	0.08	26
0.8	0.025	0.35	0.08	26
0.74	0.018	0.35	0.05	26
0.85	0.01	0.35	0.08	26
0.88	0.028	0.35	0.09	26
0.82	0.01	0.35	0.02	26
0.89	0.024	0.35	0.01	27
0.8	0.24	0.3	0.015	27
0.89	0.21	0.3	0.018	27
0.82	0.15	0.3	0.069	27
0.8	0.1	0.3	0.071	27
0.79	0.12	0.3	0.09	27
0.81	0.17	0.3	0.65	27
0.73	0.18	0.3	0.08	27
0.84	0.14	0.3	0.039	27
0.83	0.17	0.3	0.072	27
0.73	0.19	0.3	0.01	28
0.88	0.24	0.3	0.11	28
0.89	0.22	0.3	0.18	28
0.85	0.21	0.3	0.17	28
0.84	0.25	0.3	0.11	28
0.83	0.16	0.3	0.19	28
0.84	0.17	0.3	0.15	28
0.85	0.18	0.3	0.18	28
0.8	0.18	0.3	0.19	28
0.82	0.21	0.3	0.18	28
0.78	0.19	0.3	0.1	29
0.88	0.024	0.1	0.015	29
0.86	0.081	0.1	0.018	29
0.82	0.075	0.1	0.069	29
0.8	0.061	0.1	0.071	29
0.77	0.012	0.1	0.09	29

0.86	0.017	0.1	0.65	29
0.73	0.018	0.1	0.08	29
0.84	0.014	0.1	0.039	29
0.83	0.017	0.1	0.072	29
0.73	0.019	0.1	0.01	30
0.88	0.024	0.2	0.15	30
0.86	0.081	0.2	0.18	30
0.82	0.075	0.2	0.19	30
0.8	0.061	0.2	0.11	30
0.77	0.012	0.2	0.19	30
0.86	0.017	0.2	0.15	30
0.73	0.018	0.2	0.18	30
0.84	0.014	0.2	0.19	30
0.83	0.017	0.2	0.12	30
0.73	0.019	0.2	0.11	30

Appendix E
Interdependency

Table(E.1) Interdependency in the pre-construction problems

fj	j	problem
0.000001	21	F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.000001		F2
0.033	23	F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.1	24	F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.1		F2
0.033	25	F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.033		F2
0.000001	31	3
0.000001		3
0.000001		3
0.000001		3

0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001	32	3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001	34	3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.166	35	3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.033	41	4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033	42	4

0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033	43	4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.033		4
0.000001	45	4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001	51	5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.1	52	5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5

0.1		5
0.1		5
0.033	53	5
		5
		5
		5
		5
		5
		5
		5
		5
		5
0.033	54	5
		5
		5
		5
		5
		5
		5
		5
		5
		5

Table(E.2) Interdependency in the construction problems

fj	j	problem
0.11	0.000001	F2
0.1	0.000001	F2
0.12	0.000001	F2
0.1	0.000001	F2
0.1	0.000001	F2
0.15	0.000001	F2
0.18	0.000001	F2
0.19	0.000001	F2
0.12	0.000001	F2
0.1	0.000001	F2
0.11	0.033	F2
0.1	0.033	F2
0.12	0.033	F2
0.1	0.033	F2
0.1	0.033	F2

0.15	0.033	
0.18	0.033	
0.19	0.033	F2
0.12	0.033	F2
0.1	0.033	F2
0.11	0.1	F2
0.1	0.1	F2
0.12	0.1	F2
0.1	0.1	F2
0.1	0.1	F2
0.15	0.1	F2
0.18	0.1	F2
0.19	0.1	F2
0.12	0.1	F2
0.1	0.1	F2
0.11	0.033	F2
0.1	0.033	F2
0.12	0.033	F2
0.1	0.033	F2
0.1	0.033	F2
0.15	0.033	F2
0.18	0.033	F2
0.19	0.033	F2
0.12	0.033	F2
0.1	0.033	F2
0.000001	31	3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001	32	3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3

0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001	34	3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.000001		3
0.166	35	3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.166		3
0.033	41	4
		4
		4
		4
		4
		4
		4
		4
		4
		4
	42	4
0.033		4
		4
		4
		4
		4
		4

		4
		4
		4
0.033	43	4
		4
		4
		4
		4
		4
		4
		4
		4
		4
		4
0.000001	45	4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001		4
0.000001	51	5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.000001		5
0.1	52	5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5
0.1		5

0.1		5
0.1		5
0.033	53	5
		5
		5
		5
		5
		5
		5
		5
		5
		5
0.033	54	5
		5
		5
		5
		5
		5
		5
		5
		5
		5

Appendix F
Pre-Construction(one)problem

Table (F.1) Pre-Construction(one problem)

(PSO) v	e	cost	time	Ci	Si	Sij	z	Xij	problem
0	0.78	4.9E+10	820	0.02	0.03	0.01	0.7722	0.99	1
0	0.8	4.9E+10	820	0.02	0.03	0.01	0.792	0.99	2
0	0.88	4.9E+10	820	0.04	0.1	0.01	0.8712	0.99	3
0	0.88	4.9E+10	820	0.1	0.2	0.01	0.8712	0.99	4
0	0.9	4.9E+10	820	0.015	0.1	0.21	0.784297	0.871441	5
0	0.8	4.9E+10	820	0.2	0.34	0.1	0.792	0.99	6
0	0.8	4.9E+10	820	0.02	0.05	0.001	0.792	0.99	7
0	0.89	4.9E+10	820	0.025	0.04	0.019	0.8811	0.99	8
0		4.9E+10	820	0.02	0.03	0.01	0.7722	0.99	9
0		4.9E+10	820	0.035	0.1	0.069	0.8811	0.99	10
GSA									
1.61E-09	0.78	4.9E+10	820	0.02	0.03	0.01	0.7722	0.99	1
5.50E-08	0.8	4.9E+10	820	0.02	0.03	0.01	0.792	0.99	2
9.98E-09	0.88	4.9E+10	820	0.04	0.1	0.01	0.8712	0.992615	3
2.10E-07	0.88	4.9E+10	820	0.1	0.2	0.01	0.8712	0.99	4
3.86E-06	0.9	4.9E+10	820	0.015	0.1	0.21	0.891	0.990004	5
3.68E-09	0.8	4.9E+10	820	0.2	0.34	0.1	0.792	0.99	6
1.78E-08	0.8	4.9E+10	820	0.02	0.05	0.001	0.792	0.99	7
8.51E-09	0.89	4.9E+10	820	0.025	0.04	0.019	0.8811	0.99	8
0.00047	0.78	4.9E+10	820	0.02	0.03	0.01	0.7722	0.990002	9
1.28E-14	0.89	4.9E+10	820	0.035	0.1	0.069	0.8811	0.99	10

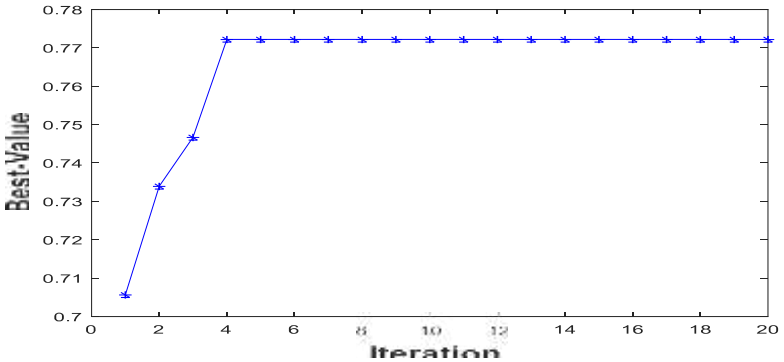

Figure (1) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 1)

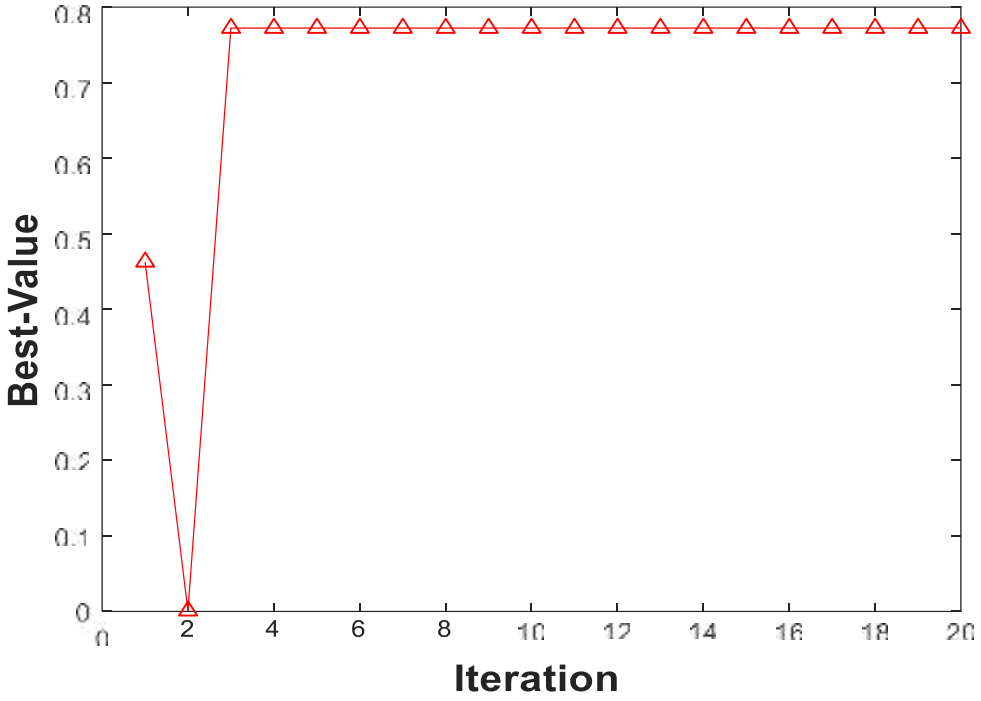

Figure (2) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 1)

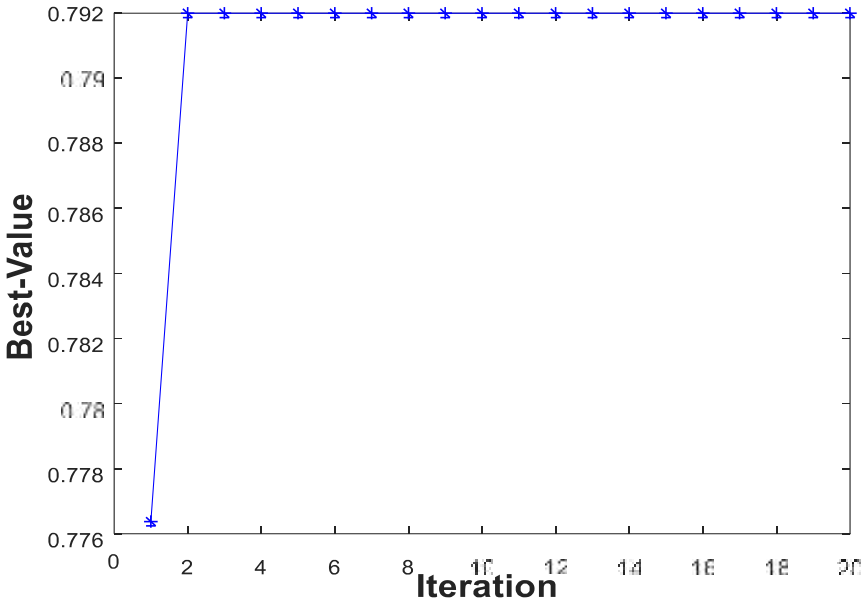

Figure (3) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 2)

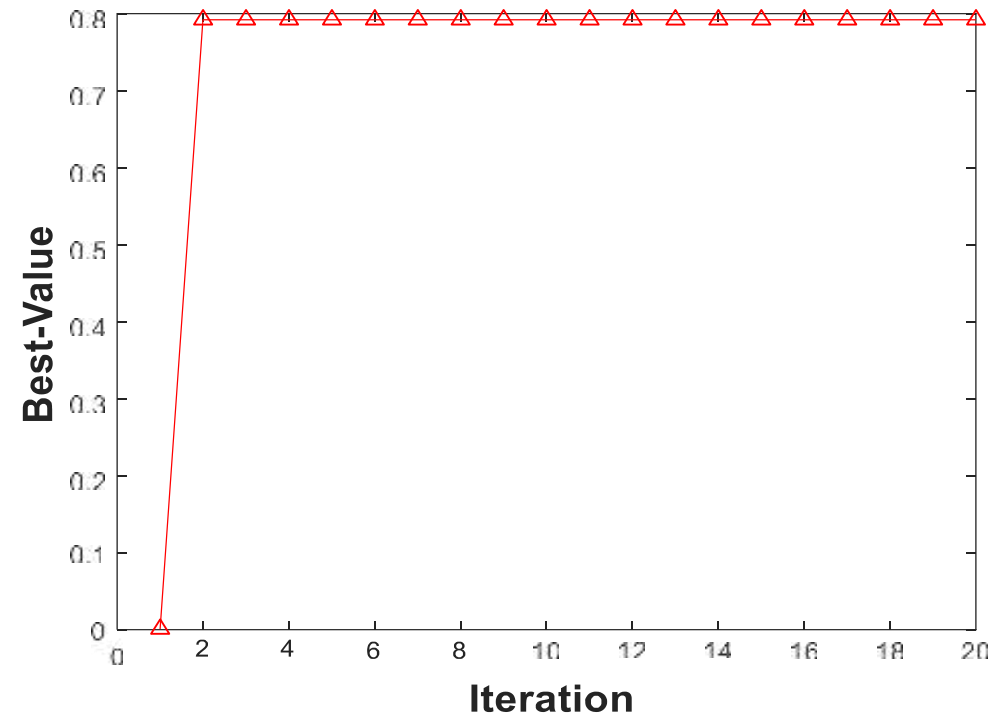

Figure (3) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 2)

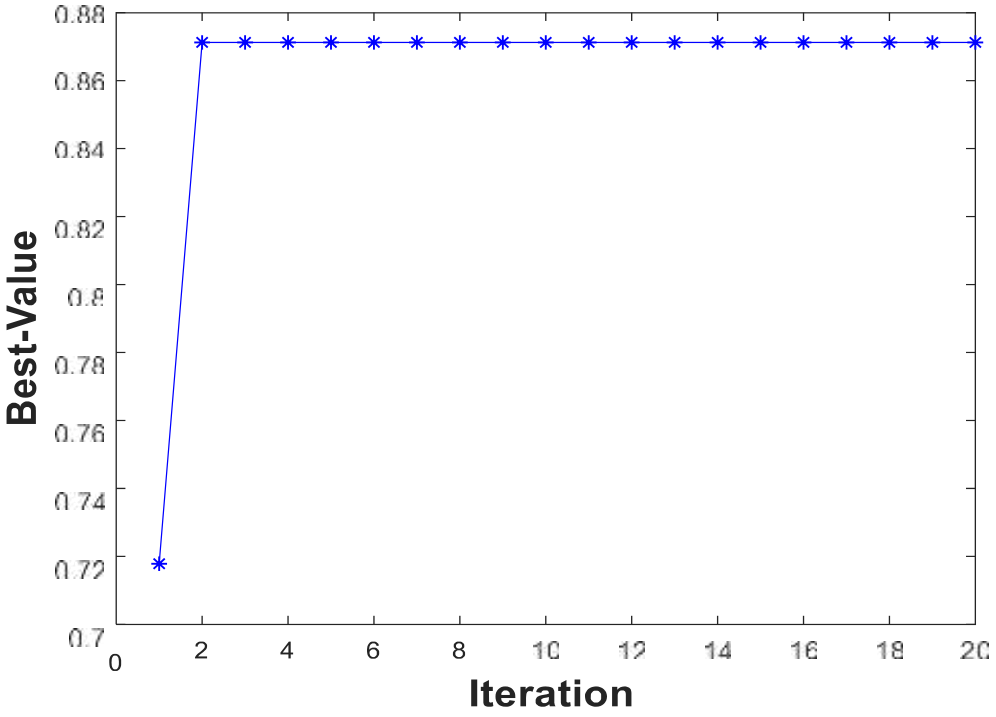

Figure (4) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 3)

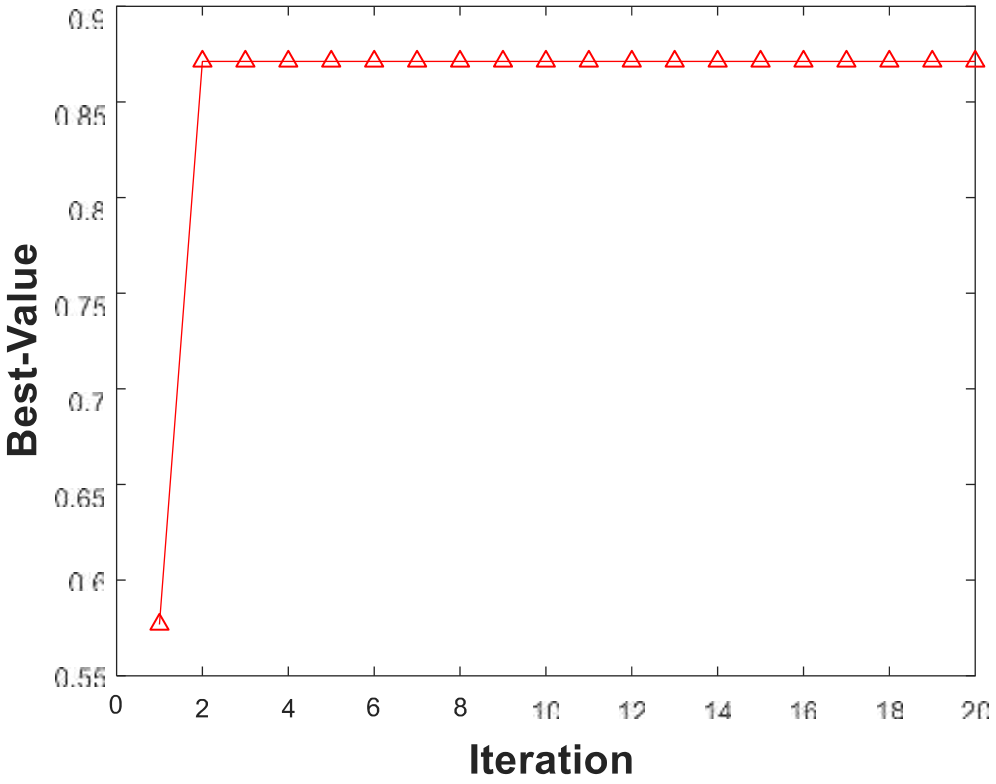

Figure (5) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 3)

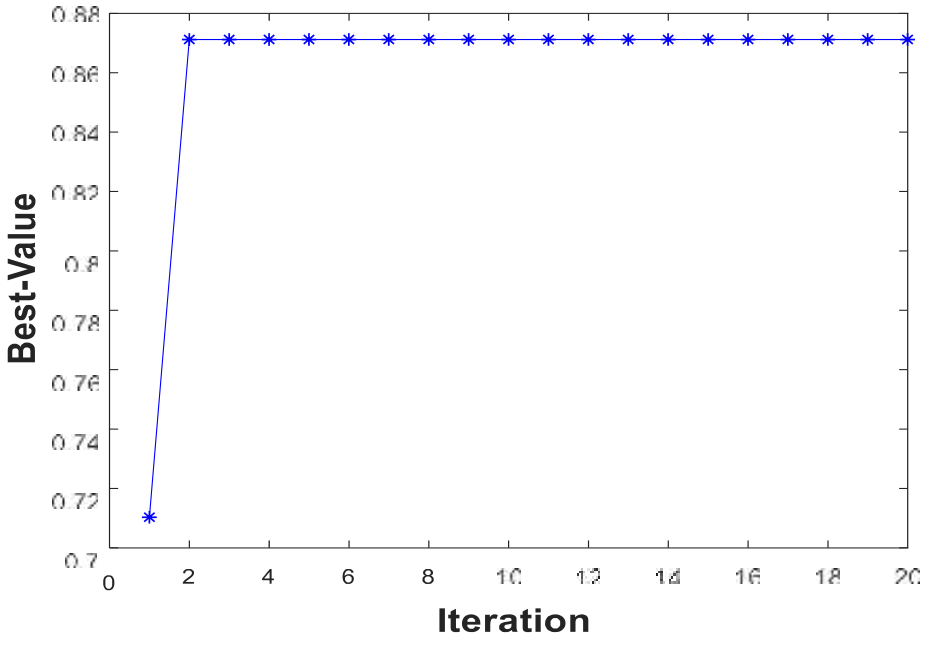

Figure (6) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 4)

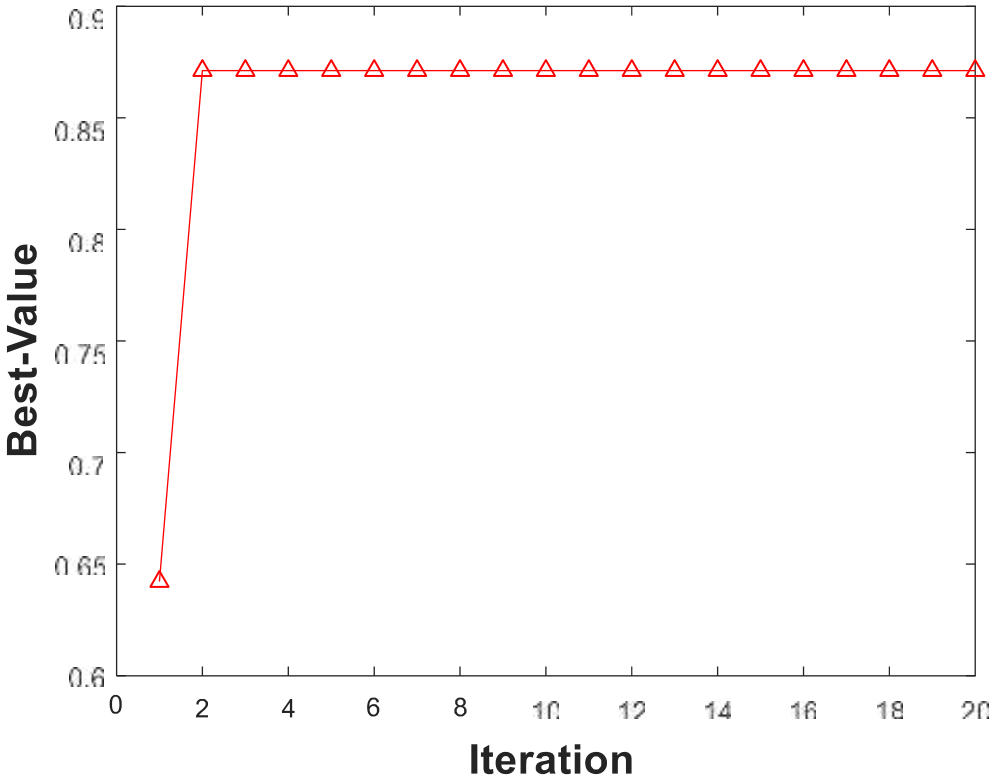

Figure (7) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 4)

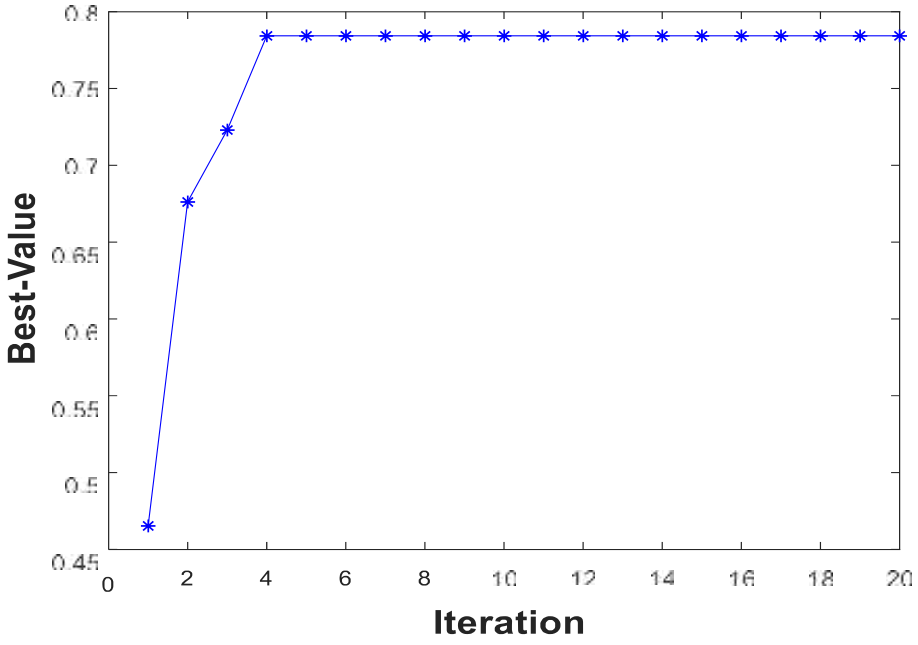

Figure (8) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 5)

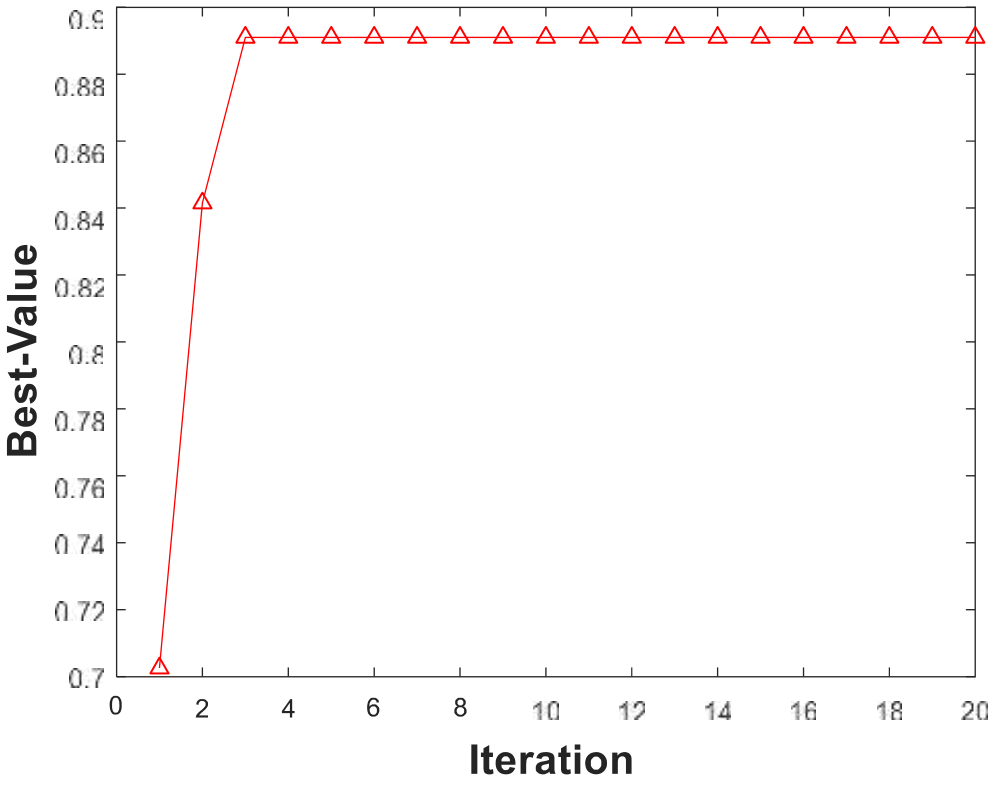

Figure (9) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 5)

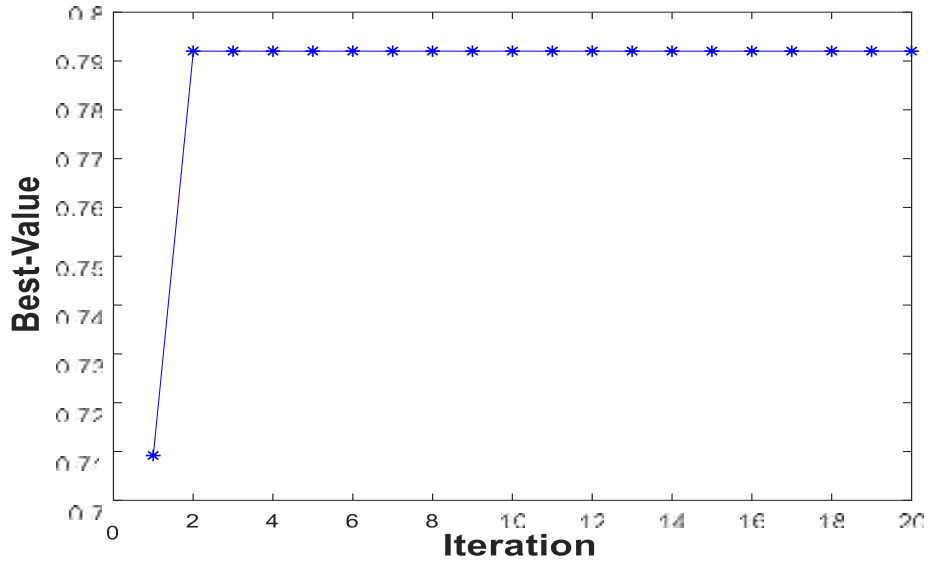

Figure (10) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 6)

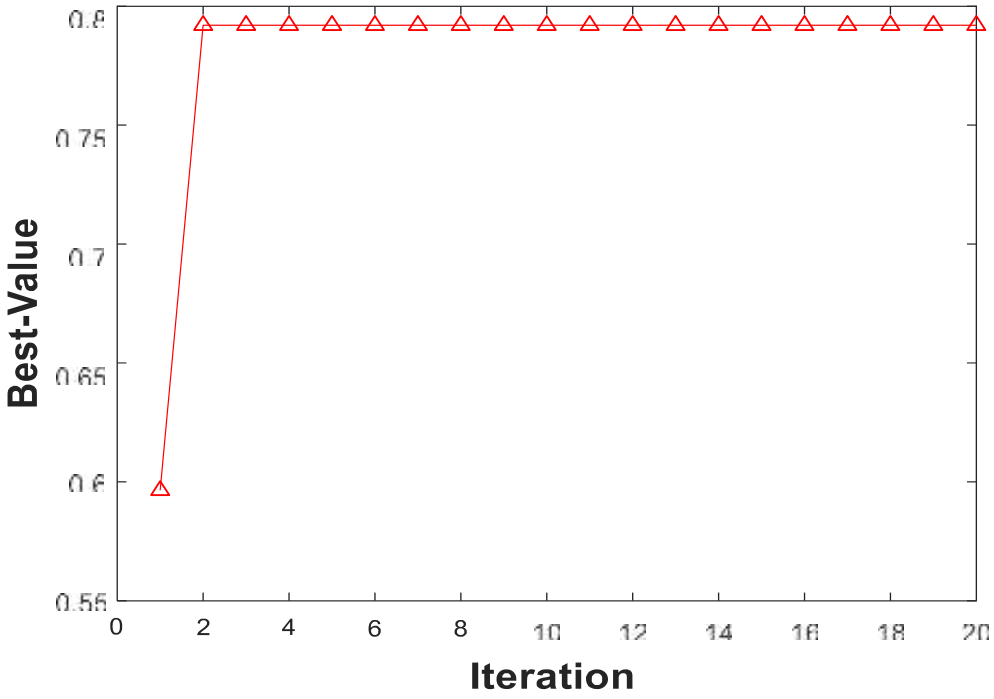

Figure (11) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 6)

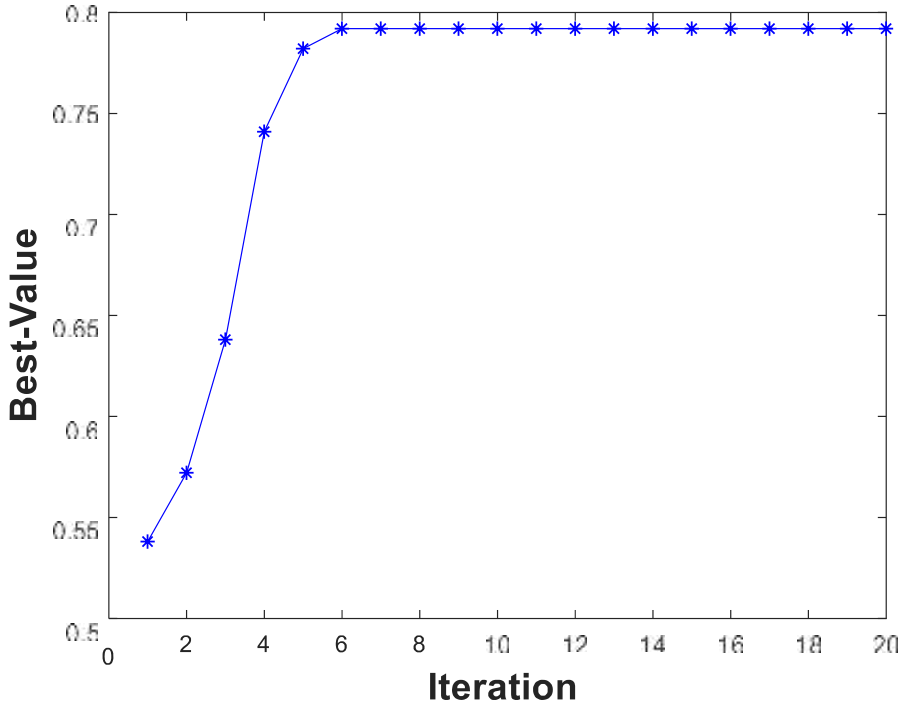

Figure (12) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 7)

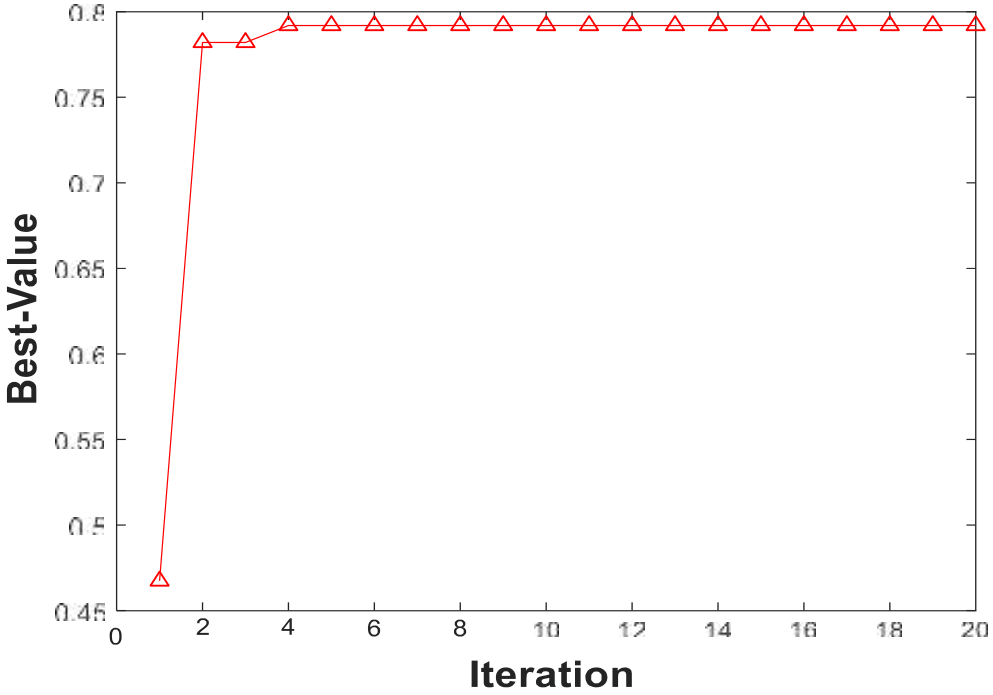

Figure (12) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 7)

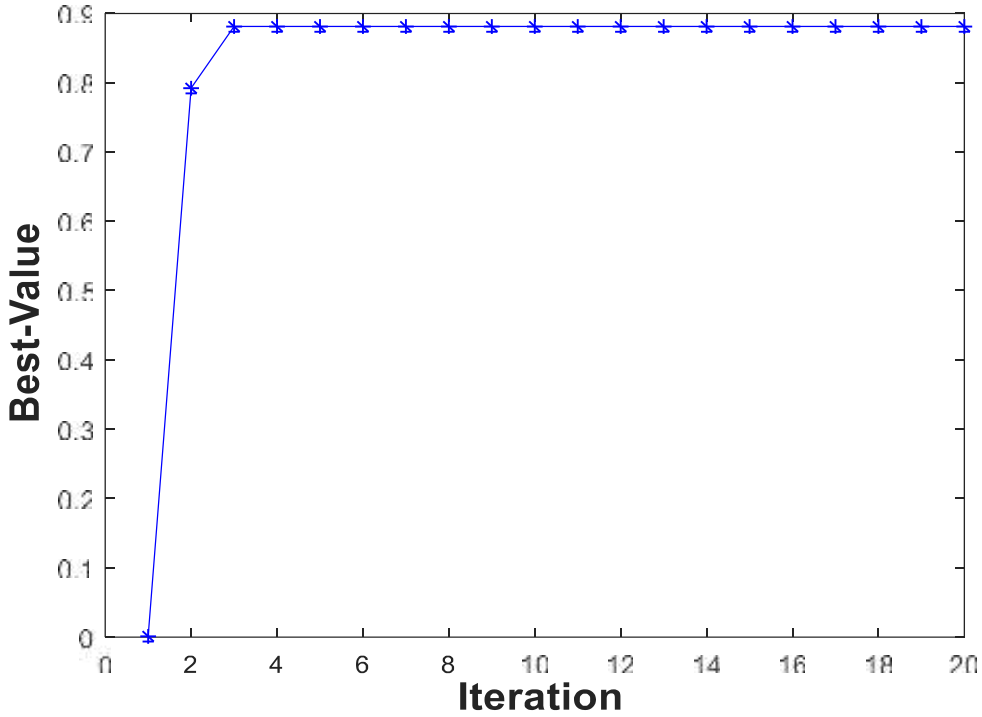

Figure (13) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 8)

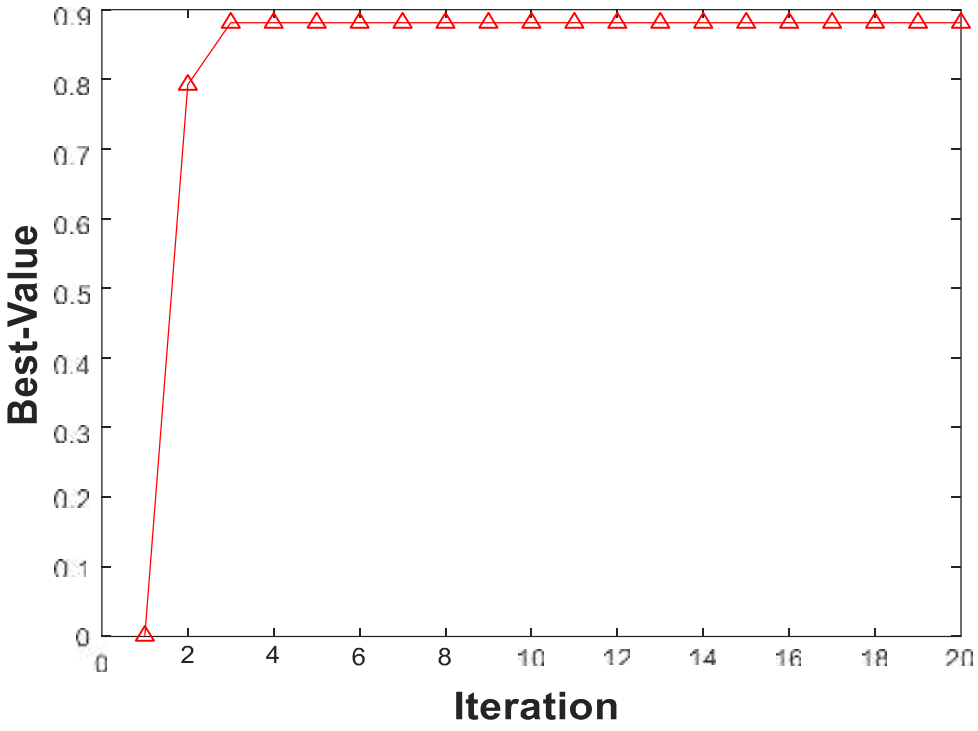

Figure (14) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 8)

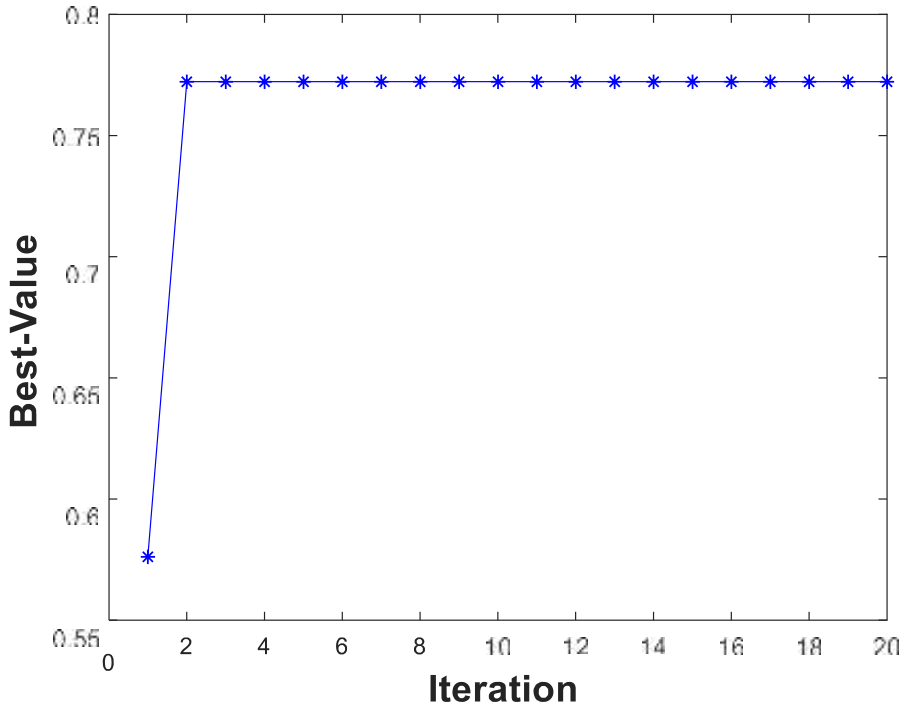

Figure (14) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 9)

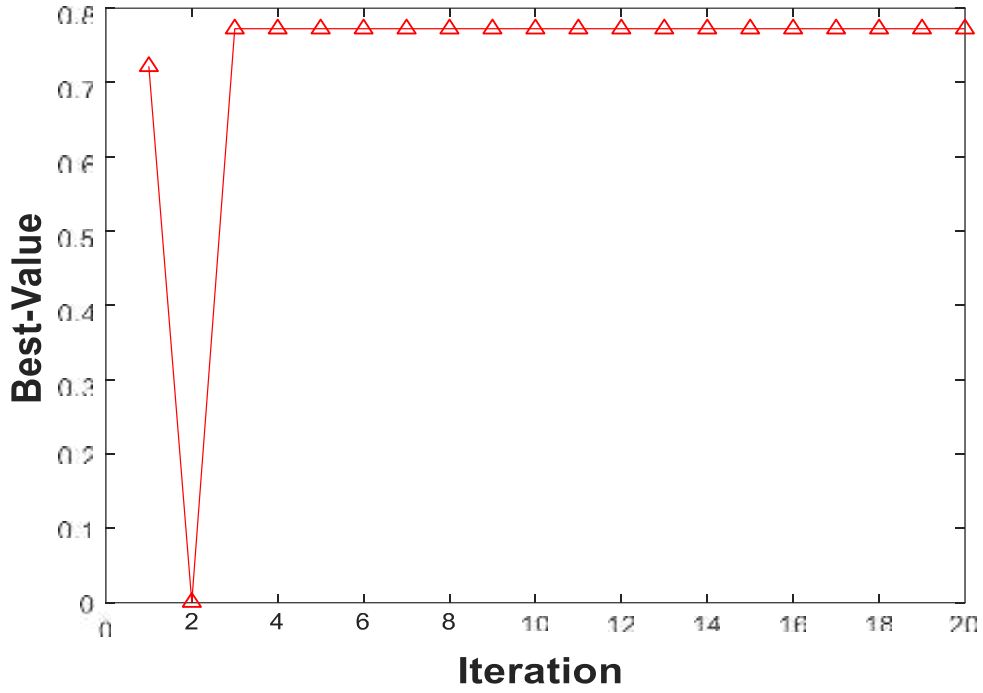

Figure (16) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 9)

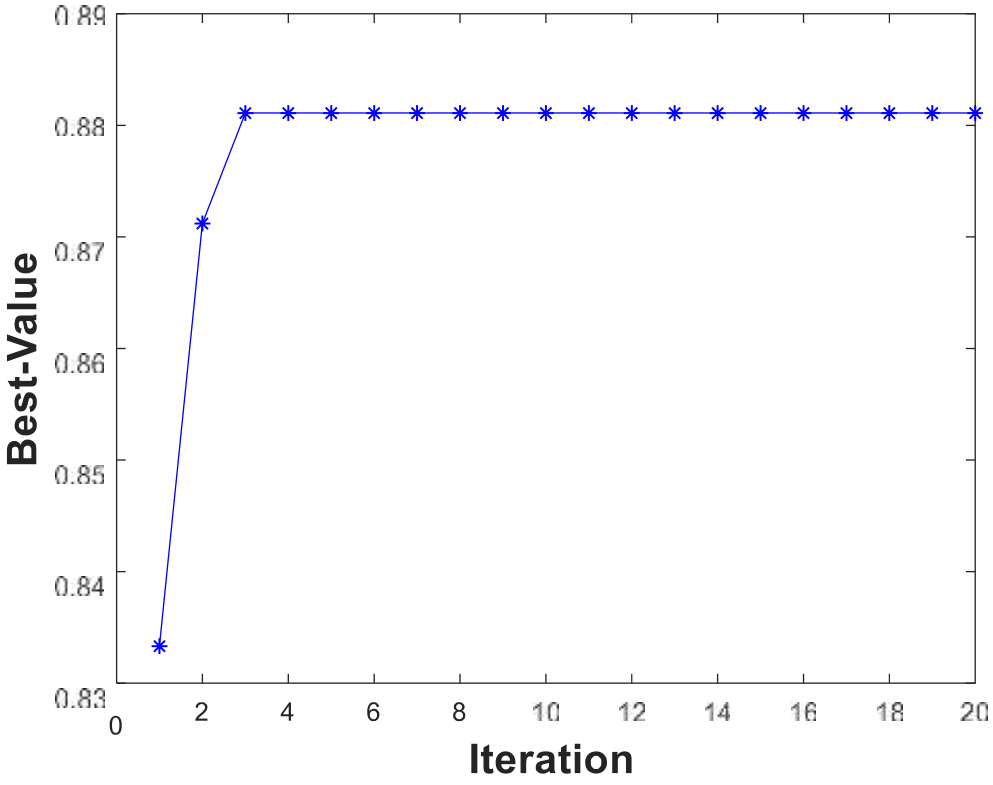

Figure (17) PSO for One Problem in the Preconstruction Phase(Project Two , Problem 10)

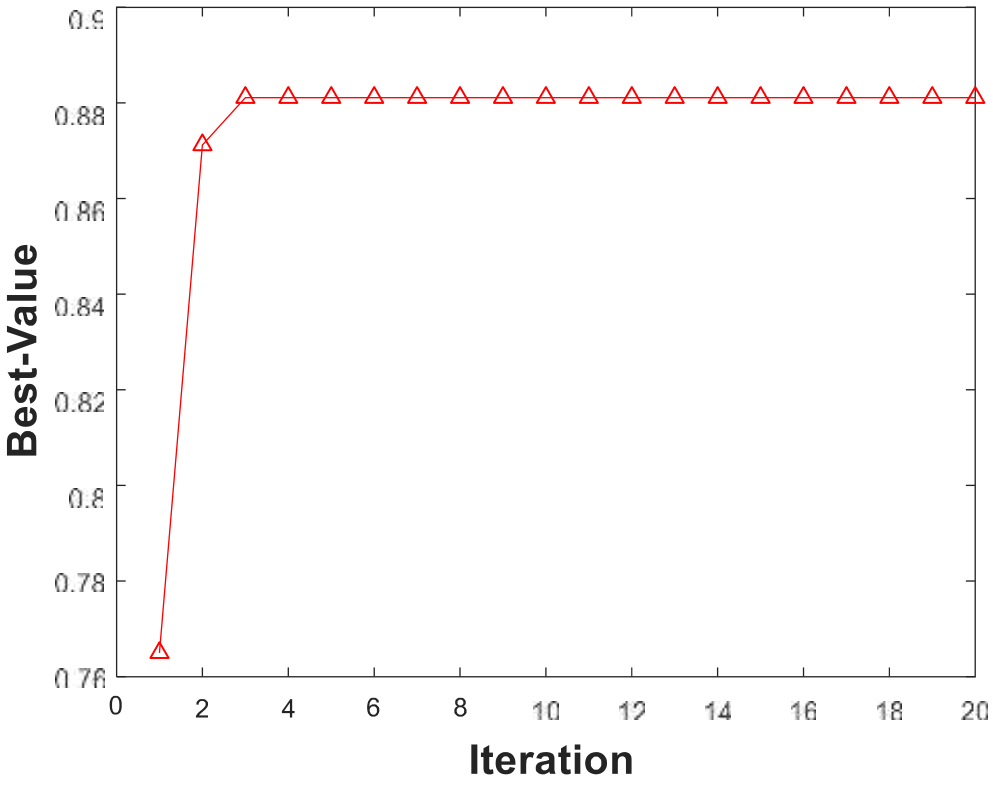

Figure (18) GSA for One Problem in the Preconstruction Phase(Project Two , Problem 10)

Appendix G
Construction
)Problem(interdependency

Table (G.1) construction problems(interdependecy)

v	wj	Di	Dj	tao	nf	lmda	tha	xij	z	problem
0		7.94E-08	5.00E-07	6.2989	0.010001	0.010001	0.173682	0.990001	0.861301	1.2
0		0.106406	0.08	0.751839	0.990001	0.010001	0.010001	0.990001	0.861301	
0		0.00015	0.015	100	0.010001	0.010001	0.206391	0.990001	0.871201	2.1
0		0.024203	0.045	1.859264	0.41776	0.220145	0.990001	0.990001	0.871201	3.1
0		0.179727	0.1	0.556401	0.010001	0.990001	0.010001	0.990001	0.861301	
GSA										GSA
9.10E-06		3.31E-07	5.00E-07	1.511247	0.853509	0.041699	0.063578	0.987687	0.831601	1.2
1.27E-08		0.000804	0.08	99.51878	-0.78167	0.518434	-0.45839	0.45985	0.861301	
2.42E-08		0.002046	0.015	7.332276	0.714472	0.013818	0.938506	0.990001	0.871201	2.1
1.45E-05		0.000165	0.0165	0.375297	0.536875	0.544276	0.738143	0.429396	0.841501	3.1
1.45E-06		0.023757	0.1	4.209225	0.859498	0.990001	0.265916	0.990001	0.861301	

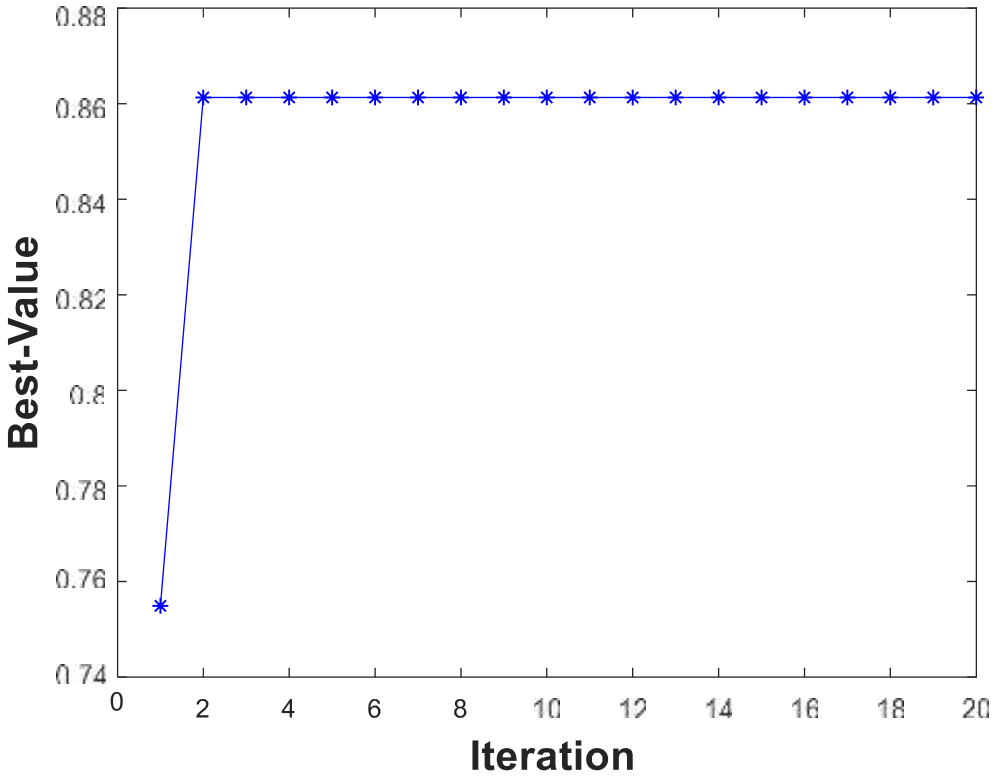

Figure (1) PSO for Interdependency in the Construction Phase(Project One , Problem 1.2)

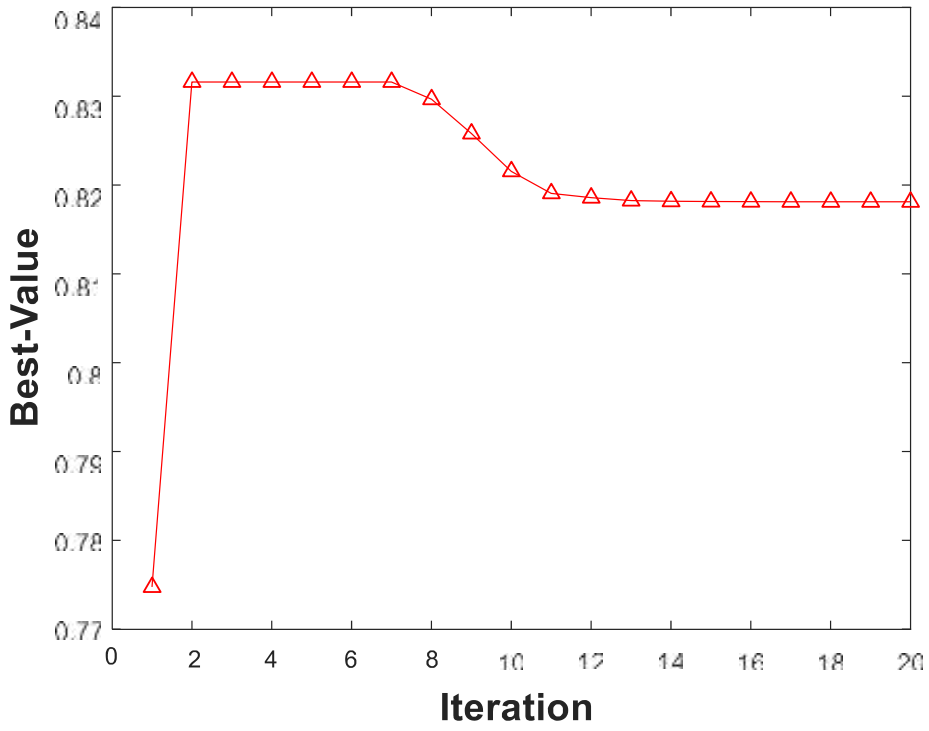

Figure (2) GSA for Interdependency in the Construction Phase(Project One , Problem 1.2)

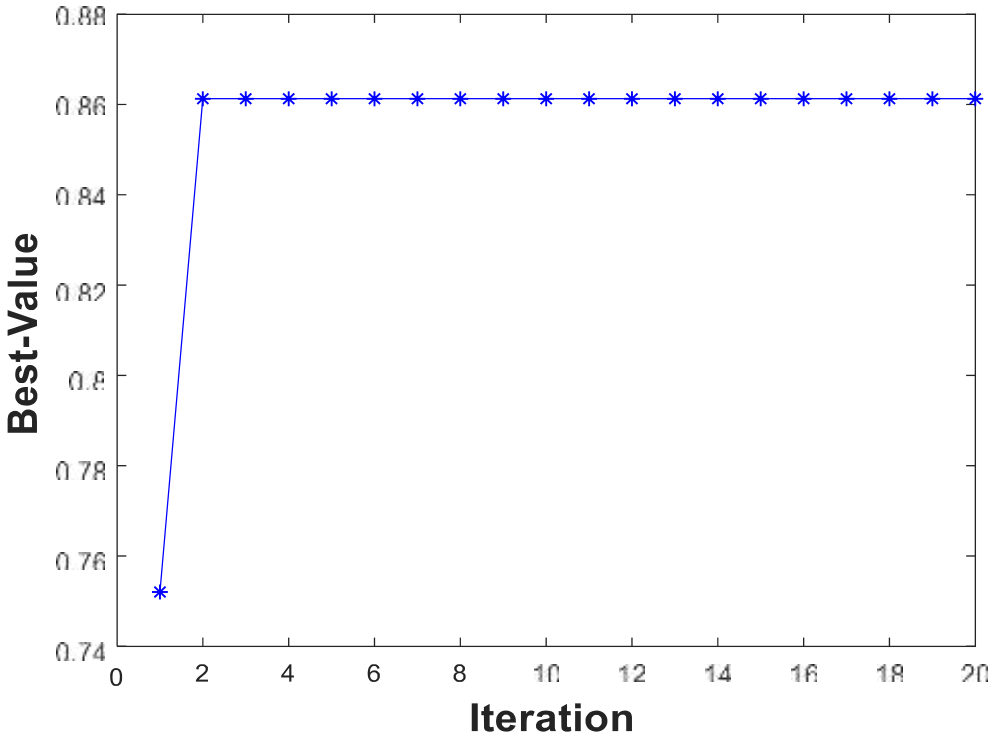

Figure (3) PSO for Interdependency in the Construction Phase(Project One , Problem 1.3)

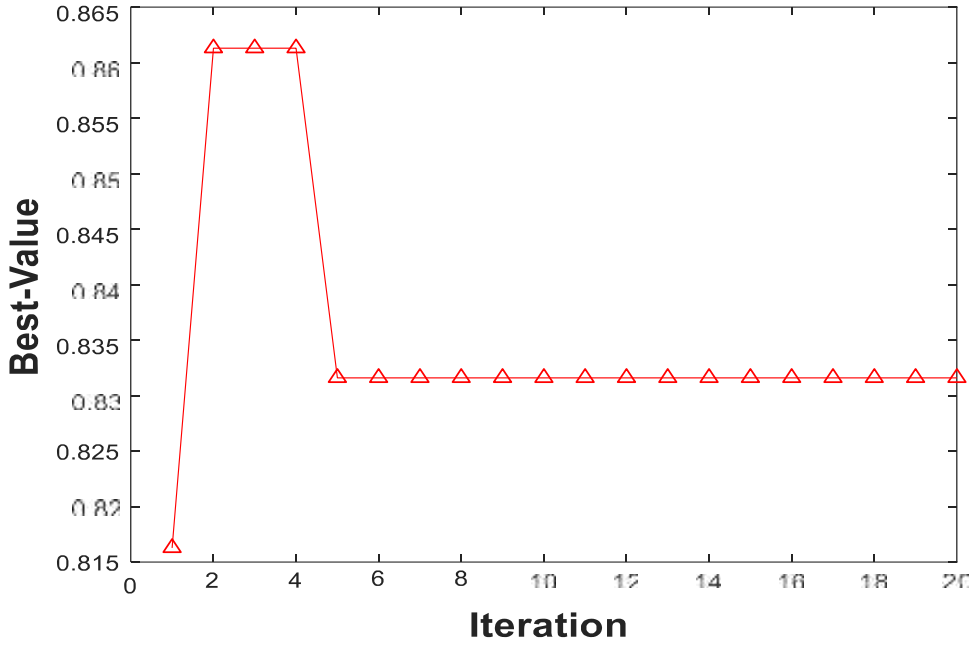

Figure (4) GSA for Interdependency in the Construction Phase(Project One , Problem 1.3)

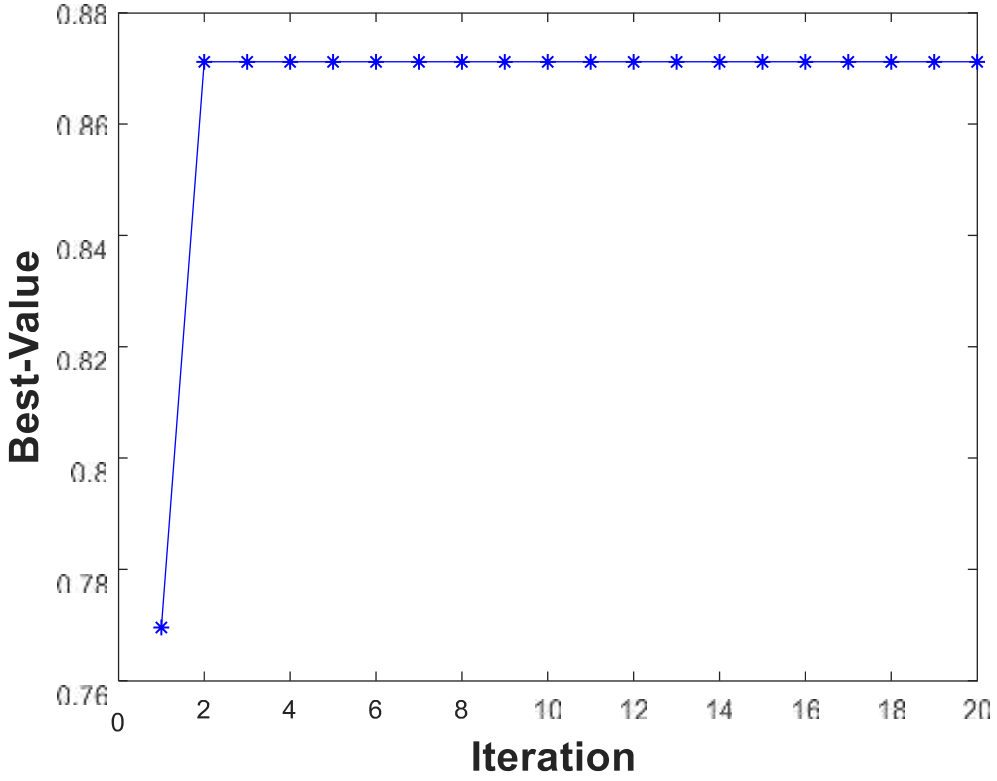

Figure (5) PSO for Interdependency in the Construction Phase(Project One , Problem 2.1)

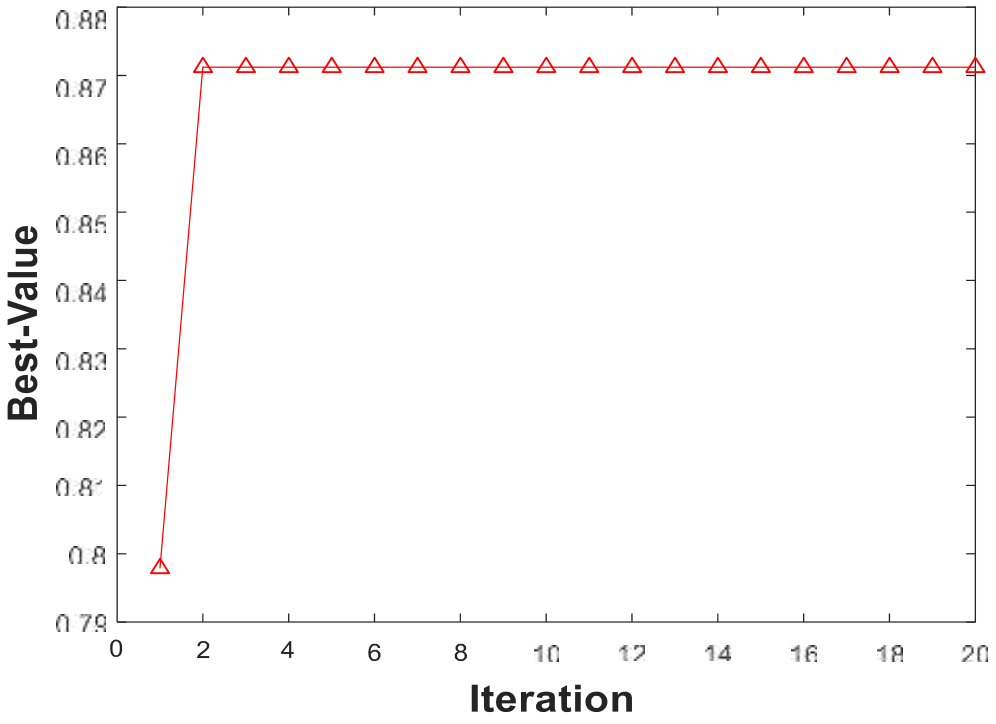

Figure (6) GSA for Interdependency in the Construction Phase(Project One , Problem 2.1)

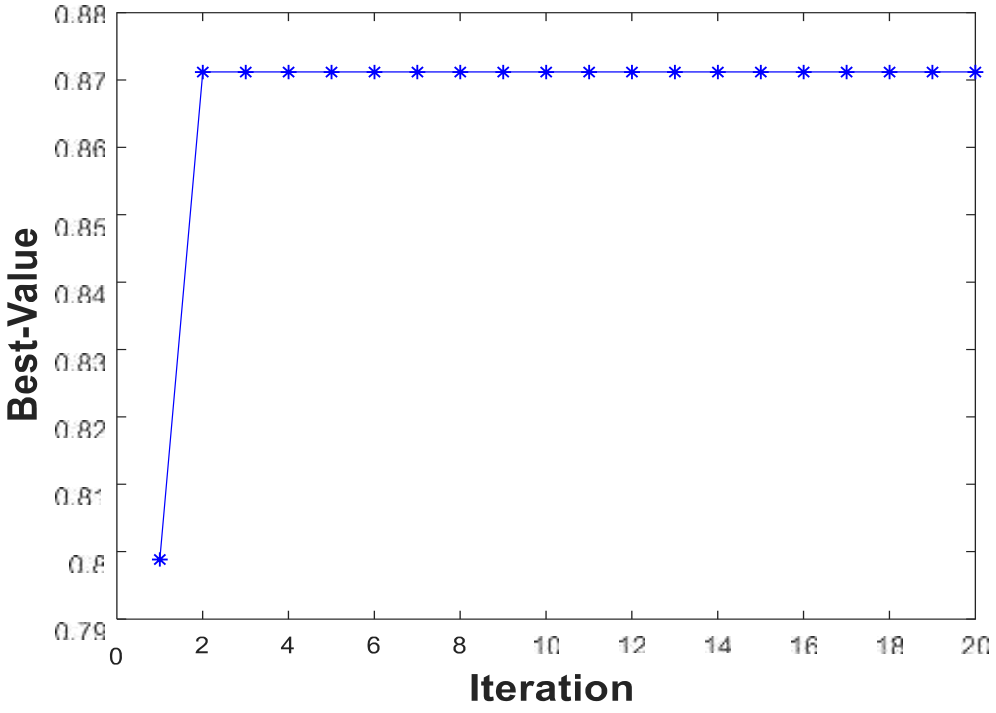

Figure (7) PSO for Interdependency in the Construction Phase(Project One , Problem 2.3)

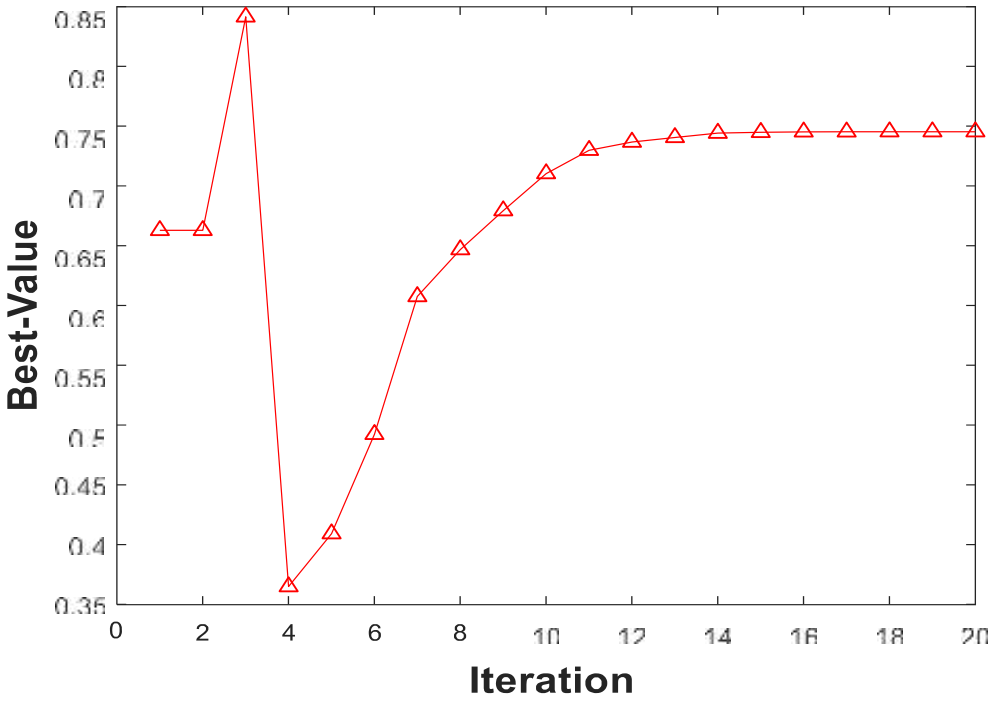

Figure (8) GSA for Interdependency in the Construction Phase(Project One , Problem 2.3)

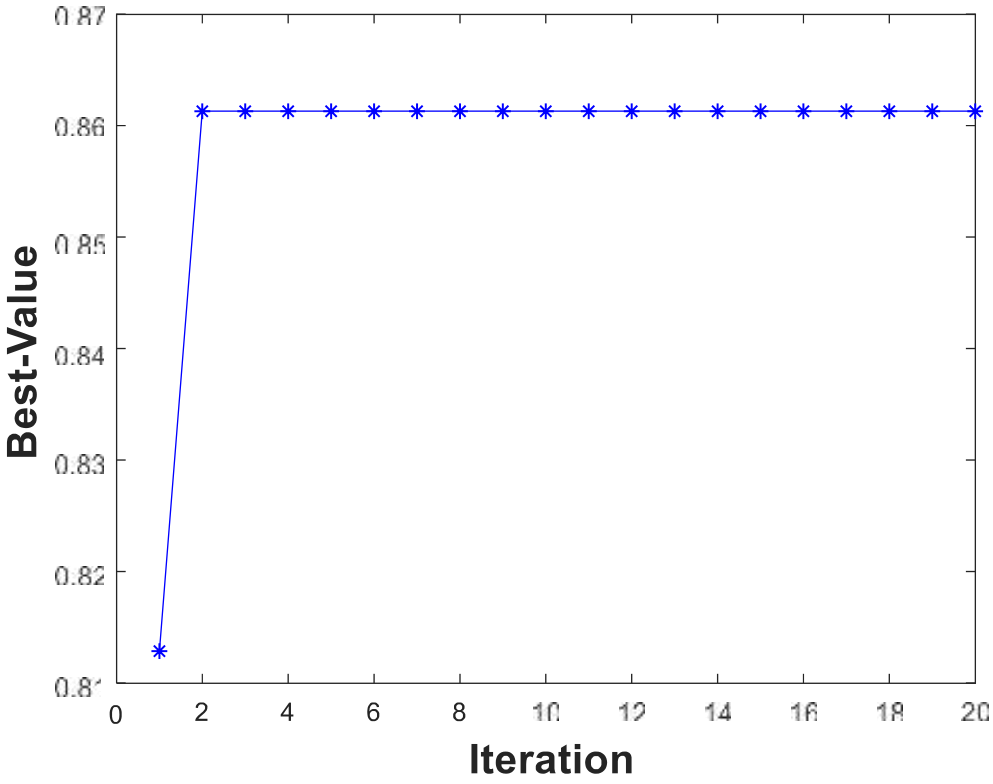

Figure (9) PSO for Interdependency in the Construction Phase(Project One , Problem 3.1)

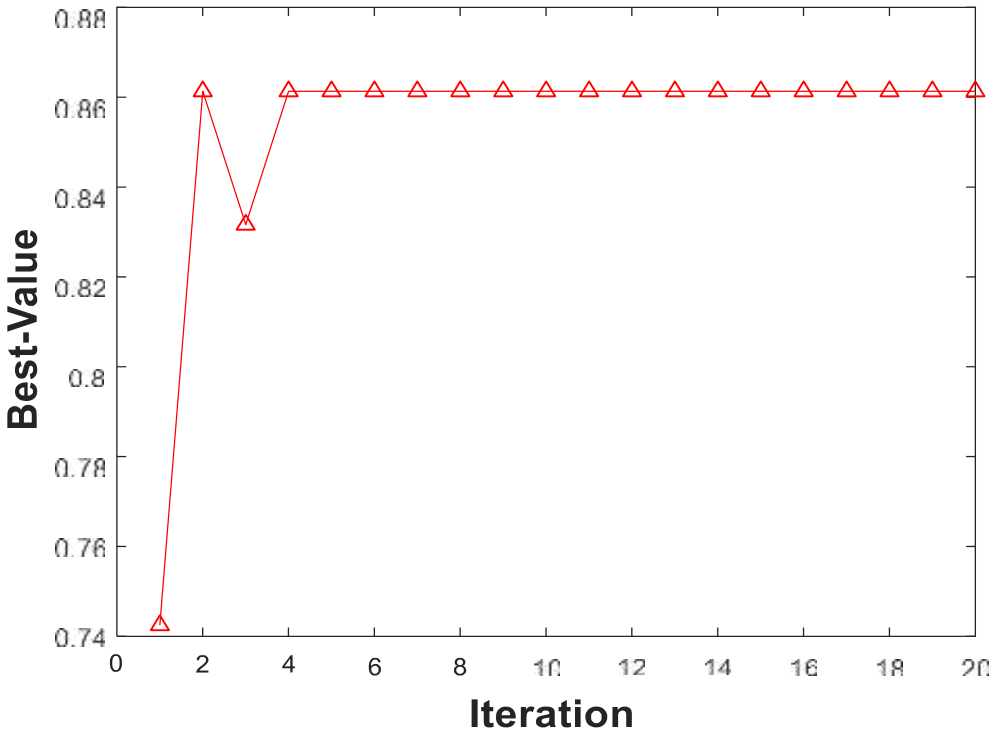

Figure (10) GSA for Interdependency in the Construction Phase(Project One , Problem 3.1)

جمهورية العراق
وزارة التعليم العالي والبحث
العلمي
جامعة ديالى
كلية العلوم

ادارة مشاكل المشاريع الانشائية باستخدام نظام خبير مع خوارزميات PSO و GSA

رسالة مقدمة الى مجلس كلية العلوم/جامعة ديالى وهي جزء من
متطلبات نيل درجة الماجستير في علوم الحاسوب

تقدمت بها الطالبة
ابتهاج حسين علي

اشراف

ا. ناجي مطر

1441هجري **العراق** **2020م**

المستخلص

نظام الخبير في عالم الذكاء الاصطناعي هو نظام في الكمبيوتر لديه القدرة على تقليد أو تكرار وظائف الذكاء للإنسان في هذا المجال في عملية صنع القرار كما تفعل المهارة البشرية الخبيرة. يمكن حل مشاكل المستوى المتطور حيث يستخدم النظام معلومات حول نطاق خبرتهم. وبالتالي سيتم تصميم نظام الخبراء اعتمادا على هذه المعلومات. من أجل أن يصبح النظام مكافئًا للتفكير الإنساني ، فإنه يستخدم بيانات واضحة في هذا المجال

يهدف البحث إلى بناء نظام خبير يعتبر فعالًا في إدارة مشكلات مشاريع البناء من حيث الوقت والتكلفة من خلال بناء نظام خبير لإدارة هذه المشكلات باستخدام التقنيات: تحسين سرب الجسيمات وخوارزمية البحث عن الجاذبية.

لتحقيق الهدف من البحث ، تتضمن دراسة نظرية مراجعة الدراسات السابقة والدراسات الميدانية التي تتضمن استبيانًا مفتوحًا ومغلقًا ، وأخيراً ، تم بناء نظام الخبراء.

أظهرت النتائج أن مرحلة البناء تعتبر مهمة للغاية ولها تأثير حوالي 25 ٪ على التكلفة و 20 ٪ في الوقت المحدد والترابط بين المشكلة متساوية تماما في مشاكل البناء بدلا من مشاكل ما قبل البناء.

يعتمد تصميم نظام الخبراء على تكوين المعرفة والحاجة إلى مشاريع البناء. تم تصميم هذا النظام لتوفير قاعدة بيانات للمشاكل السابقة التي حدثت في المشاريع. تُظهر خوارزمية PSO أداة فعالة في العثور على أفضل حل من حيث السرعة وطريقة البحث بينما GSA هي أيضًا أداة فعالة في إيجاد أفضل حل للمراهنة التي تتطلب المزيد من الوقت.

كل سرعة PSO تساوي صفرًا بينما يكون GSA دائمًا أكثر من الصفر مما يشير إلى أن PSO سريع وأيضًا في طريقة البحث كما هو موضح في المشكلة 8 و 9 تأخذ GSA طريقة مختلفة في إيجاد الحل.

التوصيات هي إجراء دورات تعليمية وتدريبية لتنفيذ نظام خبير في مشاريع البناء واستخدام نظام الخبراء في مشاكل مختلفة وفي مرحلة مختلفة ، وأخيرا اعتمادا على هذا النظام ، ابحث عن حلول للمشاكل المستقبلية.

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