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Assessment of Overhead Cost for Building Construction Projects

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بسم الله الرحمن الرحيم

وَقُلِ اعْمَلُواْ فَسَيَرَى اللّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ. وَسَتُرَدُّونَ. إِلَى عَالِمِ الْغَيْبِ وَالشَّهَادَةِ فَيُنَبِّئُكُم بِمَا كُنتُمْ تَعْمَلُونَ.

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ABSTRACT

Since the beginning of the 21st century, many specialty contractors became more and more involved in the construction industry. In such altered environment, a general contractor/construction firm overhead cost increases comparable to direct costs. Construction firms overhead cost can be approached through dividing construction costs into two classifications which are direct and indirect (overheads) costs. Direct costs are considered to be the costs for labor, materials, production equipment, and supplies that must be incorporated into a distinct feature in order to complete the work. Indirect (overhead) costs include other items that are not made a part of the completed work such as contractor's overheads, profit, and contingencies during the construction period. Overhead costs generally are divided into two categories: general overhead costs and site overhead costs.

In the absence of systematic information based technique, which could quantify overhead costs for any given construction project, in both the first and the second categories of construction companies, in Egypt. The construction firms could not take the necessary measures for achieving the optimal overhead cost percentage for any construction project.

Resulting in a firm having a small project overhead cost percentage and thus, leading to incorrectly having the lowest total bid cost. This leads to a decrease in the profitability of the company performing the project, or even unsuccessful completion of that project.

The main objective of this research is to establish a Neural Network program that will able any construction firm to assess its site overhead cost for any building project. This may improve the construction industry performance and the ability to overcome the national and international market difficulties. Through improving the bids accuracy and also leading to:

- Decrease the time, effort and money spent during overhead cost prediction;
- Some up all the governing overhead cost parameters in one well defined technique;
- Increase the probability of adequate assessment of overhead cost percentage; and

- Enhance the ability of competing with the international construction firms.

The (N-Connection 2.0 Software) was chosen to generate the Model for predicting the percentage of buildings projects site overhead costs from the total projects cost, by the identification/anticipation of all overhead cost items for building projects in Egypt, in the first and the second categories of construction companies, and leading to an adequate and exact estimate of the overhead cost percentage from the total project cost (Tender Price). This research will be performed in the following sequence:

1. Review of all previous studies both locally and internationally;
2. Leading to the identification of the all factors that contribute to the overhead costs in building projects in the international construction market;
3. Generating a questionnaire to verify or eliminate any of the factors previously gathered to perform the necessary alteration in order of reaching a list of factors that can be adaptable in the Egyptian construction market;
4. Calculating the needed amount of real-life projects data that are needed by the Model to solve this problem with the help of the (Neural Connection 2.0 Professional, User's Manual);
5. Generating a questionnaire to collect the needed real-life projects data for building projects from the selected categories in Egypt, with the guidance of a list prepared from the Egyptian Union of Building and Construction Companies, that ended with collecting 52 (fifty two) building projects constructed in Egypt during the seven year period from 2002-2009; and
6. We used 47 building projects during the designing, training, and validating of the ANN-Based Model, while the remaining 5 building projects were reserved for testing process at the end, to act as a conformation process step for the ANN-Based Model for the assessment of the percentage of site overhead cost for building project in both the first and the second category construction companies in Egypt.

The research describes the development and testing of the model using the artificial neural network (ANN) technique. N-Connection 2.0 Professional (1997), Neural Network Simulator, which uses the back propagation learning algorithm, was used for developing and training the model. The best model was obtained through the traditional trail and error process. However, over 58 network structures were experimented and the satisfactory model was obtained. This model consists of an input layer with ten input neurons, and one hidden layer with thirteen neurons and one output neuron. Data on 52 real-life building construction projects from Egypt were used in the training and validation processes. The model was tested on another 5 new building projects previously stepped aside for this reason. To verify the generalization ability of the best model, testing with 5 projects (facts) that were still unseen by the network was performed. The results of the testing for the model wrongly predicted the percentage only once (20%) from the test sample. This demonstrates the viability of neural network as a powerful tool for modeling the percentage of site overhead cost of building projects in Egypt. The model is a simple and very easy-to-use tool that can help contractors/firms during the consideration of the influential overhead cost variables and to improve the consistency of the percentage of site overhead costs decision-making process.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

In this modern world, daily life is maintained and enhanced by an impressive array of construction, awesome in its diversity of form and function. As long as there are people on earth, structures will be erected to serve them **(13)**.

Since the beginning of the 21st century, many specialty contractors became more and more involved in the construction industry. In such altered environment, a general contractor or construction firm site overhead cost continuously increases. Construction firms overhead cost can be approached through dividing construction costs into two classifications which are direct and indirect costs.

Direct costs are considered to be the costs for labor, materials, production equipment, and supplies that must be incorporated into a distinct future in order to complete the work. Indirect costs include other items that are not made a part of the completed work such as contractor's overheads, contingencies, escalation, risk, and interest during the construction period. Overhead costs generally are divided into two categories: general overhead costs and job overhead costs **(45)**.

General overhead (office overhead) costs are those costs that cannot be identified readily with a specific project. General overhead costs are items that represent the cost of doing business and often are considered as fixed expenses that must be paid by the constructor (firm). General overhead expenses include the general business expenses that are included by the home-office in support of the company's construction program (main-office or home-office expenses). They are intended to include all those expenses (items) incurred by the home-office that cannot be tied directly to a given project such as **(13)**:

- Office Secretary;
- Office Engineers; and
- Office running cost (office rental, clerical, utilities…etc.).

Therefore, these cost items are distributed over all the company projects by some basis.

Site overhead costs (project overhead costs) are similar to general overhead but it must be distributed over the associated project, since it cannot be allocated to specific work item. Site overhead costs include expenses that cannot be charged directly to a particular branch of work, but are essential to construct the project, such as **(40)**:

- Site staff;
- Cleaning site and clearing rubbish;
- Mechanical plant not previously included in the item rates;
- Site accommodation;
- Temporary services;
- Welfare, first-aid and safety provisions;
- Final clearance and handover;
- Defects liability;
- Transport of operatives to site; and
- Abnormal over time.

These above mentioned factors if not accounted for in the total bid price then the competitiveness, success, profitability of the construction firm will be affected greatly.

However, the construction industry has not changed the method of controlling overhead costs in construction companies. Traditionally, a construction company uses resource-based costing and volume-based allocation. Resources-based costing is the method in which costs are allocated to costs objects in accordance with the volume of direct labor hours, direct labor costs or contract amount **(40)**.

The Egyptian construction market is in need of a financial engineered estimating methodology (Model) that can assess projects site overhead cost prior to the submission of the bid documents. In order to achieve such a model it is imperative that different techniques be evaluated. This model will consider all the impacts of site overhead costs on both the general contractor/firm and client, through examining all the previous research and studies performed. And focusing on the fact that accurate cost categorization, cost reporting, and profit calculation are the heart of the construction business.

1.2 Problem Statement

Since the beginning of the development era in the mid 70's, Egypt had become heaven for the construction industry. This high demand for construction work attracted many investors to the construction industry sector, from all around the world as "Construction Firms". These construction firms hailing from different regions are by in large alien to the requirements of the Egyptian construction industry.

When a construction company decide to bid which implies that the direct and indirect costs that the project will consume have to be estimated. Numerous factors are involved in this highly unstructured process. Thus, the need for automated systems (Models) to assist construction firms during this complicated project phase is required.

Site overhead cost constitutes a major cost element for any construction project. Identifying the expected site overhead cost is an important issue that can materially help construction contractors to arrive at a reliable assessment for the expected tender price of their projects. Many different factors make the detailed calculation of site overhead cost a more difficult and tedious task. For example, some items of site overhead cost are directly related to the project time. Such cost items greatly increases with any extension in the project's time. Another site overhead cost elements are more difficult to be accurately estimated, although they can be nominated and identified in advance. In addition, many small items of site overhead cost are very difficult to be identified or estimated. However, site overhead costs are greatly affected by many factors. Among these factors come project type, size, location, client nature, and the project site conditions. All of these factors make the detailed estimation of such overhead costs a more difficult task. Hence it is expected that a lump-sum assessment for such cost items will be a more convenience, easy, highly accurate, and quick approach. Such approach should take into consideration the different factors that affect site overhead cost. It is expected that an ANN-based Model would be a suitable tool for building projects site overhead costs assessment.

1.3 Research Objectives

The main objective of this research is to identify and investigate the main factors that affect site overhead cost in the Egyptian building construction market, and develop an ANN-based model that will help the construction firms in assessing/predicting their projects site overhead cost. Such a model should account for the most important factors which are dependent on time. This would improve the existing construction industry performance and ability to overcome the national market competitiveness and enhance the company's international reputation. Through improving the bids accuracy and also leading to:

- Decrease the time, effort and money spent during the overhead cost prediction phase;
- Improving the ability to provide a reliable prediction of the overhead cost percentage;
- Summing up all the governing overhead cost parameters in one well defined technique;
- Reducing the probability that unanticipated overhead costs that causes difficulties during the completion of the project in-hand, thus gaining the client's confidence and enhancing the company's reputation;
- Enhancing the ability of competing with the international construction firms; and
- Enhancing the way that international parties view the Egyptian construction industry.

1.4 Study Methodology

The overhead cost estimating model for buildings construction projects is a prediction technique for any building project, in order to assess its site overhead cost as a percentage from the total projects contract value. The model will be developed for the identification or anticipation of all site overhead cost factors for building projects in Egypt for the first and the second categories of construction companies. Hence, predicting the potential consequences of those items leading to an adequate and exact estimate of the expected overhead cost as a percentage from the total project contract value.

This research study will be performed in the following sequence: **F**igure (1-1)

1. Review of all previous studies performed;
2. Identifying the list of overhead cost factors for building projects from the previous studies;
3. Comparison will be made between that generated list and the factors that contribute to site overhead costs in Egypt from the expert's opinions (with the aid of a factors identification and verification questionnaire);
4. The collection of real-life building projects from the previously selected construction companies categories in Egypt;
5. Impact analysis to understand the effect that each site overhead factor has on the percentage of site overhead costs for building projects and also to understand wither a weighting of the factors is needed or not before the program is designed;
6. Designing of an ANN-based Model to predict the overhead costs percentage for building construction projects in Egypt;
7. A sample of building projects from Egypt will be selected to act as demonstrative examples to investigate the validity of the developed ANN model; and
8. Research conclusions and recommendations will be derived from this study to help for future research and studies works.

1.5 Thesis Organization

The thesis is organized in five different chapters, three appendixes and a list of references. Chapter one is the introduction where the problem statement and the work methodology are defined. Chapter two is where all the previous researches and studies are presented. Chapter three is where the collected real life projects data are presented and analyzed. Chapter four is where the ANN model is designed and tested. Chapter five is the summary and the conclusions are derived from the thesis. Appendix (**A**) is a questionnaire for determination and verification of Egyptian building construction projects site overhead costs factors. Appendix (**B**) is the real life projects collection sheet. Appendix (**C**) is a table of the real life collected projects data.

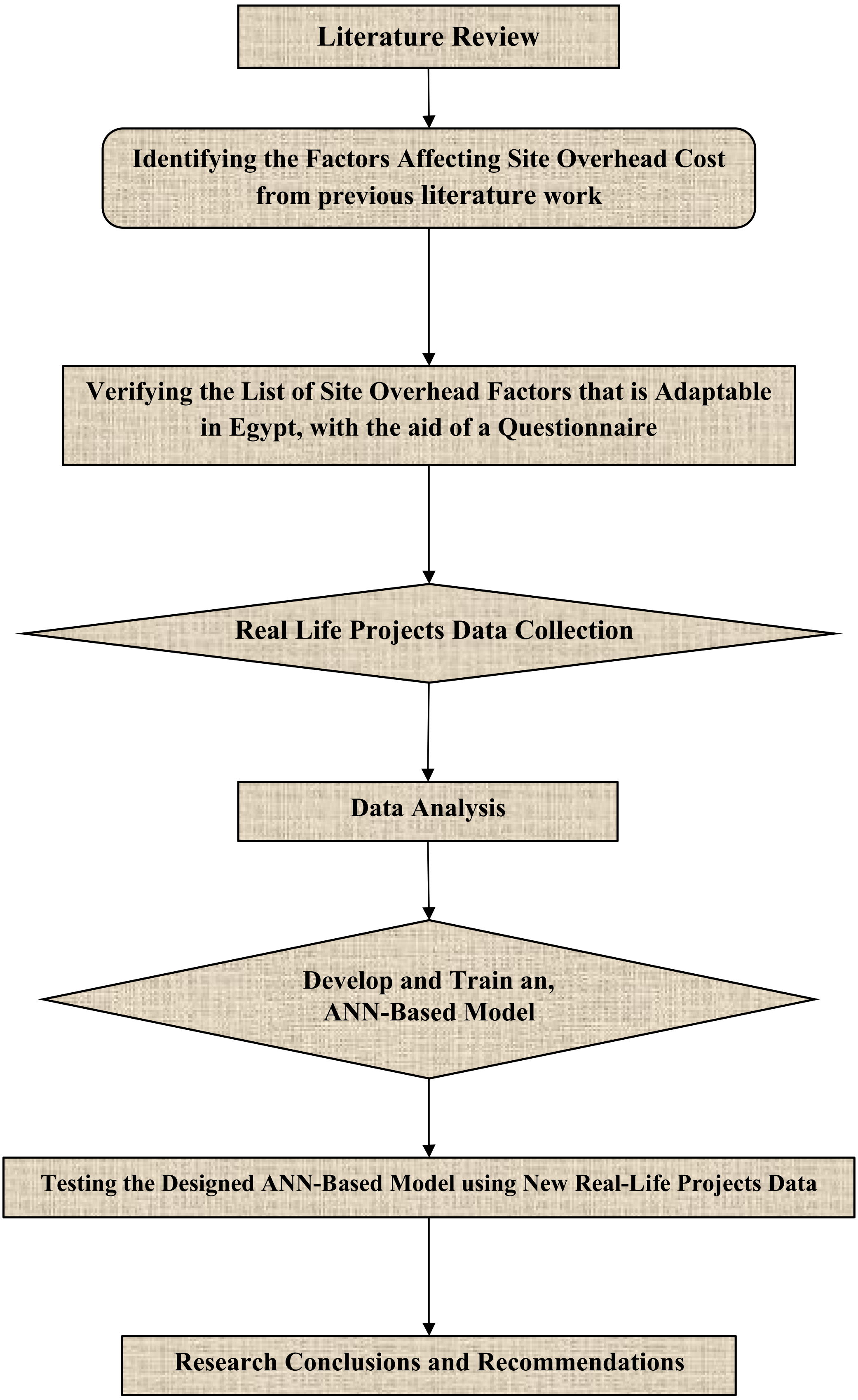


Figure (1-1) Illustration of the study methodology

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The extensive literature study is one of the most important phases in the methodology of this research. The primary aim of this detailed literature research is to acquire the comprehensive knowledge about the subject under study, "Assessment of Overhead Costs for Building Construction Projects".

The comprehensive study in this chapter will attempt to answer the following inquiries:

- What is meant by Construction Company General Overhead Cost?
- Differentiate between Site and Office Overhead Costs?
- Illustrate the items and factors that affect Site Overhead?
- Importance of the contractors/firms assessment for Site Overhead Costs?

Cost Estimating is one of the most significant aspects for proper functioning of any construction company. It is the lifeblood of the firm and can be defined as the determination of quantity and the predicting or forecasting, within a defined scope, of the costs required to construct and equip a facility. The significance of construction cost estimates is highlighted by the fact that each individual entity or party involved in the construction process have to make momentous financial contribution that depend in largely on the accuracy of a relevant estimate **(2)**.

The importance and influence of cost estimating is supported by scores of researches. Carty (1995) and Winslow (1980), for example, have documented the importance of cost estimating, mentioning it as a key function for acquiring new contracts at right price and hence providing gateway for long survival in the business. To Larry, D. (2002) cost estimating is of a paramount importance to the success of any project **(2)**.

Similar to a project owner, the construction contractor is hugely dependent on the competent preparation of estimates. Unlike other manufacturers industries who determine the product's cost from data after it is finished, a construction contractor is supposed to give the owner (client) a price much before the total production costs can really be known **(2)**.

Project cost estimate is the combination of all the costs, from the scratch that will be incurred on the construction of any particular project. In his study Clough **(13)**, mentioned that cost estimating is the collection and analysis of the many items that influence and contribute to the cost of a project. Cost estimating task is accomplished before the physical performance of the work, it requires detailed studies.

An intensive research will be performed to illustrate all the researches conducted in the field of construction cost estimation in general and construction overhead cost's in particular in order to understand its importance and contribution to the total construction project cost, thus directly affecting the company's market performance this will be achieved through the following research sequence:

- Illustrating the construction projects overhead costs;
- Review the previous work conducted in the field of construction overhead costs;
- Differentiate between office overhead costs and site overhead costs; and
- Identify the items that contribute to construction site overhead costs from previous research studies and models.

2.2 Construction Firm's Overhead Costs

Since that specialty contractors have became more and more involved in the construction industry. A general contractor or construction firm overhead costs increased comparably to direct costs. Construction firms overhead cost can be approached through dividing construction costs into two classifications, direct and indirect (Overhead) costs **(47)**.

Direct costs are considered to be the costs for labor, materials, production equipment, and supplies that must be incorporated into a distinct future in order to complete the work. Indirect (Overhead) costs include other items that are not made a part of the completed work such as contractor's overheads, profit, contingencies, risk, and interest during the construction period. Overhead costs generally are divided into two categories: general (office) overhead costs and job (site) overhead costs **(3)**.

General overhead (Office Overhead) costs are those costs that cannot be linked readily with a specific project. Office overhead costs are items that represent the cost of doing business and often are considered as fixed expenses that must be paid by the constructor (firm). Office overhead expenses include the general business expenses that are included by the home-office in support of the company's construction program (main-office or home-office expenses) they are intended to include all those expenses incurred by the home office that cannot be tied directly to a given project **(13)**.

A Job or Site overhead cost is similar to office overhead costs but it must be distributed over the associated project, since it cannot be allocated to specific work packages. Site overhead costs include expenses that cannot be charged directly to a particular branch of work, but are essential to construct the project on hand. Site overhead costs if not accounted for in the total bid price then the competitiveness, success, profitability of the firm will be affected greatly **(41)**.

Nancy Holland and Dana Hobson (1999) conducted a survey among **44** contractors from both Canada and USA. The objectives of that survey were to investigate the current practices used by the contracting industry as a whole and comparatively by general contractors, when categorizing direct costs, indirect costs, job overhead costs, and home-office overhead costs. Table (2-1)

Table (2-1)

Cost Items Categorization by Contractors

Site Overhead Factor	Office Overhead Factor
General superintendent	Construction manager
Craft superintendent	Chief warehouseman
Field engineers	Cost engineer
Guards	Schedule engineer
Automobiles/pickups	Materials engineer
Temporary access roads	Document control
Temporary drainage structures	Survey crew
Lay down area preparation	Safety engineer and staff
Fencing and gates	Secretaries and clerks
Project office	Janitors

- **Participating Construction Contractors are from both Canada and USA during the period 1993 to 1998.**
- **(Source: Nancy L. Holland and Dana Hobson) (40).**

However, the construction industry has not changed the method of controlling overhead costs in construction firms. Traditionally, a construction firm uses resource-based costing and volume-based allocation **(41)**. This resources-based costing method is illustrated clearly by a survey carried out on general contractors to identify indirect costs and how these costs are properly allocated to direct cost factors, realizing that any survey concerning costs and estimating is a sensitive subject to all contractors, the survey was structured to gather information concerning the general characteristics of the firm, general cost categorization information, and general techniques used to allocate overhead. The first step of the research study was a questionnaire containing questions concerning the techniques used by the contractors for the allocation of overhead costs items. The researchers faced a low rate of response (25.9%) possibly caused by the sensitivity and confidential nature of this subject. There surprising result was that a great number of costs for items that do not become a final part of the structure were considered to be a direct cost by the respondents. Although many of these costs are associated with a line item of the project, they would be categorized more correctly as an indirect cost but incorrect categorization makes little difference to the contractor or owner on fixed-price contracts for that the owner is paying the cost of an item plus a margin for an item that should be paid by the contractor from the contractor's margin, while for cost-plus contracts or contracts with a fixed direct cost and reimbursable expenses the contractor is including reimbursable costs as a part of the fixed-price costs, instead of being reimbursed directly for these costs. It is clear that both of these cases occur because of inconsistent cost categorization. This research study found that when considering overhead allocation techniques, it was found that only 31% of all participating contractors that responded to the questionnaire use breakeven analysis. And an equally surprising result is that 56.3% of the respondent heavy/highway contractors only review their overhead allocation on an annual basis.

Alcabes, articulated that, estimating departments is responsible for the preparation of all estimates, estimating procedures, pricing information, check lists and applicable computerized programs. And focusing on the fact that accurate cost categorization, cost reporting, and profit calculation are the heart of the construction business. In order to achieve a financial engineered estimating methodology that can assess projects overhead cost prior to the submission of the bid documents, it is imperative that different techniques be evaluated **(7)**.

Estimates of materials, time, and costs provide information to some construction decisions in a similar way that financial accounting information provides to others, Financial statements are required to comply with generally accepted accounting principles (GAAP), described in accounting literature, to ensure information is accurate and useful to decisions. An estimate must be an accurate reflection of reality. An estimate should show only the level of detail that is relevant to decisions. Completeness requires that it include all items yet add nothing extra. Attention must be given to the distinction between direct and indirect costs and between variable and fixed costs **(48)**.

Cost-estimating shares some similarities with financial accounting. Both provide financial information that is needed in important decisions by a firm's management team, as well as financial information to decisions outside the firm. Both also require standard practices that can be repeated from project to project or period to period.

Selecting estimating and accounting methods is as much an art as a science, to meet practical situations of reality. Financial accounting practice must conform to "generally accepted accounting principles", which is generic for a large group of standards, conventions, concepts, guidelines, and assumptions that guide but do not dictate accountant's decisions. A challenge to the estimator is to produce an estimate that is an accurate reflection of reality. This is first a question of professional experience and judgment, and seconds a matter of relevant historical data. To estimate at a detailed level one must mentally construct a project, selecting materials, methods, equipment, and crews to fit the design. The estimator then uses the best information available to estimate the costs of performing the required work using the selected resources. This information may be cost or crew time data from past work. It may be calculations based on detailed analysis of the construction process. It may be the estimator's best guess of cost and time. Usually it is a combination of all those. It is particularly important that the estimator doesn't select information simply for its convenience or its appearance of objectivity. All too often an estimator will use numbers that are handy or from a source that would seem to release the estimator from personal responsibility. The use of such data without knowledge of its similarity to the work at hand produces an inaccurate overall estimate **(48)**.

Further, from the contractors view angle, accurate estimating is of large importance, the profit margin of the contractor/firm depends greatly on the accuracy of his or its estimate.

2.3 Previous Work

Since the beginning of the 1970's, most of the academic research and contracting firms concern, were focused on one main issue which is how to minimize the expenses of the firm in order to increase (maximize) the net profit, the first step was to examine the total project construction cost in order to break it down into several activities for the identification of all the items and then define each of them to begin formulating different engineered calculation techniques that will help in understanding the governing relationship between all these items.

Construction contracting companies are the authorities responsible for organizing and managing the different levels of work involved in construction process. They are accountable to effectively bring together planning, design, analysis, and control measures to realize the end item, which is the facility. In other words a contractor is the company licensed to perform certain types of construction activities, Ronald B. (2003) and Carty (1995), states that contractor is the third major participant in the construction process. Clough, articulates that a contractor is the business firm that is in contract with the owner/client for the construction of the project, either in its entirety or for some specialized portion thereof. The key contribution of the contractor to the construction process is the ability to marshal and allocate the resources in order to achieve completion under maximum efficiency in time and cost **(13)**.

Construction project overhead cost is defined, illustrated, and explained through many extensive comprehensive research studies that focused on the total project overhead cost and illustrated all its items then defined each item, examined the correlation between all the constituents, and ended up with defining the prime contractor (Firm) overhead items that occur on a building construction project.

Neil (1981)**,** illustrated that site overhead costs is similar to office overhead costs but it must be distributed over the associated project, since it cannot be allocated to specific work packages. Site overhead costs include expenses that cannot be charged directly to a particular branch of work, but are essential to construct the project on hand, like site staff, cleaning site, mechanical plant equipments not previously included in the bill of item rates, site accommodation, temporary services, welfare, first-aid and safety provisions, final clearance and handover, defects liability, transport of operatives to site, and abnormal over time **(41)**.

Ahuja and Campbell (1988)**,** takes the approach of ''Final Placement'' as the flag to divide construction costs into two classifications: direct and indirect. Direct costs are considered to be the costs for labor, materials, production equipment, and supplies that must be incorporated into a distinct future of the completed work. Indirect costs include other items that are not made a part of the completed work such as firm overheads, profit, contingencies, and interest during the construction period. Therefore, costs that are a part of the final placement of a project are direct costs **(3)**.

Peurifoy and Oberlender (1989)**,** stated that indirect (overhead) costs include other items that are not made a part of the completed work such as contractor's overheads, profit, contingencies, escalation, risk, and interest during the construction period **(46)**.

Clough and Sears (1991)**,** stated that office overheads are those costs that cannot be identified readily with a specific project, and representing the cost of doing business and often are considered as fixed expenses that must be paid by the firm, including expenses of the general business expenses that are incurred by the home office in support of the companies construction program (main-office or home-office expenses) they cannot be tied directly to a given project **(13)**.

Cilensek Ron (1991)**,** illustrated that the construction industry comprises thousands of companies whose primary objectives is to build projects for the benefit of society as a whole and to obtain a commensurate rate of return (Profit) on the time and effort (Risks) invested in building these projects. These companies are more commonly referred to as contractors. They all share the same goal which is to make a profit on the work they perform. To accomplish such a goal, they must recover all their costs of performing the work from the compensation they receive for the contract **(12)**.

Pratt (1995)**,** related the categorization of costs to the quantity survey. Direct costs are defined as costs incurred for material, labor, and production equipment for items measured during the preparation of the quantity survey. General expenses of the construction project are defined as the additional, indirect costs that are necessary for the facilitation of the construction project **(44)**.

Jones Walter B. (1996)**,** presented a spreadsheet checklist technique to analyze and estimate prime contractor's overhead costs, prime contractor overhead spreadsheet checklist is a list of the prime contractor overhead items that usually occur on a building construction project. The spreadsheet is capable of performing mathematical calculations to determine the costs and ratio of prime contractor overhead. Using the checklist is analogous to using assembly or composite pricing.

He concluded that, total cost of prime contractor overhead can also be divided by some parameter to obtain a percentage of prime contractor's overhead to direct cost. Also there are other costs that can be derived like prime contractor overhead cost/month and the prime contractor overhead cost/m^2 **(27)**.

Robert I. Carr (1998)**,** conducted an estimation for materials, time, and costs that provides information to some construction decisions in a similar way that financial accounting information provides to others, financial statements are required to comply with generally accepted accounting principles, described in accounting literature, to ensure information is accurate and useful to decisions. The author suggested that general estimating principles can also similarly guide good estimating practice. Estimate must be an accurate reflection of reality and should show only the level of details that is relevant to decisions. Completeness requires that it include all items yet add nothing extra. Documentation must be in a form that can be understood, checked, verified, and corrected. Attention must be given to the distinction between direct and indirect costs and between variable and fixed costs. Contingency covers possible or unforeseen occurrences, both the expected value of possible identified events and the expectation that events will occur that cannot be identified in advance. The author concluded that estimating principles may be considered generally acceptable cost estimating principles to the extent that most engineers would generally accept them as a base for good estimating practice and move forward towards accepting them as a profession **(48)**.

Kumaraswamy and Palaneeswaran (2000)**,** showed that in ancient time the (master builder) had full responsibility for all phases of a project including engineering, aesthetic design, plan preparation drafting and project construction. But since the beginning of the 21st century, many specialty contractors became more and more involved in the construction industry. In such altered environment, a general contractor or construction firm overhead cost increased comparable to direct costs. Direct costs are considered to be the costs for labor, materials, production equipment, and supplies that must be incorporated into a distinct feature in order to complete the work and often considered as fixed expenses that must be paid by the contractor **(31)**.

Kim Yong Woo and Ballard Glenn (2005)**,** focused their study on one of the trends in construction today which is the increasing use of specialty contractors. As a result, projects are becoming more complicated and fragmented, more coordination is required, and overhead costs of the general contractors are increasing relative to the direct costs. Better ways of controlling job (Site) overhead costs are needed. They present profit-point analysis (PPA) technique. Profit point technique is assuming that the contracts between a client and a general contractor and also between a general contractor and subcontractors are fixed cost-based contracts. And studying a case where a general contractor is using 100% outsourcing (specialty contracting) in performing a project. Project management costs under the assumed condition depend largely on how to manage different subcontractors, each of which performing one or a few work divisions. The suggested overhead costs analysis method would determine the costs (especially, management costs) at each point (we call it "profit point") where a company and the subcontractors are interfaced. This would result in revealing the flow of costs and profits. Then a profit point would be the point where organic relations between the participants are met, rather than neglected. It is noted, though, that the proposed cost analysis model does not take into account the relationship between subcontractors. Then they introduced an analysis technique which is profit point analysis (PPA) where profitability information compiles from a company's management activities, which will be collected at "profit points" in a construction site by using an activity form. Then the result of activity analysis is applied to multiple cost objects. In their model, management areas, work divisions, participants, and facilities are regarded as cost objects. In addition to cost information for work divisions, costs for each management area will also be known. It would give a company insight into the relationship between a company and its subcontractors because management areas such as safety control are the core of a company's business activities in a project. On the other hand, current accounting systems put every cost information to cost accounts which combine profit points. It might result in preventing a company from understanding the relationship with subcontractors. A case study was performed to find the usefulness and limitations of this analysis. The author's concluded that the PPA is a method for analyzing on these points. This new method, found to yield valuable information for managerial control, the proposed method can be applied in the same manner to analysis of home office overhead costs to be allocated to multi projects. The importance is that the new tool can pinpoint the area to be investigated for improving the profitability relationship. It can be construed as a tool for nurturing relationship as opposed to having a quantitative target as a motivation **(29)**.

Leckie John (2006)**,** discussed the rising tide fees and the booming economy, through the case studies in both Alberta and British Columbia that have brought about substantial increases in fees of the consulting engineers. Also the boom times in western Canada bring competition for skilled engineers. This means that consulting engineering firms are struggling to attract and keep qualified staff. The dilemma faced by the consulting engineering firms is that when the economy slows down, the company still has to pay its overhead costs. Large firms can be in enough different markets to balance the workload better among staff, while small firms do not carry the same overhead costs **(33)**.

Toh Tien Choon and Kherun Nita Ali (2008)**,** They illustrated the cost estimating financial and non-financial information which quantity surveyors and estimators need to manage effectively to lead their firms to competitive success. However, the specific role of cost estimating in the quantity surveying and contracting firms differ depending on the firm's competitive strategy, organizations, and the management functions to which cost estimating is applied. Meanwhile, changes in the business environment have amended the nature of competition and the types of techniques that quantity surveyors and estimators use to succeed in their businesses including globalization, advances in construction technologies, advances in information technologies, the internet, client centered, new forms of management organization, and changes in the social, political, and cultural environment of business. They concluded that cost estimating practices diverse depending on the nature and types of organization either quantity surveying or contracting firms and hence the factors influencing the project cost estimation are also varied accordingly. By referring to the various literature syntheses being carried out so far, that cost estimating is a very subjective subject which does not possess standard methods of calculation but rather an adoption of certain basis as steps and procedure to estimate construction costs **(55)**.

Cost estimating models and techniques provided a well defined engineered calculation methods for the evaluation and assessment of all items of office overhead, project overhead, profit anticipation, total project cost estimation, and the assessment of overhead costs for construction projects that lead to competition in the bidding industry.

Ali T. (1993)**,** discussed the probabilistic cost estimating with subjective correlations by over viewing the difficulties in probabilistic estimating accounting for the existing correlations among cost components modeled as random variables. Even if the estimator is aware of the existence of correlations among random variables, also calculating accurate values of correlation coefficients is not feasible most of the time. The author presented a methodology for generating correlated random numbers in a Monte Carlo simulation for construction cost estimation. A methodology is then suggested that simplifies the process of incorporating the effect of correlation coefficients in probabilistic estimating. This methodology consists of assigning subjective measures of correlation between variables. Also, a method is suggested for adjusting the covariance matrix in which correlation estimates are not accurate. Procedures presented are further explained by two examples using actual construction cost data. The author concluded that, several areas should be further investigated. Also, the impact of using rank correlations for representing dependency among data should be studied. Development of a decision support system that performs probabilistic cost estimating when some variables are correlated. Such a system should allow the user to differentiate between independent and correlated cost components. The main input to the system would be ranges of parameters of variable cost components, along with subjective measures of correlations between correlated random variables. Analyzing the simulation output are other tasks that can greatly increase the system's power and applicability in probabilistic cost estimating **(5)**.

Bannes Lorry T. (1994)**,** presented a method for calculating general contracting fees in construction cost estimating. It provides a contractor with a way of evaluating the many and varied elements of main office overheads, profit anticipation, and an entrepreneurial perspective in planning and costs estimating process. A systematic consistent procedure to identify and quantify the fees with the intended goals and purposes of more accurate estimates and/or detailed and well communicated mutual agreement parameters for negotiating fees within any contract form or format is developed **(9)**.

Teo Ho Pin and W. F. Scott (1994)**,** developed a simple statistical model for competitive bidding in the building industry. They take a statistical approach, using a large set of actual bids (1350 renovation contracts) collected by the Builders Conference in London, United Kingdom. The distribution of bids is fitted to a normal curve, from which one may estimate the distribution of the lowest of **n** bids (representing a given contractor's competitors). Part of their study involves the estimation of various parameters, such as the coefficient of variation, which is a measure of the relative spread of bids. They where able to obtain a simple formula for the bid that has a specified chance of success (e.g. 20%, 50%, or 90%), and the theory is tested on data from five contractors. A likely consequence of the adoption of the proposed models by the industry in general would be a tendency toward tighter bidding, i.e. the difference between the winning bid and the next lowest (which is, in a sense, a loss to the construction industry caused by variations in bids) would be reduced. The author stated that widespread adoption of our model would lead companies to similar bids, and consequently to a downward drift in prices. In the event of all the contractors choosing the same probability of success, our model might no longer work; the successful contractor would be the firm with the lowest estimate. It is possible that companies would increase the probability of success, leading to lower bids, but a price war is possible in any industry, whether or not particular statistical models are used, with damaging consequences clear to all concerned. The positive aspect of this model, from the point of view of the construction industry in general, is the likely reduction in win margins **(54)**.

Kim ln Ho (1994)**,** discussed that with a tendency of increasing social overhead capital in government budgets, the amount of budget in the area of military facilities is becoming a very important concern to the people who are related to the work of budgeting and executing any military facility. The impact that effort performed at the budgeting stage have over on the whole process of later design and execution of the facilities are extremely high. And the budgeting stage includes difficulties to be overcome, which are uncertainties due to the inherent nature of predicting the events next year (during the construction phase), and having to limited data and information on the target facility at that stage. The author concluded that, this is a first step, attempting to suggest methodologies which can predict construction cost at the budgeting stage with limited information/data. He recommended that there is a need for a second research study that must be conducted for the adjustment of the predicted cost, considering different decision-makers perspectives from the distinct fields **(30)**.

Hegazy and Moselhi (1995)**,** conducted several survey studies in Canada and the United States to determine the elements of cost estimation, the survey was carried out with the participation of **78** Canadian and U.S building construction contractors in order to elicit current practices with respect to the cost elements used to compile a bid proposal and to identify the types of methods used for estimating those elements. Their results indicated that direct cost and project overhead costs are estimated by contractors primarily in a detailed manner. This is contrary to the estimation of the general overhead costs and the markup. Based on the results obtained, two recommendations were made **(23)**:

A. A set of estimating standards should be established; and

B. Effective decision-support tools for estimating purposes should be developed (Models).

Hojjat Adeli and Mingyang Wu (1998)**,** illustrated the dependency of construction management quality on the accurate estimation of construction cost. They presented a new computational model based on a solid mathematical foundation making the cost estimation consistently more reliable and predictable. Further, the results of estimation from the regularization neural network depend only on the training examples. It does not depend on the architecture of the neural network, the learning parameters, and the number of iterations required for training the system. The authors concluded that the generalization error of the regularization networks can be attributed to insufficient data examples, which can be improved by increasing the database of the examples from previous construction projects **(21)**.

Matthew J. et al. (2001)**,** illustrated the importance of project management software in the construction industry. Data were collected on: demographics and work environment, project management software usage patterns, analytical technique usage, data management, and suggestions for future research. Results indicated that construction professionals have different characteristics, needs and preferences, as compared to the overall sample. Study prevailed that construction professionals are more experienced, they tend to work on fewer projects with larger numbers of activities, and they are more likely to use Primavera (Primavera, Inc.) than Microsoft Project manager (Microsoft Corp.). Construction respondents are heavy users of critical path analysis for planning and control, resource scheduling for planning, and earned value analysis for control. Although construction professionals are generally satisfied with the quality of schedules produced by the software, they still expressed a clear interest in future research on resource scheduling/leveling and cost estimation in general. They concluded that to maximize the impact on practice development of new planning, control, and cost estimation methods should include their integration into project management software **(38)**.

Assaf S. et al. (2001)**,** investigated the overhead cost practices of construction companies in Saudi Arabia, and showed how that the unstable construction market makes it difficult for construction companies to decide on the optimum level of overhead costs that enables them to win and efficiently administer large projects **(8)**.

Yong Woo Kim and Glenn Ballard (2002)**,** criticized the traditional overhead costing methods used by construction companies/contractors and found that it would result in the following problems:

1. Cost distortion hinders profitability analysis

Construction projects have different cost codes for each resource such as project engineer or manager. They treat overhead costs separately and do not assign overhead costs to work divisions such as earthwork or to participants such as subcontractors. However, they assign overhead costs to work divisions in proportion to direct labor hours or direct labor costs when owners request the assignment of overhead costs, Sommer (2001). Such volume-based allocation results in cost distortion, Cokins (1996), Johnson and Kaplan (1987), Horngren et al. (1999). The problem of current practice regarding overhead assignment is that companies do not know real costs for each work division and those for each participants such as subcontractors because either they do not assign overhead costs or they use a uniform cost driver (i.e. direct labor costs) for assignment of overhead costs. Therefore, it is difficult to find where money is being made and lost because progress payments for each work division or building from clients contain overhead costs. In other words management personnel have difficulties in doing a profitability analysis.

2. Little Management attention to Activities or Processes of Employees

Little management attention is paid to activities or processes since every cost is assigned and reported resource by resource. In other words, little management attention is paid to supporting activities. As a result, management personnel do not have information on how much resources and what services are provided to participants such as subcontractors. It does not help nurture relationships with the subcontractors.

This research study adopts activity-based accounting (ABC) tool because activity-based costing has been advocated as a means of overcoming the systematic distortions of traditional cost accounting and of bringing relevance back to managerial accounting.

- Activity-Based Costing

Traditional cost accounting has been criticized for cost distortion and the lack of relevance during the last 20 years, Johnson and Kaplan (1987). A traditional system reports where and by whom money is spent on, but fails to report the cost of activities and processes Miller (1996). Many organizations, including petroleum and semiconductor companies in the manufacturing industry, have adopted the new costing method, activity-based costing (ABC).

There are two purposes of activity-based costing. The first is to prevent cost distortion. Cost distortion occurs because traditional costing combines all indirect costs into a single cost pool. This pool is allocated on the basis of some resource common to all of the company's products, typically direct labor. Cost distortion is prevented in ABC by adopting multiple cost pools (activities) and cost drivers. The second purpose is to minimize waste or non-value-adding activities by providing a process view.

This was demonstrated on a case study to exemplify the new method. Confined to the perspective of the general contractor who is subcontracting most of the work. It is noted that numbers regarding a case study are modified because they are confidential to a company. This research study concluded that the new analysis is feasible on actual construction projects and has many positives with some limitations. It is noted that the proposed method can be applied in the same manner to analysis of home office overhead costs to be allocated to multi projects. The importance is that the new tool can pinpoint the area to be investigated for improving the profitability relationship. It can be constructed as a tool for nurturing relationship as opposed to having a quantitative target as a motivation **(57)**.

Leroy J. and W. Back (2002)**,** studied the effect of multiple simulation analysis for probabilistic cost and schedule integration by development of reliable project cost estimates and schedules. Two techniques available for achieving this goal which are range estimating and probabilistic scheduling. This research looks at the integration of these techniques as a mean for further controlling the risk inherent in the undertaking of construction projects. Least-squares linear regression is first considered as a means of relating the data obtained from the application of these techniques. However, because of various limitations, the application of linear regression was not considered the most appropriate means of relating the results of range estimating and probabilistic scheduling. Integration of these techniques was, therefore, achieved through the development of a new procedure called the multiple simulation analysis technique (MSAT). This new procedure combines the results of range estimating and probabilistic scheduling in order to quantify the relationship existing between them. Having the ability to accurately quantify this relationship enables the selection of high percentile level values for the project cost estimate and schedule simultaneously. The authors concluded that MSAT combines discrete event simulation, regression analysis, and numerical analysis in order to develop a model that explains the relationship between the stochastic cost estimate and the schedule data. This allows much more detailed and integrated project planning than which was possible in the past, when range estimating and probabilistic scheduling were independently applied to construction projects. Using the MSAT procedure allows cost estimate and project schedule values, both having high percentile levels, and which are related to each other in some meaningful way, to be selected. MSAT was applied to several projects, and was found to provide consistent results in all cases. It is, therefore, recommended to view the MSAT as a reliable means of truly integrating the results of range estimating and probabilistic scheduling **(34)**.

M. Skitmore and S. Thomas (2002)**,** illustrated that on the contrary to expectations, the analytic solution is relatively straightforward. Rather than the traditional statistical variance of total project cost that is usually estimated by means of Monte Carlo simulation on the assumption that exact analytic approaches are too difficult, it is also shown that the coefficient of variation is unaffected by the size-floor area of the project when using standardized component costs. A case study is provided in which actual component costs are analyzed to obtain the required total cost variance. The results confirm previous work in showing that the approximation of the second moment-variance, under the assumption of independence considerably underestimates the exact value. To conclude the major limitation of their research is in the simulation of component costs and quantities. And that future research should undertake an empirical analysis of actual component unit cost and quantity estimates as a check on the validity of the simulations **(52)**.

Brian L. Smith (2002)**,** illustrated that modern infrastructure systems, ranging from transportation to water, sewer systems, and building projects are becoming increasingly dependent on software. In other words, software has transformed what were previously considered to be largely static systems into active, dynamic systems. In general, infrastructure system software is characterized by an emphasis on the following functions:

A. Sensor Management;
B. Data Management;
C. Data Analysis; and
D. Equipment Control Interfaces.

As the nature of the infrastructure systems changes, the tools available to support their design and management must change as will. However, such tools are not readily available to support the cost estimation of the software component of infrastructure system development and construction. In this research, a widely used software engineering cost-estimation technique, the construction cost model (COCOMO), was examined to determine if it is effective for infrastructure system application. The researcher was able to demonstrate by examination that (COCOMO) is extremely sensitive to small variations in an estimator's judgment, and that the foundation of the (COCOMO) model is poorly suited for infrastructure system application. The author through this research recommended the need to initiate a research and development program to develop tools to support the cost estimation of infrastructure system software. The elements of this program should include:

1. Wide-scale collection of data on completed infrastructure system, software should include types of systems, number of function points, lines of code, language, and total project cost.
2. Data collected in point No. **1** should be used to derive estimation models similar in nature to the (COCOMO) parametric models.
3. An ongoing element of the program is needed to revisit items **1** and **2** periodically to account for changes in applications and software development practices.

While such a program may seem extreme for one particular segment of software development, consider the impact of infrastructure construction on the world's economy and the growing reliance of infrastructure on software, and it is clear that this problem demands such a great attention **(11)**.

Ali Touran (2003)**,** proposed a probabilistic calculation model for project cost contingency by considering the expected number of changes and the average cost of change. The model assumes a Poisson arrival pattern for change orders and independent random variables for various change orders. The probability of cost overrun for a given contingency level is calculated. Typical input values to the model are estimated by reviewing several U.S. Army Corps of Engineers project logs, and numerical values of contingency are calculated and presented. The author concluded that similar models must be developed for schedule contingency. Interaction of schedule delays and cost increases is another area that deserves further research. Also, an extensive survey of various project types can be conducted to calculate typical input values for specific types of projects. As an example, by reviewing the historical data of a specific transit agency, one can calculate rates of changes, size and distribution of changes, and times between changes for similar projects and prepare risk profiles or cumulative probability curves for various values of contingency. The outcome can be used during the budgeting phase of a project to ensure that consideration is given to potential costs (overheads) after the project starts **(4)**.

Ottesen Jefferey and Dignum Jack (2003)**,** discussed the quantification of a contractor's home office overhead costs (HOOH) in real-time. The owner needs to select the best technologies to equitably quantify HOOH and resolve HOOH claims prior to project completion. It was found that extended overhead costs occur when extension of the performance period of a construction contract leading to an increase in the overhead costs for the project **(43)**.

Youngsoo Jung and Sungkwon Woo (2004)**,** monitored the integration of cost and schedule control systems that has been an issue of great concern for researchers and practitioners in the construction industry. Nevertheless, the real-world implementation of this promising concept has not been popular enough to maximize the benefits that this integration has to offer. One of the major barriers is the overhead effort to collect and maintain detailed data. The authors proposed a flexible work breakdown structure (WBS) that optimizes the overhead effort by means of reducing the amount of data to be controlled. In order to have a flexible structure, the WBS numbering system needs to utilize standard classification codes and should not have a common strict hierarchy for all components. He also outlined the practical implications as will. The authors concluded that different conditions in the project delivery systems, project contract type, and the management policy will also affect the "practicability" of integrated cost and schedule control. Using flexible WBS cannot only enhance its practicability, but also maintain valuable historical data for permanent reuse **(58)**.

Mark Kaiser, Allan Pulsipher and Jimmie Martin (2005)**,** discussed the cost of site clearance and verification operations in the Gulf of Mexico based on nearly 300 jobs performed by (B & J Martin, Inc.) during the period of 1997 to 2001. A description of the activities and regulatory requirements involved in site clearance verification establishes the manner in which service cost is determined. The authors derived and provided descriptive statistics and relations that estimate the time and cost of clearance and verification based on various descriptor variables. The expected size and potential value of the site clearance verification market in the Gulf of Mexico was also estimated. A major conclusion derived from this analysis is that the cost of site clearance verification is a time-variant and a site-dependent function, which these researchers couldn't overcome in order to be able to predicted prior to performing the service. This analysis represents the first empirical study to construct clearance and verification cost functions for the Gulf of Mexico region **(36)**.

J. Fajardo, C. Alcudia and J. Zaragoza (2006)**,** Presented an integrated system for construction project planning and control. This model proposes guidelines to improve project management current practices, through a better organization of the flow of information in all processes seeking to obtain an adequate "timely" decision making. The model addresses four areas which are:

1. Project planning;
2. Resources management (materials, labor, equipment, and subcontracts);
3. Cost control; and
4. Cost forecasting.

They concluded that Planning is addressed very lightly by Small and Medium Size Construction Companies in Mexico (PYMES), after winning a contract, a comprehensive model system to integrate time and cost, for planning and control purposes, model incorporates valuable managers opinions. It is aimed to be a guide for PYMES to prepare a comprehensive planning and pre-control process expeditiously, it should also be the basis for resource management, cost and time control, the model and the computer program will comprise an integrated system for planning and controlling construction projects and will require testing and validation, the system should be flexible enough to be adapted to all the companies needs and demands **(25)**.

Ying Zhou and Lie Yun Ding (2006)**,** examined and illustrated the digital construction management techniques, through applying data mining technology in construction cost control system to solve the shortcomings in traditional management. It satisfies the managers with providing project's cost information from all views and improves the share-out in overhead cost. Also, it represents the cost information more fully and turns from passive management to active and enhances the cost management efficiency. They introduced an advance new method which uses data mining technology in construction management to break traditional Management Information System (MIS) structure. As global competitiveness increases, so will the expectations of higher level of construction digital management. Cost control system based on data mining technology provides multiple angles to observe cost information. However, this method requires several conditions **(56)**:

A. Practitioners need to collect more data or they may get misleading conclusions;

B. Managers should be aware of their targets more clearly and it's relation with the data dimension defining;

C. Information system should be upgraded to make maximum use of just in-time techniques by providing instantaneous information to all involved parties, Forbes and Ahmed (2003); and

D. Each member of the construction team should share their data equally to ensure system reliability.

Grogan Tim (2006)**,** studied the factors that drive ENR's cost indexes, Building Cost Index (BCI) and Construction Cost Index (CCI), report material prices and wages since 1909. The indexes are designed as a general purpose tool to chart basic cost trends of construction materials. The original use of common labor as a component of the CCI was intended to reflect wage rate activity for all construction workers. The BCI labor component is the average union wage rate, plus fringes, for skilled laborers. The materials component is the same as that used in CCI both indexes are designed to indicate basic trends of construction costs in the U.S. The author concluded that these methods examined are not adjusted for productivity, managerial efficiency, labor market conditions, contractor overhead and profit or other less tangible cost factors **(18)**.

Seo kyung Won, Seon chong Kang and Sun kuk Kim (2007)**,** studied the relatively tight time schedule of shopping mall projects for the prompt payback of the investment cost. Hence, delay factors in construction schedule should be thoroughly identified and dealt with at the preconstruction stage. The delay of structural work schedule causes delay in the overall project schedule in return increases overhead costs, and crashing of the overall project. They concluded their study by using the derivation of the proposed computation equation for the delay rate as an alternative for the improvement on the existing schedule management, to collect and analyze more data continually in the future. They planned to supplement the inadequate actual data from the past and to upgrade the improvement alternative in their follow-up studies **(51)**.

Fitton Daniel et al. (2008)**,** illustrated that equipment used in the construction domain is often hired in order to reduce cost and maintenance overhead. The cost of hiring is dependent on the time period involved and doesn't take into account the actual used time that the equipment was used for. They conducted an initial investigation into how physical objects augmented with sensing and communication technologies can measure use in order to enable new pay-per-use payment models for equipment hiring. Also explored the use of interaction between pay-per-use objective via mobile devices. The interactions that take place within the prototype scenario range from simple information access to transactions involving multiple users. They presented the design, implementation and evaluation of a prototype pay-per-use system motivated by real world equipment hiring scenario's, also giving insights into the various challenges introduced by supporting a pay-per-use model, including data storage and security in addition to user interaction issues **(16)**.

In the following section a detailed examination will be performed on the research that where conducted on construction projects overhead cost, in order to understand and illustrate the cumulative effect of all construction project overhead cost factors, while considering their combined effect on the total budget of the project. And focusing on the assessment of overhead costs, incorrect biding document preparation, and the increase in the total projects duration. Which, leads to a major decrease in net profit of the construction firm. Thus, contributing to the unsuccessful participation of the firm in the construction market.

Becica Matt, Scott Eugene R. and Willett Andrew B. (1991), discussed the importance of equitable allocation of responsibility for project delays and it's essentiality to the resolution of many construction disputes. Contractors frequently assert that they have been delayed for reasons beyond their control, but owners often remain unconvinced that the contractor is legitimately entitled to a time extension. Large dollar amounts may hinge upon the outcome of a dispute over project delay, since most construction contracts allow the owner to recover either liquidated or actual damages for delay and the contractor may be entitled to extended field and home office overhead costs because of owner-caused delays. The authors found that consequently, a thorough schedule analysis of the project delays is essential for the equitable resolution of delay-related disputes **(10)**.

Martindaie Steve (1991), drew attention early to the concept of remodeling vs. new home construction: expect higher overhead costs, higher subcontractor costs, more time for project completion, and to provide detailed contract documents. The author concluded that more intensive research to this concept is recommended **(37)**.

Shimazu Youji and Uehara Toshihiro (1994), drew early attention to the fact of the time consumed during claim settlements due to compensation of losses suffered for unanticipated work that can arise during construction. They illustrated that through an actual claim made by a contractor to his employer for the compensation of losses suffered due to changes of ground conditions during the construction of a waterworks supply tunnel in Hong Kong. This took 12 years for finally settling it, since this claim was so debatable and had been disputed in various courts and even at the Judicial Committee of the Privy Council United Kingdom. The actual ground conditions of this tunnel were completely different from the original anticipation made by the consultant, and the quantities of steel rib support and concrete lining increased by 73 and 7 times respectively. Therefore a construction period 2 times longer than the anticipated was required, and the contractor filed the claim to the employer for the additional cost of machinery depreciation, site expenses, overhead costs…etc. which was incurred during the extended construction period **(53)**.

Saunders Herbert (1996)**,** conducted a survey to assess change order markups, clauses changes are among the most heavily used parts of the construction contract. Mechanisms exist within the clauses to compensate contractors for their overhead costs and to allow a reasonable profit as a part of the price adjustments associated with work added to the contracts. The author recognized a frequent controversy regarding the adequacy of these allowances. The components of the price adjustments and the relative risks associated with them are discussed. Using twelve contract forms from state departments of transportation and transit agencies in the southeastern United States for the survey, four private consensus forms and the federal acquisition regulation form were examined and compared for consistency in treatment of the major components of price and overhead and profit. He used different approaches to criticize and compare between all the different alternatives. He concluded a recommendation that further researches need to be made **(50)**.

Jeffrey Russell, Edward Jaselskis and Samuel Lawrence (1997)**,** introduced a process whereby owner, engineer, and construction contractor organizations can use continuous or time-dependent variables to predict project outcomes from start of detailed design through construction completion. Continuous variable data were collected from **54** construction projects. S-curves were developed for two project outcome categories:

A. Successful (meeting or exceeding budget and schedule expectations); and

B. Less-than-successful (not meeting budget and/or schedule owner's expectations).

Statistical analysis was performed to identify those variables showing a statistical significant difference between the two projects outcome categories. Variables exhibiting a significant difference between the S-curves for "successful" and "less-than-successful" projects can be used as predictors for project's outcome. The results show that different variables were predictors for success at different intervals in time during the project life cycle. The authors concluded that their process represents the foundation for further data collection and analysis using continuous variables to predict project success. And that they have not demonstrated the only form in which quantitative models can be developed **(26)**.

Fayek Aminah, Young David and Duffield Colin (1998)**,** conducted a survey for the tendering practices in the Australian construction industry, among the civil engineering construction contractors. Common practices for assessing risks & opportunities, assessing the competition, setting margin, and developing competitive tendering strategies were their target. They reached a major conclusion, that much of the process is subjective and based on experience and judgment, and that assessing of the competition is almost always done on an informal basis without using historical competitor data, and that the margin-size decisions (i.e. corporate overhead and profit) are usually done in the final few hours prior to tender submission with little or no formal methods of analysis. They concluded that most of the time, effort, and decision-making are directed towards estimating the direct costs, in formulating the construction methodology and design alternatives, and in assessing the risks and opportunities **(15)**.

Nancy Holland and Dana Hobson (1999)**,** explained the importance of the drafters of contracts clearly defining direct and indirect costs for contract items receiving cost reimbursement. They asked contractors to classify a list of **44** items as their company would, with respect to project's home-office overhead, direct, and indirect costs. The results of this indicated a lack of standard usage of these terms by the construction industry. They also investigated the manner in which contractors allocate home-office overhead to contracts. They concluded that the results should be seen as an indication of current due to the low rate of response (**25.9**%) possibly caused by the sensitive and confidential nature of the subject. It is clear that the investigation did provide some insight into the practices currently being used for cost categorization but when considering overhead allocation techniques, it was found that only (**31**%) of all contractors that responded use breakeven analysis. An equally surprising result is that (**56.3**%) of the respondent heavy/highway contractors only review their overhead allocation on an annual basis **(40)**.

Faniran Olusegun, Love Peter and Li Heng (1999)**,** described how efficient allocation of resources for construction activities requires construction planning of resource requirements to be determined on a cost-effective and value adding basis. In spite of some research studies did indicate that increasing resource allocations to construction planning activities leads to improved project performance, other research studies have indicated that investing in construction planning beyond an optimum point will lead to deterioration in project performance. The concept of optimal planning is examined on **52** building construction project, all in Australia. They derived a model using logistic, linear, and curvilinear regression analyses to represent the relationship between planning input (ratio of planning costs to total project costs) and the probabilities of achieving (poor and good) performance. They were able to derive a probable optimum planning input based on the sample that was studied. They concluded that any additional planning efforts beyond this optimum point would be essentially wasted because the additional planning costs would not achieve any savings in project cost but merely add to the overhead costs and therefore increase the overall project's costs **(14)**.

Sadi Assaf et al. (1999)**,** the authors conducted a survey that investigated project overhead cost practices in Saudi Arabia. They stated that contractors should carefully examine contract conditions to make sure that project's overhead costs are properly covered. Data needed for the research were collected by a questionnaire that was developed based on a thorough review of the related literature. It reflects the existing level of overhead costs and how local contractors deal with them. The questionnaire covered three parts: the construction firm, overhead cost. The first part contained **22** questions to elicit general information about the participating contractors. The second part contains **8** questions about overhead in general and explores contractor's background and their opinions on overhead. The third part contained **11** questions about project's overhead and addresses issues such as the percentage of project's overhead cost to the direct cost of the project, and whether the project's overhead has increased or decreased during the past years, and why. Also addressed what the components of project overhead costs include, the percentage of each?, the methods used to estimate project's overhead, and why it is used, and the factors that affect the amount of project overhead. The designed questionnaire also asked what steps contractors are taking to reduce project overhead cost. The population of this study included all of the building contractors classified by the Kingdom of Saudi Arabia Ministry of public works and housing (MPWH) in the first three grades for Saudi contractors and in the first five grades for foreign contractors.

The total number of contractors included was 230, out of these, 61 contractors participated in the research. The survey results showed that projects overhead costs varied from project to project and that they are increasingly important, since they have increased in recent years and because contractors have no control over them. They concluded that the results of this survey indicate that project to another. They range from 11 to 20 percent of the indirect costs. The overall ratio is 14.9 percent. The majority of contractors believe that projects overhead has increased in the past few years; reasons for this include delayed payments and financing costs, client requirements, and inflation. The four highest projects overhead costs are for supervision, equipments, temporary construction, and financing. Contractors use two methods for overhead estimation, the majority estimate project overhead costs directly from the contract documents, while the others uses methods like projects total direct costs as a base to calculate project overhead. Some factors that affects project overhead are project's complexity, location, size, percentage of subcontracted works, payment schedule, and contractors need for work. There is concern about the rising financing and insurance costs, which constitute a significant amount, yet contractors, can not control them **(49)**.

Lam Peter and Kung Francis (2004), examined the innovative and sustainable construction for a footbridge system in congested Mongkok, Hong Kong by proposing a footbridge system to provide direct pedestrian access between the KCRC and the MTRC Mongkok Stations to alleviate the current situation in the area. In July 2000, Lam Construction Co. Ltd. was awarded the Contract by SHKPCF for the design and construction of the footbridge system based on a tender design prepared by Hyder Consulting Ltd. The objectives of the design are; to minimize disruption to both residents and commercial activities to meet the very tight program, and to achieve overall cost savings (decreasing overhead costs). The authors described the innovative design and construction of the footbridge system along Mongkok Road and Sai Yee Street, utilizing a completely precast solution, including the piers, which is believed to be a unique approach to bridge construction in Hong Kong **(32)**.

Goh Rick Mong et al. (2004), demarcate construction: through a new form of tree-based priority queues, these priority queues employ the demarcation process to systematically split a single tree-based priority queue into many smaller trees, each divided by a logical time boundary. These new demarcate construction priority queues offer an average speedup of more than twice over the single tree-based counterparts and outperform the current expected O(I) Calendar Queues in many scenarios. The authors concluded that generality in small to large queue sizes, insensitivity to priority increment distributions and low overhead costs, render them suitable for many applications **(17)**.

Hanna Awad et al. (2004)**,** described the cumulative effect of project changes for electrical and mechanical construction by illustrating that Change is inevitable on construction projects, primarily because of the uniqueness of each project and the limited resources of time and money that can be spent on planning, executing, and delivering the project. Change clauses, which authorize the owner to alter work performed by the contractor, are included in most construction contracts and provide a mechanism for equitable adjustment to the contract price and duration. They found by survey that, owners and contractors do not always agree on the adjusted contract price or the time it will take to incorporate the change. So they acknowledged the importance of formulating a method to quantify the impact that the adjustments required by the change will have on the changed and unchanged work. Owners and legal system professionals recognize that contractors have a right to an adjustment in contract price for owner changes, including the cost associated with materials, labor, lost profit, and increased overhead due to changes. However, the actions of a contractor can impact a project just as easily as those of an owner. From here arises the complexity of determining the cumulative impact that a single or multiple change order may have over the life of the project. The authors presented a method to quantify the cumulative impact on labor productivity for mechanical and electrical construction resulting from changes in the project. Statistical hypothesis testing and correlation analysis were made to identify the factors affecting productivity loss resulting from change order. So a multiple regression model was developed to estimate the cumulative impact of change orders. The model includes six significant factors:

(**1**) Percent change;
(**2**) Change order processing time;
(**3**) Over manning;
(**4**) Percentage of time the project manager spent;
(**5**) Percentage of the changes initiated by the owner;
(**6**) Whether the contractor tracks productivity or not.

They concluded that sensitivity analysis was performed on the model to study the impact of one factor on the productivity loss (% delta). The model can perform the following:

- The model can be used proactively to determine the impacts that management decisions will have on the overall project productivity; and
- The model may also be used at the conclusion of the project as a dispute resolution tool.

The authors noted that every construction project is unique, so these tools need to be applied with caution **(19)**.

K. Caceres and G. Ruiz (2006)**,** explained that in developing countries it is often very difficult to estimate the cost of constructing municipal infrastructure projects because the legal environment and public policy often dictates that the government to act as the general contractor for the work instead of allowing independent private contractors the opportunity to participate through competitive bidding. This research focused on identifying the "Real" saving when government manages the construction of public infrastructure projects and in determining the principal factors that influence municipal-infrastructure project's costs. They concluded that accuracy of cost estimates seems to be tied to the fee that the designer receives for preparing the plans and specification and creating the final estimate. Therefore, it is recommended that carefully reviewing their fee structures as a method for impacting the quality of project estimating **(28)**.

Missbauer Hubert and Hauber Wolfgang (2006)**,** have undertaken a study of bid calculation for construction projects: regulations and incentive effects of unit price contracts through studying the Austrian contract awarding system for construction projects is characterized by the unit price contract being an important contract type. The bid price is a decisive criterion for the selection of the construction company that performs a project, and the bid price is calculated from the unit prices and the specified production volumes of the project activities. Since the actual production volumes can differ from the specified volumes, the actual payment can differ from the bid price according to these deviations. In practice there can be asymmetric information on the production volumes. The authors found that this leads to an incentive for the bidders to "skew" the bid calculation by asymmetric allocation of overhead costs to project activities. They analyzed this agency-theoretical situation and develop a model that decides on the allocation of overhead costs to project activities in order to maximize the actual payment for a predetermined bid price. They also highlighted this through presenting a case study and it's implications for the model of contract awarding system in the construction industry **(39)**.

Hessing Henry (2006)**,** reviewed the effect of Design/Build/Operate Maintain (DBOM) on overall project costs through the project of designing the major fully automated JFK Air train. The 1.9 billion dollar Airport Access Project connecting John F. Kennedy International Airport (JFKIA) located in Jamaica, New York with two major intermodal connections - Long Island Rail Road (LIRR) and New York City Transit (NYCT). Design/Build/Operate Maintain (DBOM) was the method selected for delivering the project. DBOM shortened design and construction time by several years. The short time duration was reflected in lowering in the overhead costs for the project and that lead to the reduction in overall project's costs **(22)**.

Illia Tony, Angelo William, Cho Aileen and Gonchar Joann (2006)**,** illustrated the strain of rising construction prices and real-estate prices in Las Vegas are distorting the market for construction labor and contracting capacity. But in the tight market, local bidders are choosing their targets, while the high-rise growth is attracting outsiders with experience in vertical construction. The condo market is starting to show signs of exhaustion in the face of soaring real-estate costs. The overhead construction market has sparked intense competition for labor, contractors, and materials **(24)**.

To conclude, any rapid examination of cost data is very crucial and unworkable to achieve by manual calculations or estimations in this modern days, especially in the construction industry where decisions are taken in a very rushed and short periods of time. That's why; computer based cost models are necessitated to enable accurate responds, ease the data analysis process and shorten the time required to accomplish the job.

Through all these surveyed and overviewed studies it is clear that building construction overhead costs assessment is of a great importance and concern. This concern has been formulated in the considerable amount of scientific work for the assessment, identification and quantification of overhead costs for construction building projects. Table (2-2) represents the collection of overhead costs factors for building construction projects from previous studies performed during the period of 1980-2009.

It is clear that for the assessment of construction site overhead cost through any of the above mentioned and discussed techniques require the application of a diverse and wide range of resources, and the application of these resources can be viewed in terms of level and authority by which decisions and management is being made. This explicates the importance of qualified construction management engineers and the state of the art overhead costs assessment techniques (Models).

Table (2–2)
Factors Contributing to the Site Overhead Percentage
From Previous Work Conducted in this Field

S / N	FACTOR
1	The need for specialty contractors.
2	Percentage of sub-contracted works.
3	Consultancy and supervision.
4	Contract type.
5	Firms need for work.
6	Type of owner/client.
7	Site preparation needs.
8	Projects tight time schedule.
9	The need for special construction equipments.
10	The delay in projects duration.
11	The firm's previous expertise with the same projects type.
12	Legal environment and public policy in the home country.
13	The projects cash-flow plan.
14	Projects size.
15	Projects location.
16	Constructions Firms Category.

- **Source**: Performed literature review study on construction site overhead costs factors from work conducted during the period from 1980-2010.

The Overhead Cost Estimating Model for Construction Buildings Projects will be a prediction technique to in apple construction firms/contractors to assess the overhead cost as a percentage from the total project cost (total project contract amount). Through the identification or anticipation of all overhead costs factors for construction building projects in Egypt, for the first and the second categories construction companies. Predicting the potential consequences of those items. Leading to an adequate and exact estimate of the percentage of site overhead costs from the total project cost. To improve the existing Egyptian construction industry performance and ability to overcome the market financial constraints. Through improving the bids accuracy, leading to:

- Decreasing the time, effort and money spent during the overhead cost prediction phase;
- Increasing the probability of adequate prediction of overhead cost percentage;
- Summing up all the governing overhead cost parameters in one well defined technique;
- Eliminating any probability of unanticipated overhead cost factors;
- Enhancing the ability of competing with international construction firms; and
- Enhancing the way that international parties view the Egyptian construction industry.

In the following Chapter a data collection plan will be designed and implemented in order to compare, verify and collect the needed real-life projects data for the list of building construction projects site overhead factors that can be adapted in Egypt. The needed projects data will act as raw materials during the programming of the neural network site overhead predicting model.

CHAPTER THREE

DATA COLLECTION AND ANALYSIS

3.1 Introduction

The research conducted an extensive literature study. The key objective of this literature survey were to acquire in depth understanding and immense knowledge regarding the factors affecting the percentage of site overhead costs for building construction projects, in Egypt, concerning the first and the second categories of construction companies.

The necessary information and required projects data were collected on two successive yet dependent stages which are:-

1. Comparison between the list of site overhead factors collected from the previous literature review study phase and the applied Egyptian site overhead assessment of factors technique's that is adapted by the first and the second categories of construction companies in Egypt, from the participating Egyptian experts opinions; and
2. Collection of the required site overhead data for a number of projects in Egypt to be used during the analysis phase and the design of a site overhead cost assessment model.

The findings from the previous Chapter served as key source in the identification of the main factors affecting site overhead costs for building construction projects, based on an extensive review for the previous studies conducted in this area of work Table (2-2). Such factors mainly include project's need for specialty contractors, percentage of sub-contracted works, consultancy and supervision, contract type, firm's need for work, type of owner/client, site preparation needs, project's tight time schedule, need for special construction equipment, delay in project's duration, firm's previous experience with project's type, legal environmental and public policies for the home country, project's cash-flow plan, project's size, and project's location. This Chapter will be slanted to shed a great deal of light on the area of the percentage of site overhead costs for building construction projects in Egypt.

3.2 Seeking Experts Opinion

This is one of the most important phases of this research methodology, as it incorporates a detailed evaluation of the developed list for site overhead cost factors in building construction projects and making the necessary adjustments on it in-order to make it fit to be used during the origination of the model. Such factors mainly identified based on the experts opinions from selected groups of prominent industrial professionals and qualified academicians from the two prominent universities in Egypt. The principal objective of this survey study was to reinforce the potential model, based on the expert's opinions from the aforementioned expert professionals. This study will eventually lead to the modification of the developed potential list of factors previously identified in Table (2-2) if required.

Expert opinion included the reviews from nineteen prominent industrial professionals and sixteen qualified academicians from the American University in Cairo and the Arab Academy for Science, Technology and Maritime Transport (Cairo and Alexandria branches). Reviews from experienced industrial professionals were essential for developing the overall model as these professionals are directly associated with the leading Egyptian building construction firms. Where, as the reviews from building construction academicians are vindicated by the fact that academicians are the professionals who have strong influence on national research and scientific work.

Each expert from both contractor and academic background were approached based on their personnel experiences. Half of the responses were obtained via personnel interviews and the other half were obtained through delivering the questionnaire and collecting back the same, E-mail or Fax.

As this phase of seeking expert's opinions consist of the walk-through observations of the selected specified industrial professionals and academicians connected to the construction industry. These reviews provided us with qualified remarks and suggestions, which will lead to making the necessary alterations on the list of the previously identified overhead cost factors to make it adaptable to the Egyptian building construction industrial market. This is an essential step to have a more firm and yardstick final model for the assessment of the percentage of site overhead costs for building construction projects, in Egypt.

3.3 Data collection

This phase is divided into two stages, first stage is to perform a comparison between the overhead cost factors from the comprehensive literature study and the Egyptian construction industry for the identification of overhead costs factors for building construction projects, in Egypt. The second stage is to collect data for as much as needed projects from several construction companies that represent the first and the second categories of construction companies, in Egypt.

3.3.1 The questionnaire

In the first section of the data collection process, a questionnaire was prepared to investigate the main factors affecting site overhead cost for building construction projects, in Egypt. (Appendix **A**)

The questionnaire consisted of three sections, the first section contained nine (**Yes or No**) questions to confirm or eliminate any of the list of factors that have been collected previously from the literature review study Table (2-2). The second section is where the experts illustrate the factors currently accounted for by construction firms, in Egypt. The third section is where the experts are asked for their own opinions for the factors that are not accounted for and should be in-order to stroll with the construction industry, in Egypt. The characteristics of the participating experts, the contractors and the academicians are setting the basis for the findings of this study. The mentioned characteristics of contractors include their personnel professional experience, size of the firm they are associated with. The distinctiveness of academicians described includes their designation, area of specialization and essentially their years of experience.

Experts for this extensive research are very scrupulously identified to obtain comprehensive and precise results. The highly capable experts were selected among the practicing, experienced contractor's professionals in Egypt and the highly qualified academicians from the two renowned universities not only in Egypt, but in the entire region in the field of building and construction engineering.

3.3.2 Academicians

Academicians are the professionals, who have strong influence on national research and scientific work. As part of this thesis, expert appraisals from faculty members belonging to Construction Engineering and Management or Civil Engineering fields from two prestigious universities in Egypt (AUC & AAST). The Academicians engaged for this research are icons from academia. Their expertises are articulated by the fact that, seventy percent of the respondents are either Professor or Associate Professor in the two renowned universities. Majority of the academic experts involved are PhD. holders from the most renowned universities in United States of America, Europe, and a few of them received PhD. from the prestigious Egyptian universities. Along with the aforementioned colossal qualification levels, the traits of the participating academic professionals include their experience, classified based on the number of years in academia. Thirty one percent of the interviewed experts are dedicating their services to the academic discipline from more than 20 years. Another forty four percent of the academic experts have 10-20 years of practicing experience (twenty five percent have from 15-20 years and nineteen percent have from 10-15 years) and twenty five percent have less than 10 years of professional experience in academia. Figure (3-1)

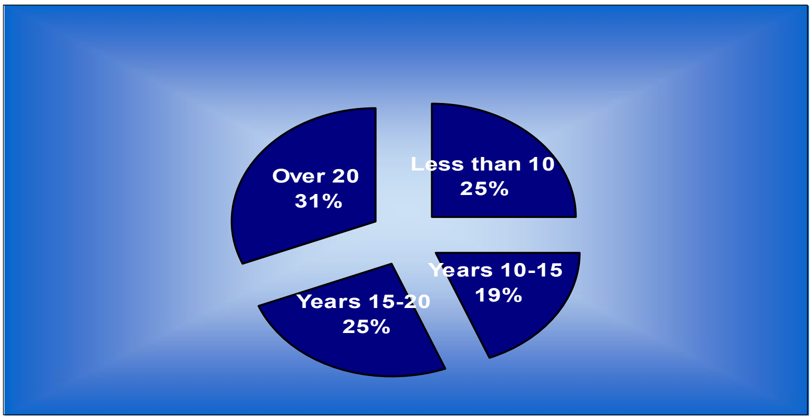


Figure (3-1) Academicians Years of Experience

3.3.3 Contractors

The participating contractors (Cost Estimating Engineers) are highly experienced professionals from the construction industry. About fifty percent of the experts have more than 20 years of professional experience in the construction business. The remaining has experience less than 20 years. These vastly experienced industry professionals occupy senior and highly ranked administrative positions within their firms. Seventy percent of the experts are ranked as General Managers Engineers. The remaining thirty percent work as project cost estimating engineers. The participants work for successful construction firms belonging to the first and the second categories of construction companies, in Egypt. Twelve experts work for first category construction companies, five experts work for second category construction companies, and two experts work for a major construction consultancy firm all within Egypt. Figure (3-2)

The views of the contracting experts from firms of different grades were sought to get a more diversified and comprehensive reviews. Along with possessing the professional work experiences, expertise in the domain of building construction, cost estimating, and contracting fields, it is justifiable to infer that the construction industry professionals identified for this research have adequate knowledge of activities and functions associated with construction cost estimation and building construction project management.

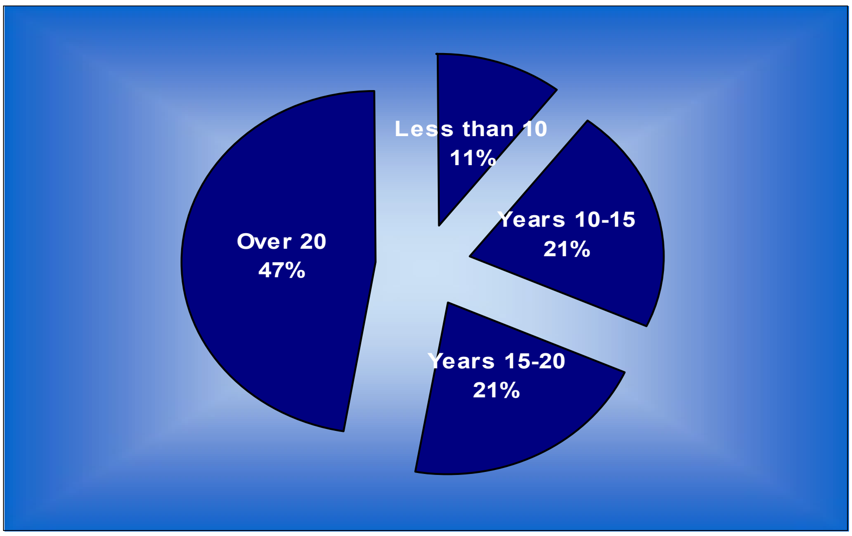


Figure (3-2) Contractors Years of Experience

The analysis of the collected questionnaires illustrated that there is a difference between the factors that govern the assessment of building construction site overhead cost in Egypt and the list of factors collected from the extensive literature review study performed in the previous Chapter, which was summarized in Table (2-2). Many factors are not accounted for in Egypt due to it's insignificance in the local market while it is a great contributor in both Europe and North/South America construction markets. Moreover in Egypt there is a trend between contractors to combine two or more contributing items in one main factor, the academicians contravened that behavior and characterized it to be an unprofessional attitude because it depends entirely on the person that is performing the task and his/her experience with the project on hand (personalization). So after cross-matching and making the necessary alterations on the questionnaires collected from both the contractors and academicians, in Egypt. A final list of factors was generated that represent both the parties and it can accurately represent the factors that contribute to the building construction site overhead cost percentage in the Egyptian construction market, Table (3-1).

Table (3-1)

Factors Contributing to Construction Site Overhead Cost Percentage In Egypt

No.		Factor
1	-	**Construction Firms Category.**
2	-	**Project Size.**
3	-	**Project Duration.**
4	-	**Project Type.**
5	-	**Project Location.**
6	-	**Type-Nature of Client.**
7	-	**Type of Contract.**
8	-	**Contractor-Joint Venture.**
9	-	**Special Site Preparation Requirements.**
10	-	**Project need for Extra-man Power.**

- **Collected from the Participating Egyptian Experts Experiences, by a Questionnaire.**

3.4 Comparative assessment of building construction site overhead cost percentage associated with each site overhead constituent (Factor)

In this section, a comparative analysis is performed between building construction site overhead cost and each constituent of site overhead regarding building construction projects, with the aid of (**52**) completed building construction projects. These projects were executed during the seven year period from 2002 to 2009. Such projects were collected from different locations in Egypt. The comparison is made in terms of cost influence for each factor on the percentage of site overhead cost in order to recognize and understand the governing relationship between each factor and the percentage of site overhead cost.

It must be illustrated that for all the projects collected the adapted construction technology was typical traditional reinforced concrete technology. This is due to the participating experts opinion, because that technology represents over (**95**%) of the adopted building construction technology, in Egypt. Contrarily if any specific construction technique is required for a certain project it must be accounted for by the construction firm cost estimating department in an exceptional manner.

The collected projects represent several construction circumstances that differs in many factors, starting from the location of the project having projects constructed inside the boundary of the city and projects in a rural area, projects that needed extra man-power during some periods of the project time, projects executed by different construction companies that represents both the first and the second categories of construction companies, projects with different projects time duration, projects with different contract types, projects with different size measured by the total project contract value, different type of client having a private or public owners are represented with projects, also having projects that needed special site preparation requirements, Contractor-Joint Venture on the same project are also represented by projects, and also the influence of projects type having residential buildings and different non-residential building projects, all are discussed through out this research study. These needed projects data were collected from many construction companies with the help of a data collection sheet which is attached at the end of this thesis. (Appendix **B**)

It is imperative to clarify that the percentage of site overhead cost herein mentioned in this research study is calculated by dividing the total cost of site overhead by the total contract value (total bid amount).

To maintain the confidentiality of the data, no information regarding the operator was identified and only aggregate statistics are presented herein. The collected data will be summarized in (Appendix **C**) at the end of this thesis.

3.4.1 The influence of project size on the percentage of site overhead cost

- **Project size**

The projects were characterized by the total projects contract amount (EGP.). That gave us seven classification groups, starting with a group of four projects with total contract amount under fifteen million Egyptian pounds, five projects with total contract amount under thirty million Egyptian pounds, nine projects with total contract amount under sixty million Egyptian pounds, twenty-five projects with total contract amount under two hundred and fifty million Egyptian pounds, four projects with total contract amount under five hundred million Egyptian pounds, five projects with total contract amount over five hundred million Egyptian pounds and under one billion Egyptian pounds, and four projects with total contract amount over Egyptian pounds. For each group the average mean value for the percentage of site overhead was calculated in-order to represent the percentage of site overhead that is sufficient for the success of a project having the same total contract amount. The results of this analysis are shown in Table (3-2) and Figure (3-3).

Table (3-2)

Contract Value and the Percentage of Site Overhead Cost

Total Contract Value (V) (EG. Pounds)	Percentage of Site Overhead (%)	
	Range	Average
(V) ≤ 15 (Million)	(6.0 – 7.6)	(6.69)
(V) ≤ 30 (Million)	(6.5 – 9.347)	(7.37)
(V) ≤ 60 (Million)	(7.3 – 11.5)	(9.55)
(V) ≤ 250 (Million)	(7.8 – 13.5)	(10.05)
(V) ≤ 500 (Million)	(10.68 – 11.09)	(10.87)
500 (Million) < (V) ≤ Billion	(10.86 – 11.0)	(10.93)
(V) > Billion EGP.	(10.9 – 11.3)	(11.06)

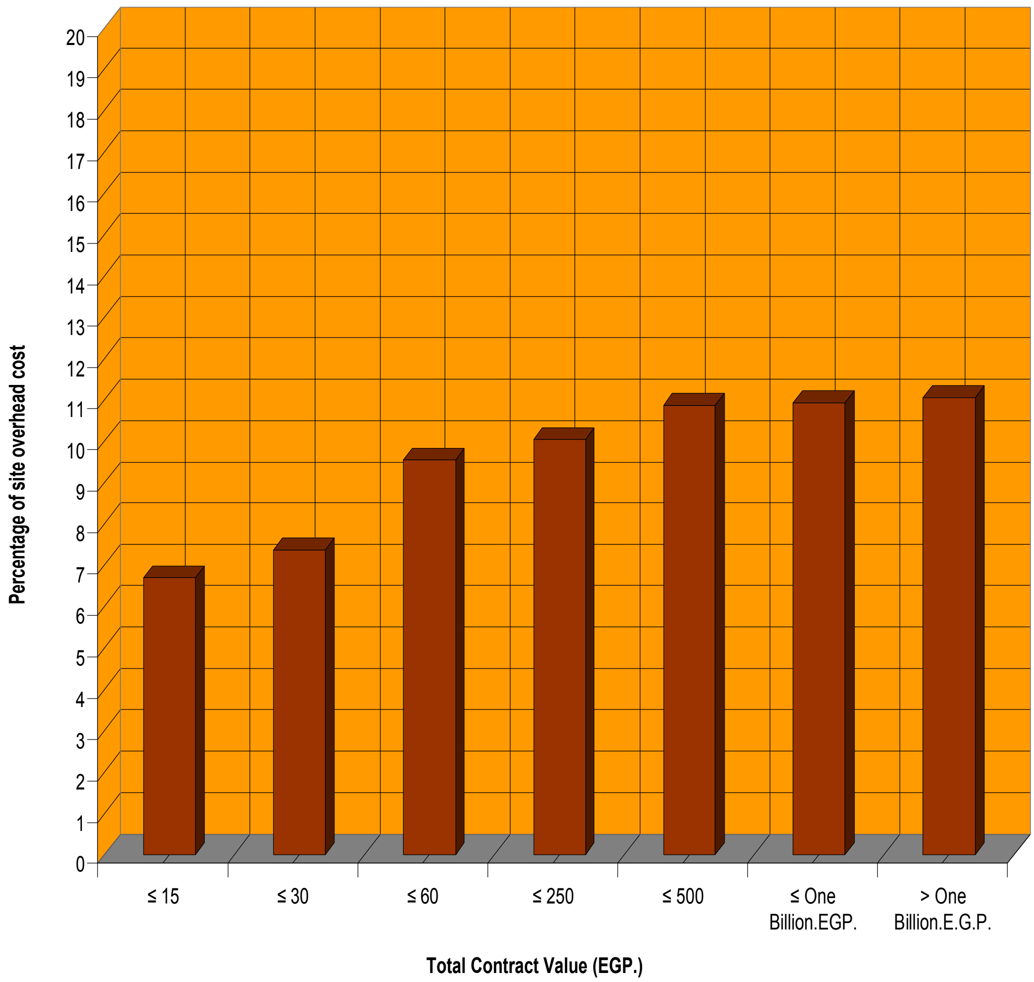


Figure (3-3) Site Overhead Percentage vs. Total Contract Amount

A careful inspection to Figure (3-3) clearly shows that there is a directly proportional relationship with a certain ratio between the total contract value and the percentage of site overhead cost for the building construction projects in Egypt, for both the first and the second categories of construction companies.

3.4.2 The influence of projects duration on the percentage of site overhead cost

- **Project duration**

All the construction firms in Egypt attribute great attention to the projects duration for it includes two crucial and significant items that must be accounted for while performing the necessary calculations, which are:

1. Total project duration; and
2. Project time-delay factor.

The projects collected were characterized with its wide variety, they were classified into six groups, starting from a group of projects with total duration under (**18**) months, till reaching a group of projects with total projects duration that exceeds (**48**) months. The results of this analysis are shown in Table (3-3) and Figure (3-4).

Table (3-3)
Project Duration and the Percentage of Site Overhead Cost

Total Projects Duration (Month)	Percentage of Site Overhead (%)	
	Range	Average
18 Months and Under	**(6.0 – 9.1)**	**(7.18)**
From **18** to **24**	**(7.0 – 10.0)**	**(8.45)**
From **24** to **30**	**(7.8 – 10.64)**	**(9.58)**
From **30** to **36**	**(8.0 – 11.0)**	**(10.27)**
From **36** to **48**	**(10.82 – 12.0)**	**(11.18)**
More than **48** Months	**(11.0 – 13.5)**	**(11.71)**

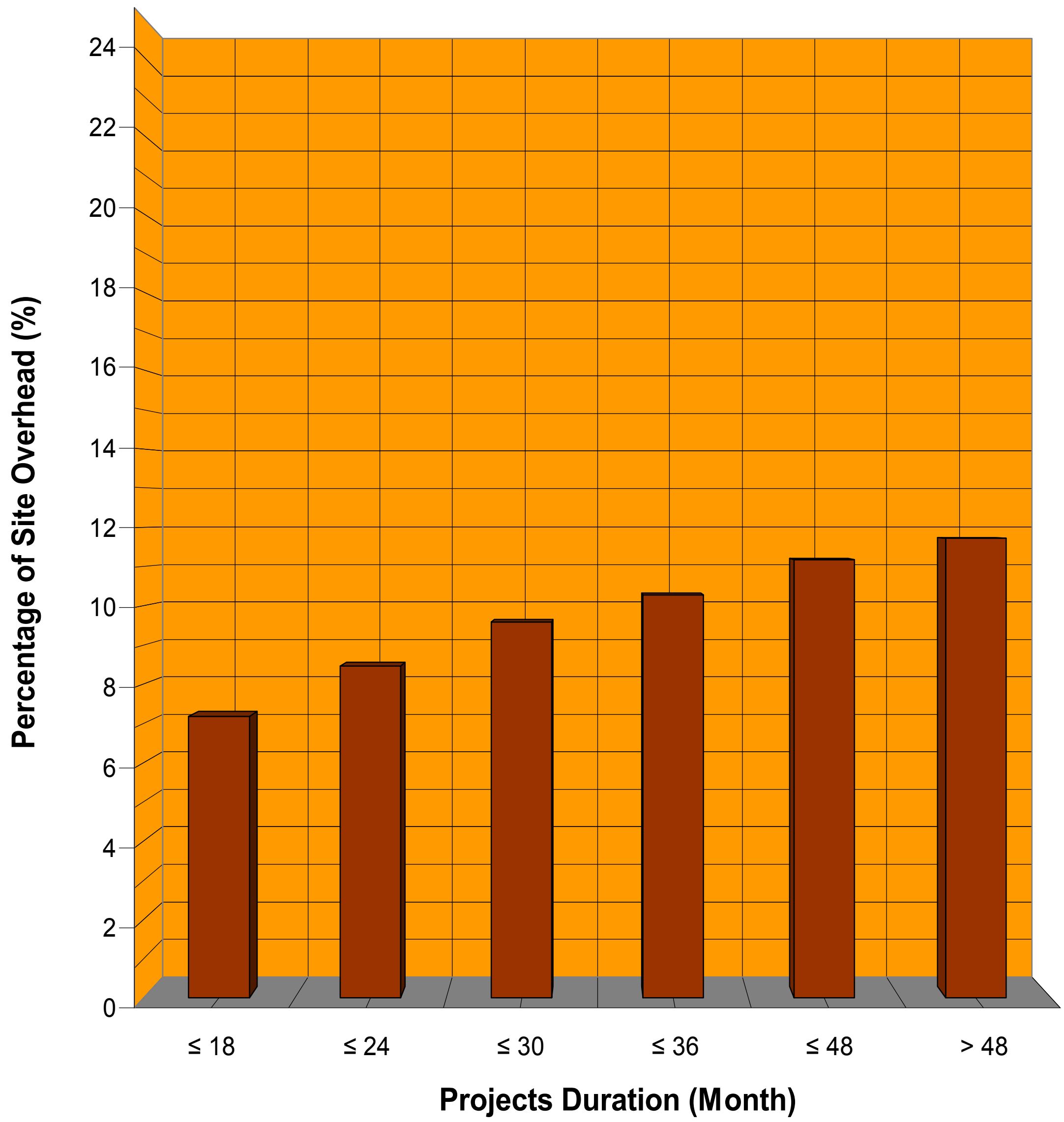


Figure (3-4) Site Overhead Percentage vs. Projects Duration

As illustrated from the analysis shown in Figure (3-4) projects duration has a large effect on the percentage of site overhead cost, which clarifies and proves the fact that there is a directly proportional relationship with a certain ratio between the projects duration and the percentage of site overhead cost for the building construction projects, in Egypt.

3.4.3 The influence of project type on the percentage of site overhead cost

- **Project type**

Project type, characteristics or purpose they all lead to one important and crucial meaning, the client/owner future needs or demands that must be satisfied completely by the project on many different but yet parallel and non negotiable terms which are:

- Client/Owner demands and requirements for the project;
- Projects architectural designs;
- Projects total quality management plan;
- Projects safety program during and after construction; and
- Projects building construction requirements.

The collected projects were carefully chosen to represent most of the common known projects types that are constructed on a frequent bases in Egypt, and they are as follows, seven bank projects, sixteen office buildings projects, eleven multi-purpose housing facility projects, two sports facility (clubs) projects, six malls and shopping centers projects, four educational institutes projects, five restaurants and hotels projects, and one multi-villa compound project. The difference in project type can make an enormous change in the total project contract value and the percentage of site overhead cost, due to the changes that occur in the above mentioned items for each project type. The results of this analysis are shown in Table (3-4) and Figure (3-5).

Table (3-4)

Projects Type and the Percentage of Site Overhead Cost

S/N	Project Type	Percentage of Site Overhead (%)	
		Range	Average
1	Sporting Clubs	(7.8 – 8.0)	(7.9)
2	Multipurpose Housing Facility	(6.0 – 11.02)	(8.06)
3	Office Buildings	(7.2 – 11.43)	(9.27)
4	Schools and universities	(8.5 – 11.0)	(10.25)
5	Banks	(8.13 – 11.71)	(10.24)
6	Restaurants & Hotels	(9.54 – 11.09)	(10.66)
7	Villas Compounds	(10.5)	(10.5)
8	Malls & Shopping Centers	(10.9 – 13.5)	(11.7)

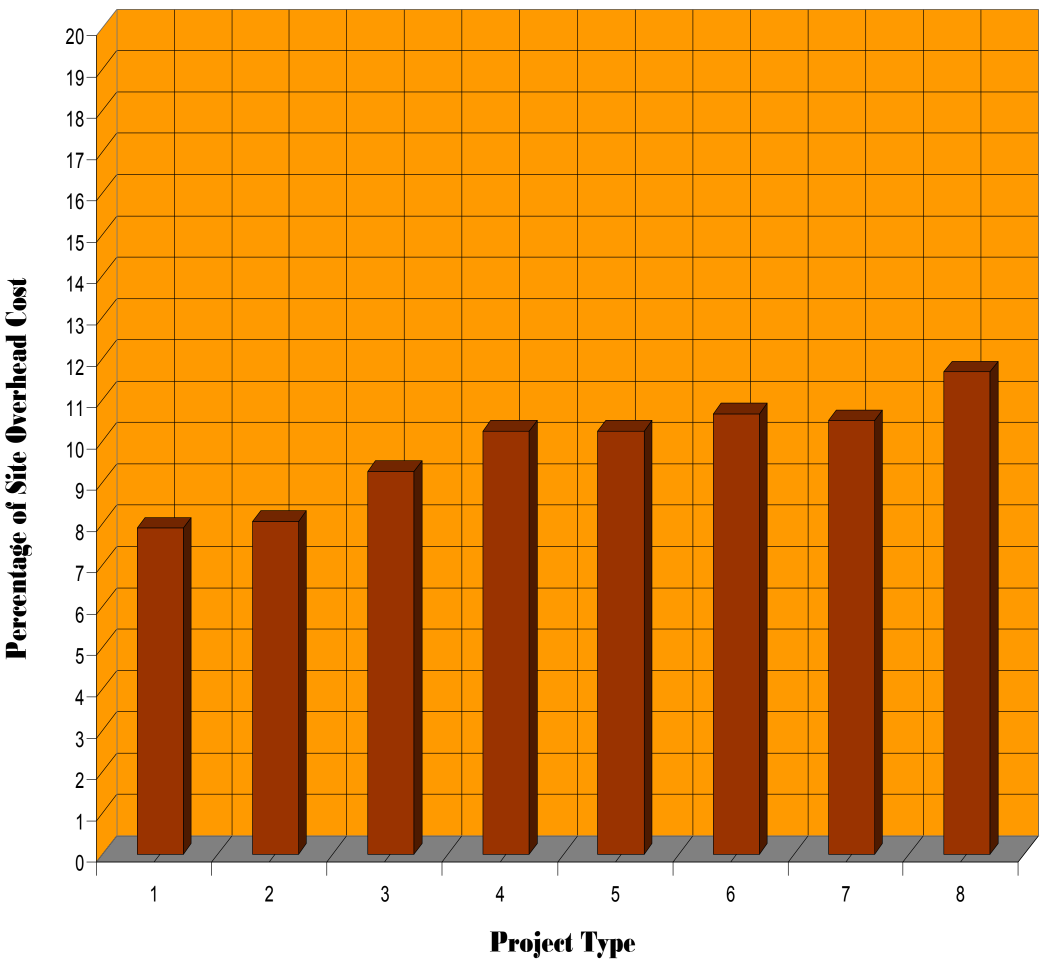


Figure (3-5) Site Overhead Percentage vs. Project Type

By the analysis of the collected data shown in Figure (3-5) it was found that, the percentage of site overhead cost is affected by the project type, due to the enormous engineering demands and final project purpose that differ between each project type. After calculating the average mean value for the percentage of site overhead cost in each of the eight categories the lowest mean value was (**7.9**%) which was for the sporting clubs projects and the highest mean value was (**11.67**%) for malls and shopping center projects. Projects like multi-purpose housing facility projects, office buildings projects, educational projects, bank projects, and restaurants/hotels projects, they all had an average mean value that came within that range (7.9-11.67%).

Thus, the governing relationship between the percentage of site overhead cost and the project type is found to be a non-homogeneous relationship that cannot be formulated into an equation nor can be related to a governing formula, but it can only be linked directly to one of the above mentioned categories that is found to cover most of the building construction industry, in Egypt.

3.4.4 The influence of project location on the percentage of site overhead cost

- **Project location**

The project location is a strong influencing factor on the percentage of site overhead cost for construction building projects in Egypt (Experts opinion). In fact all the construction firms agreed that the first question which is asked about any new project is (What's the location of the project**?)**. During the collection of data phase the main concern was to broader the number of locations/cities (governorates) as much as possible in-order to have at least two to three projects from each project type in each chosen location in Egypt. In order to analyze the collected data in an accurate and more detailed scientific manner. However, this was faced with the traditional problem known in Egypt, you can have what the construction firm will offer, so more effort were given during the analysis phase by performing many individual consultation with many experts from the field in-order to cover any misleading information in the collected data about any certain location. The results of this analysis are shown in Table (3-5) and Figure (3-6).

Table (3-5)

Project Location and the Percentage of Site Overhead Cost

S/N	Project Location	Percentage of Site Overhead (%)	
		Range	Average
1	Inside the City	(6.0 – 11.3)	(8.83)
2	Rural Area	(7.8 – 13.5)	(10.68)

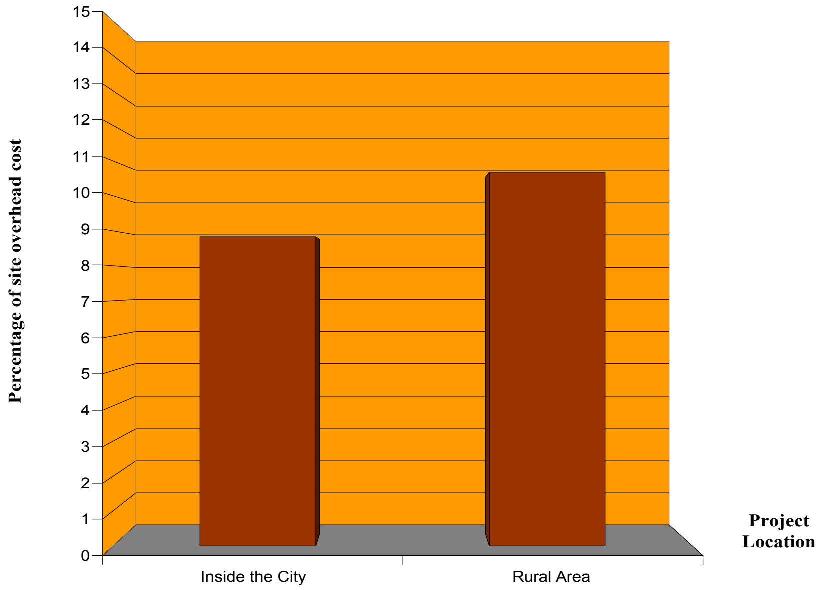


Figure (3-6) Site Overhead Percentage vs. Project Location

The results of the analysis for the collected data shown in Figure (3-6) which were gathered from different locations (governorates), and the opinions of the experts from the field were astonishing due to the rather small difference that separates between the average mean value for the percentage of site overhead cost which is (**8.83**%) inside any given city boundary and the average mean value for the percentage of site overhead cost which is (**10.68**%) in a rural area (desert area's, new settlements zones, countryside…etc.). Some experts related that to the large contract amount for the collected projects that represented the (inside the city) category (55% from the total projects), while most of the contract values of the other collected projects that represented the (rural area) category (45% from the total projects) were of projects with smaller total contract amount.

3.4.5 The influence of nature of client on the percentage of site overhead cost

- **Nature of client**

The nature of the client is an essential contributing factor not only for the percentage of site overhead cost, but it exceeds that to reach wither or not the firm will seek to handle the project. This is because this factor is one of the main indicators for the client's financial capital prospective and cash-flow capabilities, which are main factors that construction firms seek to insure before even deciding to tender for any given project. The results of this analysis are shown in Table (3-6) and Figure (3-7).

Table (3-6)

Client Nature and the Percentage of Site Overhead Cost

S/N	Client Nature	Percentage of Site Overhead (%)	
		Range	Average
1	Public Identity	(7.2 – 11.43)	(8.68)
2	Private Client	(6.0 - 13.5)	(9.81)

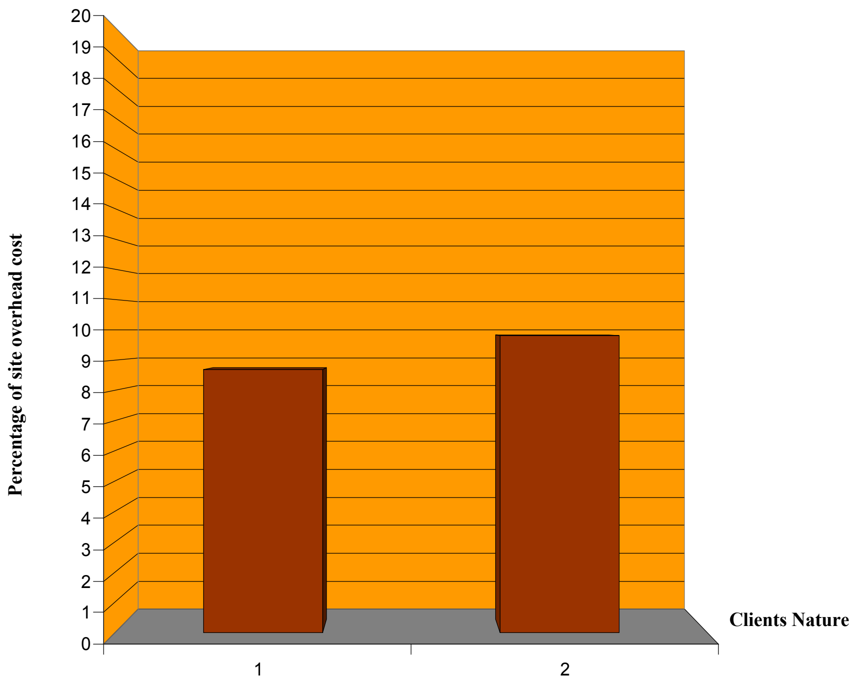


Figure (3-7) Site Overhead Percentage vs. Clients Nature

The analysis shown in Figure (3-7) were the collected projects data are categorized into two categories, the public identity where the client is the government in some way or another and they represented nearly (20%) from the total number of collected projects and it was found that their average mean value for the percentage of their site overhead cost is (**8.68**%). Then came the private identity where the client is either, a company with large number of participating investors or a single investor that will finance/own the project and even the international identity (investor) where the client is an international non Egyptian owner/organization that will finance and own the project and they represented around (80%) from the total number of collected projects and it was found that their average mean value for the percentage of their site overhead cost is (**9.81**%). This difference in the percentage of site overhead cost can be related to many items that differs between the two as the, high technical engineering site specifications requirements, the high quality control measures required, projects safety demands, the high competition between construction contractors to wine a governmental project contract due to their assured ability to secure the needed cash-flow plan while limiting the chance of having change order during the construction duration, and the very strict project management plane that are a main policy for the private client either this client was local or foreigner investor.

3.4.6 The influence of contract type on percentage of site overhead cost

- **Type of contract**

The type of contract was and will always be the most important and critical element in the building construction work package. First the contract is the document that will save the firms rights and obligations towards the client. Secondly depending on the type of contract that will be used, all the departments will have to make the necessary changes that must be done for each type of construction contract. There are many types of contracts that are used in Egypt, but due to the availability and the experts opinions this study will focus on only two of the most widely used types of contracts:

1. Cost plus Contracts;

2. Fixed Price Contracts:

  A. Unite price Contracts; and

  B. Lump-sum Contracts.

For documentation these two types of construction contracts represents the most commonly used contracts in Egypt (Experts opinion), The results of this analysis are shown in Table (3-7) and Figure (3-8).

Table (3-7)

Contract Type and the Percentage of Site Overhead Cost

S/N	Contract Type	Percentage of Site Overhead (%)	
		Range	Average
1	Fixed Price Contracts	(6.0 – 13.5)	(9.47)
2	Cost Plus Contracts	(7.3 – 11.43)	(10.36)

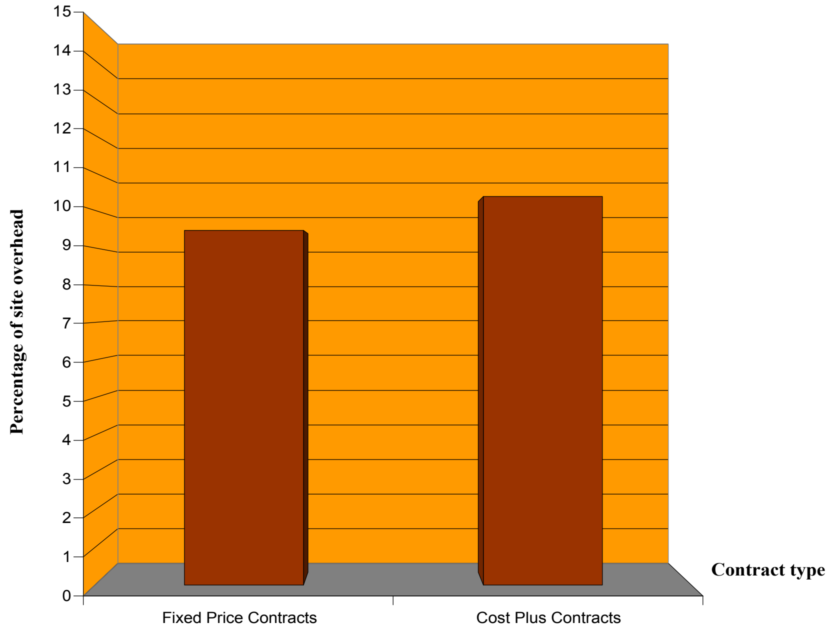


Figure (3-8) Site Overhead Percentage vs. Contract Type

After the analysis shown in Figure (3-8) for all the collected projects it was found that the percentage of site overhead costs for building construction projects changed between the projects that used the two most adopted contract types, in Egypt. Fifteen percent (15%) of the collected projects had cost plus contracts and their average mean value for the percentage of site overhead cost was found to be (**10.36**%), while eighty five percent (85%) of the collected projects contracts were fixed price (unite rate or lump-sum) contracts with an average mean value for their percentage of site overhead cost equal to (**9.47**%).

The analysis demonstrates that the fixed price contracts are the most commonly used in Egypt and it's percentage of site overhead cost is lower than the second most adopted contract type. This may clarify the reason that construction firms find fixed price contracts to be the most effective kind of building construction contracts for the Egyptian building construction market.

3.4.7 The influence of contractor-joint venture on percentage of site overhead cost

- **Contractor-Joint Venture**

Many construction projects are broken down into many sub-projects or even into sub-items and then distributed among two or more construction companies; by this we mean alliance between different construction firms on the same project, but on different projects activities and/or phases. This trend is widely used in Egypt for many financial and/or technical purposes. The results of this analysis are shown in Table (3-8) and Figure (3-9).

Table (3-8)

Contractor-Joint venture and the Percentage of Site Overhead Cost

S/N	Contractor-Joint venture	Percentage of Site Overhead (%)	
		Range	Average
1	Yes	(7.2 – 12.0)	(10.31)
2	No	(6.0 - 13.5)	(8.95)

Contractor-joint venture is a well known building construction tradition in Egypt among the construction firms and it appears greatly in all the large building construction projects for many client and/or project specific technical specifications. This factor is found to have a great magnetite on the percentage of site overhead cost. Contractor-joint venture is a completely different construction trend than the sub-contracting trend which is also widely used in Egypt, but is not discussed during this research study.

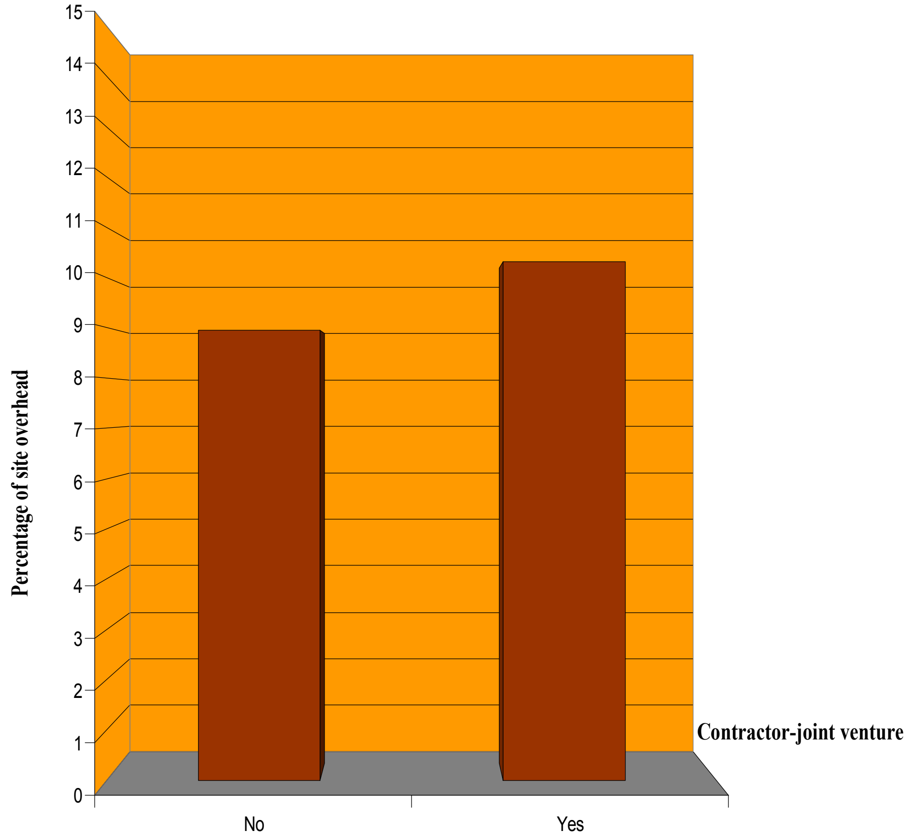


Figure (3-9) Site Overhead Percentage vs. contractor-joint venture

After the analysis and calculations shown in Figure (3-9) for the percentage of site overhead cost in the projects that did not have a contractors-joint venture which represented exactly (50%) from the total collected projects data the average mean value was found to be (**8.95**%), while the other (50%) that had contractors-joint venture the average mean value for the percentage of site overhead cost was (**10.31**%) from the total contract amount of these projects. This was explained and linked to the fact that when there is a contractor-joint venture on the same construction project each contractor require and prepares additional site and project preparations either permanent or non-permanent requirements, such as: project permanent staff assignment, work preparation, company's engineering site requirements demand, transportation of project's staff.

3.4.8 The influence of special site preparation requirements on the percentage of site overhead cost

- **Special site preparation requirements**

The site preparation in some construction projects can affect the percentage of site overhead cost tremendously. In some projects there will be a need for special construction equipment that will need a special site preparation requirement which definitely will increase the cost of site overhead for this project by an unimaginable amount. The following are some site preparation requirements taken from previously constructed building construction projects, in Egypt:

1. The need for the construction of a temporary accesses roads to the project;
2. The need for the construction of a security fencing around the whole project site;
3. The need for a special construction equipment needed for this particular project;
4. The need for temporary project staff accommodations preparations; and
5. The need for the construction of a warehouse for the materials.

The results of the analysis for the effect of site preparation requirements on the percentage of site overhead costs are summarized in Table (3-9) and Figure (3-10).

Table (3-9)

Special site preparation requirements and the Percentage of Site Overhead Cost

S/N	Special site preparation requirements	Percentage of Site Overhead (%)	
		Range	Average
1	Yes	(10.5 – 13.5)	(11.33)
2	No	(6.0 – 12.0)	(9.00)

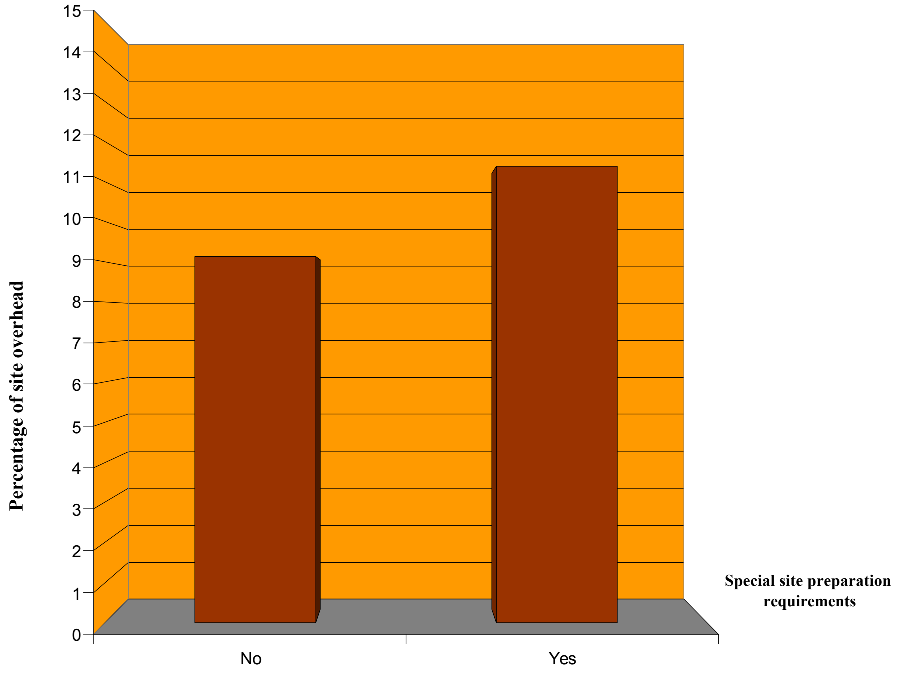


Figure (3-10) Site Overhead Percentage vs. Special Site Preparation Requirements

After the inspection of Figure (3-10) it is clear that, special site preparation requirements has a great influence over the percentage of site overhead costs in a directly proportional relationship. Thus, it can be clearly stated that special site preparation needs, is a crucial and important factor during the assessment of site overhead percentage in the bid document preparations phase.

3.4.9 The influence of project need for extra-man power on the percentage of site overhead cost

- **Need for extra-man power**

The need for extra-man power on any building construction project means extra labor working hours. Thus, more money that has to be paid, this of course is due to many factors, such as:

- Need to crash-time;
- Delay-in-time by the Contractor; and
- Certain project characteristics.

During the data collection phase all the construction firms that helped with the data collection emphasized on the importance of this factor as an essential and crucial element during the bid documentation stage. They gained their feeling of importance for this factor from their previous experiences. Fifty percent of the collected projects needed extra-man power in order to fulfill the project on hand, while the other fifty percent did not need any extra-man power during the entire time period of these projects in-order to complete them. The results of this analysis are shown in Table (3-10) and Figure (3-11).

Table (3-10)

Project need for extra-man power and the Percentage of Site Overhead Cost

S/N	Project need for extra-man-power	Percentage of Site Overhead (%)	
		Range	Average
1	Yes	(8.1 – 13.5)	(10.9)
2	No	(6.0 – 10.892)	(8.32)

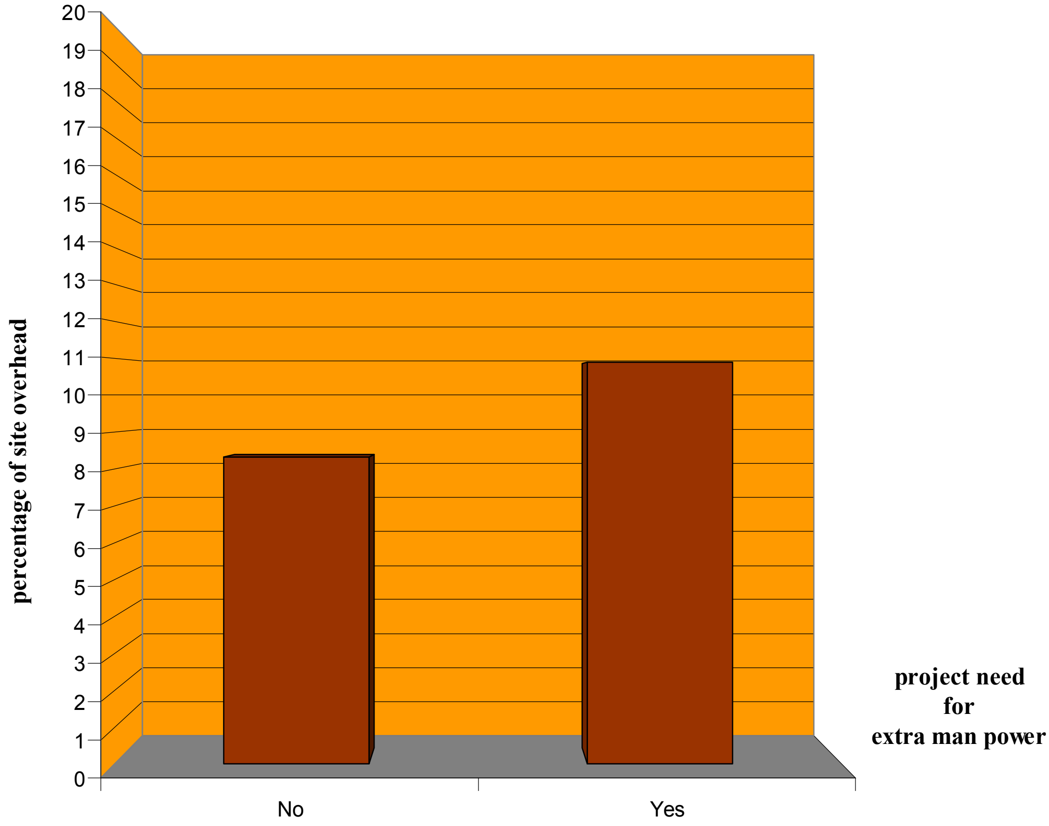


Figure (3-11) Site Overhead Percentage vs. Need for Extra-man-power.

The analysis shown in the Figure (3-11) explained the enormous effect that the need for extra-man-power have on the percentage of site overhead cost, fifty percent of the collected projects needed extra-man-power that lead to having an average mean value for the percentage of site overhead cost equal to (**10.9**%). The other fifty percent did not need any extra-man-power during the construction period of these projects that lead to having an average mean value for the percentage of site overhead equal to (**8.32**%).

3.4.10 The influence of contractor/firm category on the percentage of site overhead cost

- **Contractor category**

In Egypt there are several categories for construction companies, those categories are an indicator to their financial, professional experiences, and the total permanent hired qualified man-power. Many of the owners/clients clearly identify in their tender documents proposals the category of construction firm that can apply for their given projects.

- ***Impetuses behind Benchmarking or Standardizing the Contractors firms***

The stated goal of defining a benchmark contractor in Egypt was to "raise the standards of the practice of the contractors", thus benefiting all parties involved in the construction industry, including peoples (the final beneficiaries).

Alter and Sims, enlighten that the impetuses or the driving force behind the need for certifying or qualifying or benchmarking a contractor as defined by American Institute of Construction is to **(6)**:

1. Increase specialization of construction processes and organizations;
2. The need for closer coordination and cooperation;

3. Owners placing more emphasis on management skills, service delivery and the execution of projects by demanding better performance, productivity and quality in the construction process;
4. More involvement by construction contractors in direct consultation with projects owners;
5. A more diverse work force;
6. Increasing governmental regulation with regard to working conditions, hiring practices and safety;
7. Decreasing profit margins throughout the industry;
8. Increasing the complexity of the construction project;
9. Declining image of construction work and workers; and
10. Need for implementation of new technologies in the construction process.

This research study focused only on the first and the second categories of construction companies, in Egypt, as they represent the pack-bone of the construction industry and due to the important fact that they are the only two construction categories having a large and as much detailed data base for their construction projects as possible. More importantly, most of them possess the two most important departments needed to fulfill this research study which are: The Cost Estimation and Construction Management Departments. The results of this analysis are shown in Table (3-11) and Figure (3-12).

Table (3-11)

Contractors Firms Category and the Percentage of Site Overhead Cost

S/N	Contractors category	Percentage of Site Overhead (%)	
		Range	Average
1	First category	(7.8 – 13.5)	(10.54)
2	Second category	(6.0 – 11.5)	(8.41)

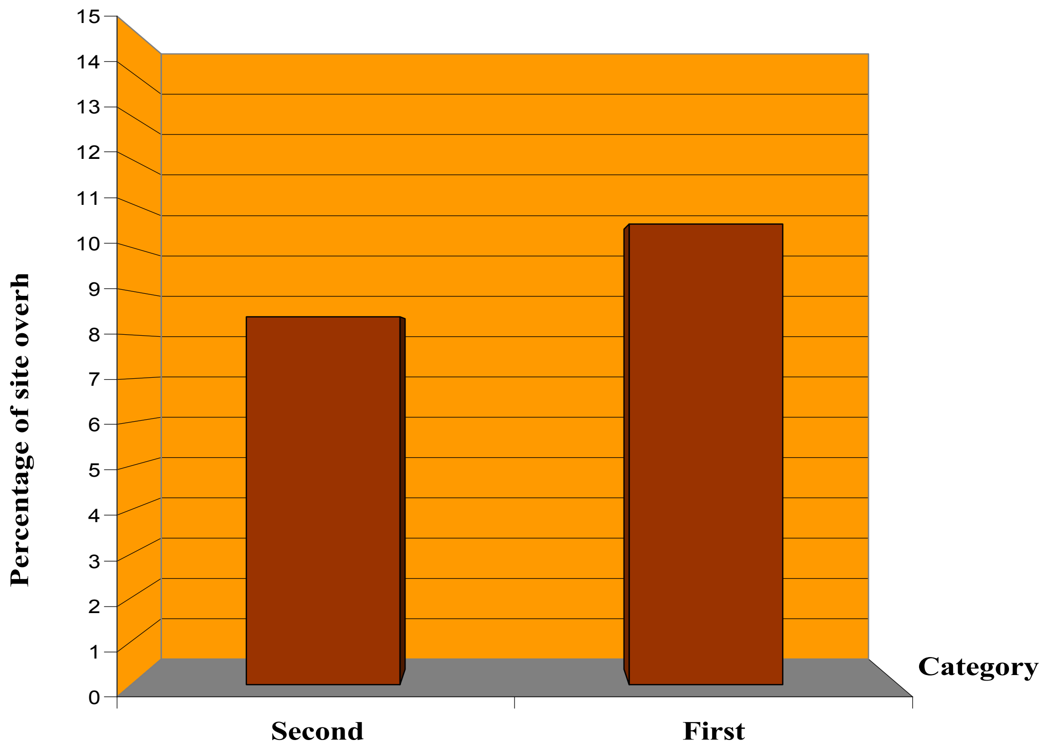


Figure (3-12) Site Overhead Percentage vs. Construction Firm Category.

After a careful inspection to Figure (3-12) it is clear that in-spite of the enormous difference between the two categories in the types of projects that are handled by each from the total contract value point of view or projects original planned time, and the experiences that handle the daily works at any project site. Astonishingly, the results that were revealed by the data analysis for the (52) collected building construction projects data unraveled the following, sixty five percent of the projects that had been constructed by a first category construction company their average mean value for the percentage of site overhead costs reached (**10.54**%) from the total projects contract amount. While the remaining thirty five percent of the projects were constructed by a second category construction company and after calculating their average mean value for the percentage of site overhead costs it was found to be (**8.41**%) from the total projects contract amount.

This was related to many factors from the field expert's point of view, such as: the longer durations of the project, total quality management expenses, and most importantly the large difference in the projects size that a first category construction company will takeover.

3.5 Summary

The major and minor finding of the entire research was summarized in this part of the research. Based on the findings the current and further recommendations are developed as the base for further research in the very context of building construction projects overhead cost for the first and the second categories of Egyptian construction companies.

The analysis illustrated many facts that needed to be clarified and understood about the percentage of site overhead costs for building construction projects in Egypt, those facts will be the structure (backbone) for the development of an Artificial Neural Network Based (ANN-based) Model, for the assessment of site overhead cost as a percentage from the total contract amount for building construction projects, in Egypt. This can be simply summarized in the following three facts:

- **A.** Through the literature review and the expert's opinions ten potential factors that are found to influence the percentage of site overhead costs for building construction projects in Egypt, were identified.
- **B.** The analysis of the collected data gathered from fifty-two real-life building construction projects from Egypt during the seven year period from 2002 to 2009, illustrated that project duration, total contract value, project type, special site preparation needs, and project location are identified as the top five factors that affect the percentage of site overhead costs for building construction projects, in Egypt.
- **C.** Nature of the client/owner, type of contract, and contractor-joint venture are the lowest affecting factors in the percentage of site overhead costs for building construction projects, in Egypt.

CHAPTER FOUR

SITE OVERHEAD NEURAL NETWORK MODEL

4.1 Introduction

Applications of ANN (Artificial Neural Networks) in construction management in general go back to the early 1980's. These applications cover a very wide area of construction issues (topics). Neural network models have been developed to assist the managers or contractors in many crucial construction decisions. Some of those models were designed for cost estimation, decision making, predicting the percentage of mark up, predicting production rate …etc.

One of the objectives of this study is to develop a neural network model to assess the percentage of site overhead costs for building construction projects. This can assist the decision makers during the bidding document preparation in the Egyptian building construction market. This Chapter presents the steps that were followed to develop the proposed model.

This Chapter describes the design of an ANN model for predicting the percentage of site overhead costs in building construction projects, in Egypt. All factors that affect building construction site overhead costs in Egypt were identified as outlined in Chapter (3). These factors were considered as the input variables for the proposed neural network (ANN) model, while the project's site overhead cost as a percentage from the total project contract amount is considered as the output variable for this model.

N-Connection Professional Software version 2.0 (1997), is based on the Feed Forward Back-Propagation Learning Algorithm Technique, was used to develop, train, test, and validate the designed neural network model structure.

A number of alternative neural network model structures were investigated to obtain the minimum percentage of error (Minimum RMS Value) Table (4-2).

The guidelines of N-Connection 2.0 Professional software, user manual were used to obtain the best model structure. Moreover, for verifying this work the traditional trial and error process was performed to obtain the best model structure.

The following sections presents the steps performed to design the artificial neural network based model (ANN-Based Model).

4.2 Steps to Design the Artificial Neural Network Model

Neural network models are developed through the following basic five steps **(20)**:

1. Define the problem, decide what information to use and what network will do;
2. Decide how to gather the information and representing it (Data Coding);
3. Define the network, select network inputs and specify the outputs;
4. Structure the network;
5. Train the network; and
6. Test the trained network. This involves presenting new inputs to the network and comparing the network's results with the real-life results for the same projects. Figure (4-1)

4.2.1 Define the Problem

As stated earlier in Chapter (1) the percentage of building construction site overhead costs in Egypt is affected by numerous numbers of factors. For this reason, developing the neural network model to predict the percentage of site overhead costs can assist the planners, managers and cost estimation engineers (staff) to save the effort required for projects study and projects total cost estimation during the bid documentation phase, together with the incredible difference in the accuracy percentage and eligibility of the firm's tender documents submitted for any given project, in Egypt.

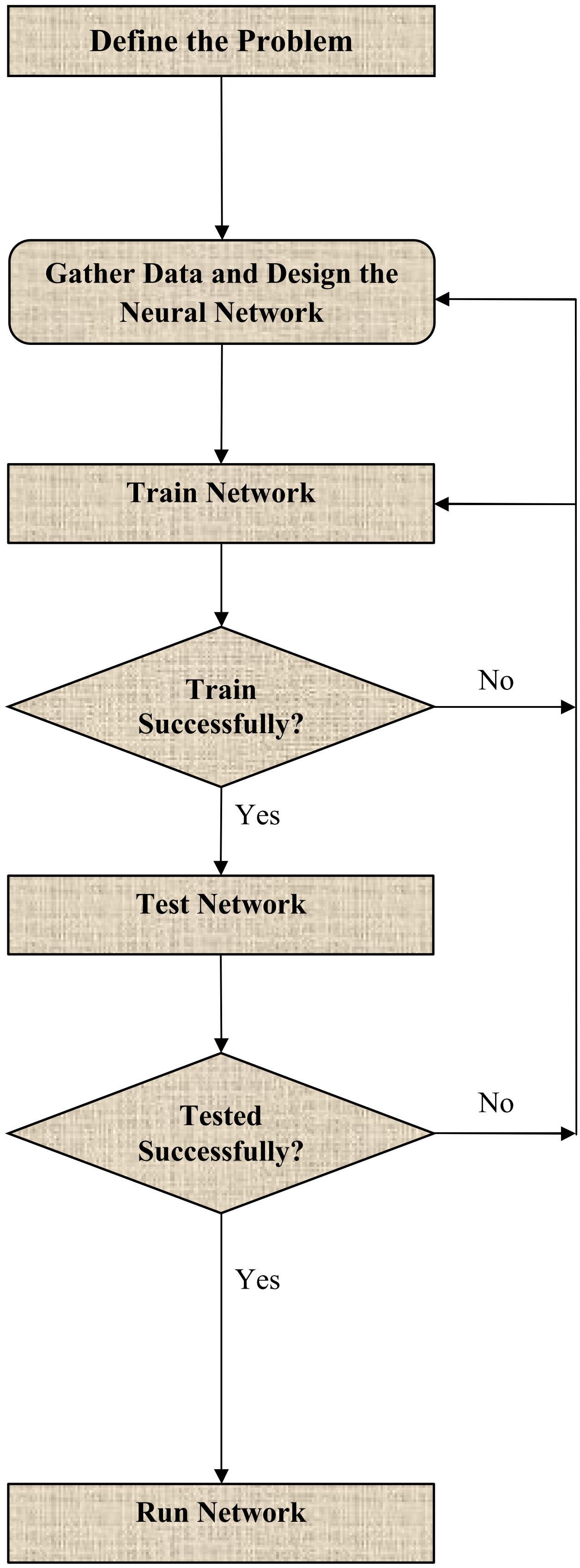


Figure (4-1) Neural Network Design, **(35)**.

4.2.2 Data collection and Design of the Neural Network

All factors that affect the percentage of site overhead costs for building construction projects in Egypt were identified and demonstrated in Chapter (3). After determining these effective factors, data for training and testing the proposed ANN-based model were collected from fifty-two real-life projects constructed in Egypt. These projects included Sporting Facilities, Hotels, Malls, Educational Institutes, Multi-Purpose Housing Facilities and Office Buildings. Data used in model development which were collected from the real-life building projects constructed in Egypt are represented in (Appendix **C**) at the end of this study.

4.2.3 Design of the Neural Network Model

In this step, the following sequences were followed:

4.2.3.1 Selection of the Neural Network Simulation Software

Many design software are used for creating neural network models. As stated earlier in Chapter (2), many researchers used Neural Network software in construction management in general. In this study, the N-Connection Professional Software version 2.0 (1997) (Neural Network Simulation Software) was used to develop the needed Neural Network Model.

This implicational software is very easy to use and its predicting accuracy is very high compared to other software program. It is compatible with Microsoft Windows all versions.

The N-Connection 2.0 software uses the back-propagation algorithm in its engine. The past researches proved that the back-propagation rule is a suitable learning rule for most problems. It is the most commonly used technique for solving estimation and prediction problems **(35)**.

Firstly, in order to design the neural network model the N-Connection 2.0 software, guidelines were used for assistance. Moreover, to verify this research work the trial and error process was used to obtain the best model structure. During this procedure if the network is not trained satisfactory, adding or removing of hidden layers and hidden nodes that are within each hidden layer will be performed until reaching the required acceptable model structure that can predict/assess the percentage of projects site overhead cost percentage with an acceptable error limit. The learning rate, training and testing tolerance are fixed automatically by the N-Connection 2.0 software (**42**).

4.2.3.2 Determining the Best Network Architecture

There are two questions in neural network design that have no precise answers because they are application-dependent: How much data do you need to train a network? And, How many hidden layers and nodes are the best to use? In general, the more facts and the fewer hidden layers and hidden nodes that you can use, is the better. There is a subtle relationship between the number of facts and the number of hidden layers/nodes. Having too few facts or too many hidden layers/nodes can cause the network to "Memorize". When this happens, it performs well during training but tests poorly. The network architecture refers to the number of hidden layers and the number of hidden nodes within each hidden layer. The two guidelines that are discussed in the following section can be used in answering these two very important questions **(42)**.

4.2.3.2.a Determining the Suitable Number of Training Data

Firstly, the number of collected data should be checked if it is enough to train the network and solve the problem on-hand or not.

- **Guideline 1**: Optimum number of projects (Facts) that is needed for the program to training, validation properly and then be tested by the programmer;

- **Minimum Number of Training Facts** (Project) = **2 * (I**nput + **H**idden + **O**utput**)**.
- **Maximum Number of Training Facts** (Project) = **10 * (I**nput+ **H**idden+ **O**utput**)**.

This formula suggests that the number of training facts needed is between two and ten times the number of neurons (Nodes) in your network.

Where:

- Inputs = **10** = Factors that were determined in Chapter (3).
- Output = **1** = Cost of site overhead as a percentage from the total contract amount.
- Hidden = A hidden neurons (nodes) in a hidden layer which stores information needed for network to make predictions.

There are several ways to determine a good number of hidden neurons (nodes). One solution is to train several networks with varying number of hidden neurons and select the one that tests best. A second solution is to begin with a small number of hidden neurons and add more while training if the network is not learning **(42)**.

A third solution is starting to get the right number of hidden neurons by using the guideline **2** as follows:

- **Guideline 2**: Number of Hidden Neurons:

Number of Hidden Neurons = (Input + Output) / 2

(10 + 1) / 2 = **6** Neurons.

Substituting the result of applying the equation of guideline (**2)** in equation of guideline (**1)** introduces the following:

- Minimum Number of training Facts (Projects) = 2 x (10+ 6+ 1) = **34 Facts**.
- Maximum Number of training Facts (Projects) = 10 x (10+ 6+ 1) = **170 Facts**.

The number of the actual data obtained is fifty-two real-life projects, from Egypt. Therefore, this number is satisfactory because it is more than the recommended minimum number that is obtained from guideline number (**1**).

These two guidelines can help in getting started with first network architecture. Then, after training and testing phases, the changes in the number of hidden layers and the number of hidden neurons (nodes) will be performed in each model guided by the percentage of error of the network (RMS) until the best network structure (model) is reached that will have the minimum (RMS) value from all the trials conducted.

4.2.3.2.b Determining the Number of Hidden Layers/Nodes

Hidden layer is a layer of neurons in an artificial neural network (ANN) that does not connect to the outside world but connects to other layers of neurons.

Hegazy, stated that one hidden layer with a number of hidden neurons as one-half of the total input and output neurons is suitable for most applications (theoretically), but due to the ease of changing the network architecture during training, an attempt will be done to verify that research work, through finding the network structure that generates the minimum (RMS) value for the given problem variable parameters **(13)**.

Before starting to build, train and then validate the network model structure, there are two parameters that should be well defined to have a good training manner:-

i. Training and Testing Tolerance

Training and testing tolerance is a value that specifies how accurate the neural network's output must be in order to consider it correct during training and testing. The most meaningful tolerance is specified as a percentage of the output range, rather than the output value **(42)**.

A tolerance of 0.1 (10%) which is automatically set by the program means that the output value from the program must be within at least 90% from the actual value of the project to be considered a correct prediction. Selecting a tolerance that is too loose (large) or too tight (small) can have an impact on the network ability to make predictions. It is important that the selected tolerance will give responses close enough to the pattern to be useful. However, it is not always possible for N-Connection 2.0 software to train if it begins with a very small tolerance. In this study the tolerance is set automatically by the program to 0.1 (10%).

ii. Learning Rate

The learning rate specifies how large an adjustment N-Connection 2.0 will make to the connection strength when it gets a fact wrong. Reducing the learning rate may make it possible to train the network to a smaller tolerance. The learning rate pattern is automatically set by the N-Connection 2.0 Software Program in a way that maximizes the performance of the program to achieve the best results available **(42)**.

4.2.4 Training the Network

Training the network is a process that uses one of several learning methods to modify weight, or connections strength. All trial models experimented in this research study was trained in a supervised mode by a Back-Propagation Learning Algorithm. A training data set is presented to the network as inputs, and the outputs are calculated. The differences between the Calculated Outputs and the Actual Output are then evaluated and used to adjust the network's weights (automatically by the program) in order to reduce the differences. As the training proceeds, the network weights are continuously adjusted until the error in the calculated outputs converges to an acceptable level. The Back-Propagation Algorithm involves the gradual reduction of the error between model output and the target output. Hence, it develops the input to output mapping by minimizing a root mean square error (RMS) that is expressed in the following equation **(42)**:

$$\mathbf{RMS} = \sqrt{\sum_{i=1}^{n} (O_i - P_i)^2} \; \mathbf{/\, n}$$

Where $\mathbf{n}$ is the number of samples to be evaluated in the training phase, $\mathbf{O_i}$ is the actual output related to the sample **i** (**i**=1,….**n**), and $\mathbf{P_i}$ is the predicted output. The training process should be stopped when the root mean square error (**RMS**) remains unchanged. The training file has **90** percent of the collected facts, i.e. has **47** facts (projects). These facts are used to train and self examine the network.

4.2.5 Testing the Network

Testing the network is essentially the same as training it, except that the network is shown facts it has never seen before, and no corrections are made when the network is wrong. It is important to evaluate the performance of the network after the training process. If the results are good, the network will be ready for use. If not, this means that it needs more or even better data or even redesign the network. A part of the collected facts (projects) around (10%), i.e. five facts (projects) is set aside randomly from the set of training facts (projects). Then these facts are used to test the ability of the network to predict a new output where the absolute difference is calculated automatically by the program for each test project outcome by the following mathematical formula **(42)**:

$$\textbf{Absolute Difference \%} = \left(\frac{\text{Real Life Target Outcome - Predicted Model Outcome}}{\text{Real Life Target Outcome}} \text{x}100 \right)$$

An absolute difference of **10** means that there is a Ten percent difference between the models predicted outcome value and the actual real-life outcome value for that given project. This difference can be positive or negative difference (i.e. absolute difference range = ±10) and that must be clearly stated when testing phase is completed for it represents one of the main features of the constructed Neural Network Model characteristics **(42)**.

4.2.6 Creating Data File for Neural Connection

N-Connection is a tool that allows creating definition, training fact, and testing facts for Neural Connection 2.0 Software Program. The database that feeds into the Excel file consisted of **47** examples (projects) of building construction site overhead costs percentage for projects constructed during the period 2002 to 2009 in Egypt, and Five examples were been set aside for the final best model testing. The N-Connection 2.0 program will need around **34** (73%) of the facts for training, which are the calculated minimum needed number of facts for the program to train properly, which leaves **13** (27%) of the facts for validation (program self-testing) **(42)**.

➢ **<u>Program Development Sequence:</u>**

1. Start N-Connection icon in the Neural Connection 2.0 folder;
2. Drag the following three small icons from the right hand side icon toolbar on the program main screen, and distribute them on the program main screen in the same sequence of order;
    - **Input 1;**
    - **MLP 1;** and
    - **Text 1.**

3. Right click on the **Input 1** icon and choose connect then direct the arrow to the **MLP 1** icon, that will connect between these two icons;
4. Right click on the **MLP 1** icon and choose connect then direct the arrow to the **Text 1** icon, that will connect between these two icons; Figure (4-2)

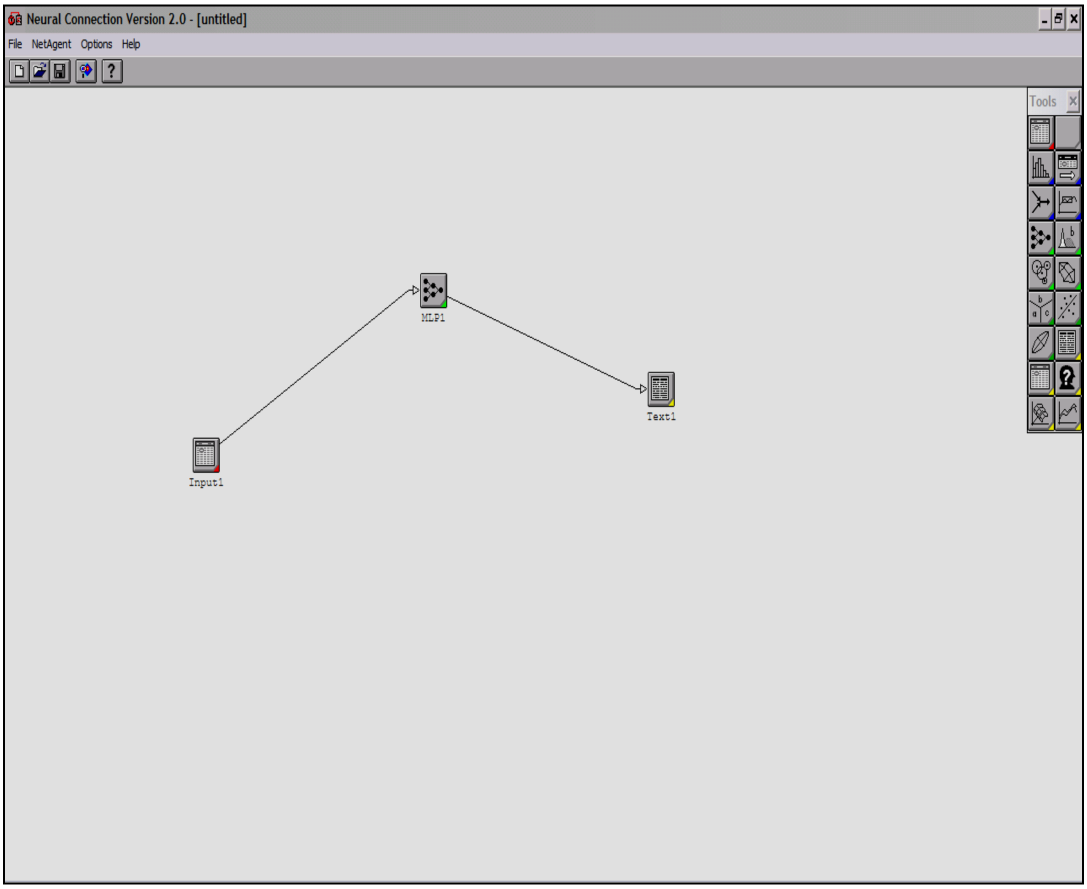


Figure (4-2) Main Program Screenز

5. The input data file that will be used, must already have been generated and stored in partition (**C**), in the following sequence of order **(42)**: Figure (4-3)
   a. The file that contains the problem data must be generated as an Excel-Sheet under the following rules:
      - Symbolic or categorical fields must be converted to numeric formats (Data Coding) before being applied to a neural model, since different values of symbolic variables usually have no relationship to each other.

- The problem of limited data that can occur during the design of a neural network model, once the training data have been separated from the test data each of the training data records can be duplicated user. This serves is to increase the number of records (projects) that can be used from the original training data file. Hence, the duplication permits use to be made of more real examples and consequently improves the performance of the neural model.
- Each entire row represents a single problem and the columns are problem variables, while the last column (on the right) represents the targeted output variable for each problem.
- The data file must be stored in a Micro Soft Excel 5.0/95 format in partition (**C**), under any file name.

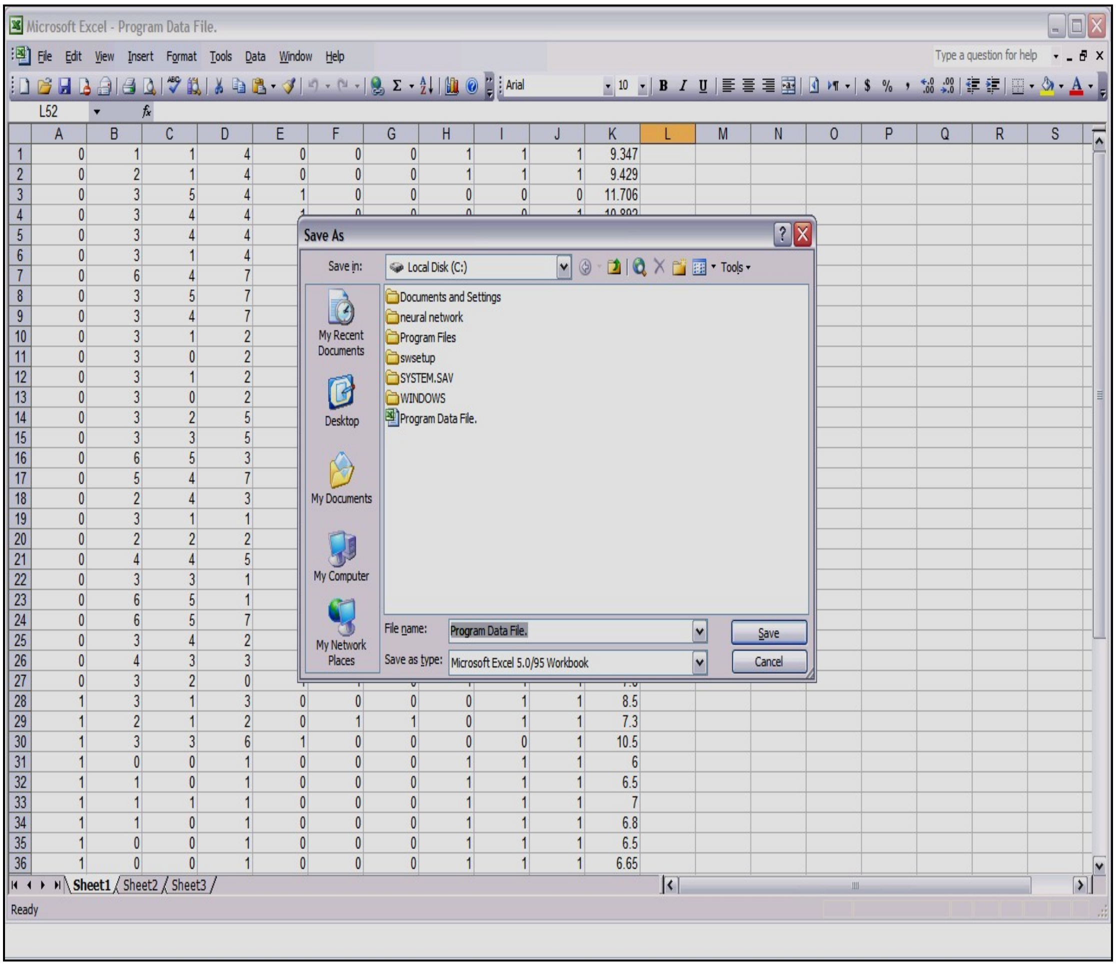


Figure (4-3) Original Generated Data Excel Sheet.

⇒ ***Then we return to the program main screen***;

6. Open the view from the **Input 1** icon on the program main screen;
7. A new command screen will open, choose open new folder from the menu bar then highlight flat-file check box and press configure then choose the Excel file name and format that was previously stored in partition (**C**); Figure (4-4)

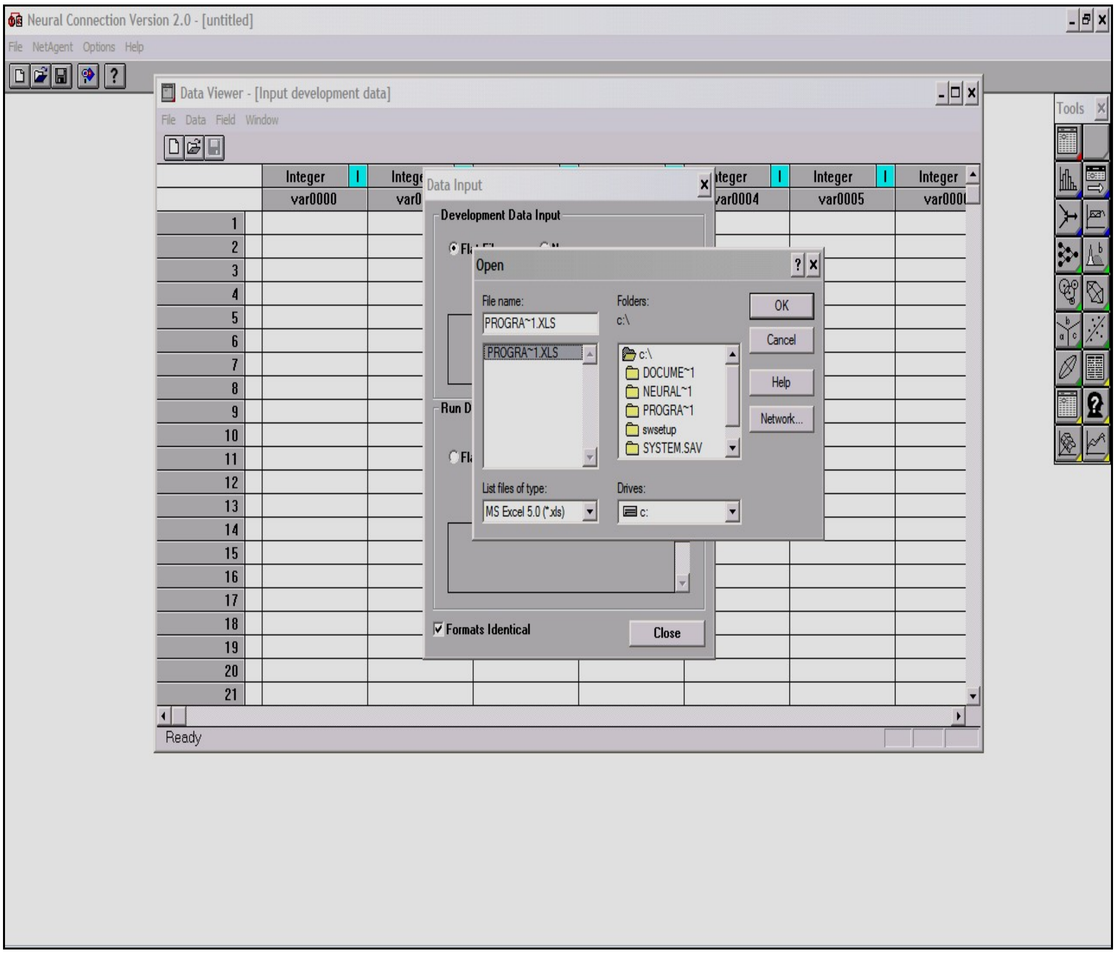


Figure (4-4) Program Data Input Tool.

8. Then from the menu bar choose **Data** then **Allocation**, configure the amount for each of training, validation, and test file records that the program will use to solve the problem; Figure (4-5)

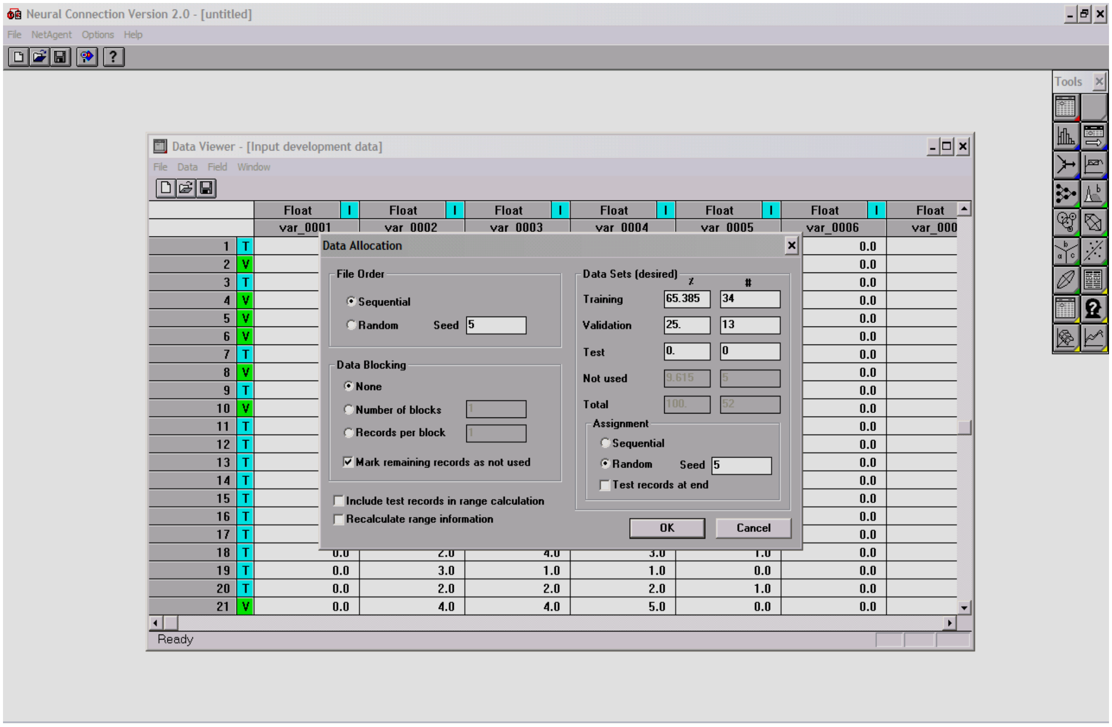


Figure (4-5) Program Desired Data Sets Sizes

9. Then from the menu bar choose **file** then **save as** and type the <u>name you will save this Model under</u> in partition **C**, folder Neural Network the format is set by the program automatically. Figure (4-6)

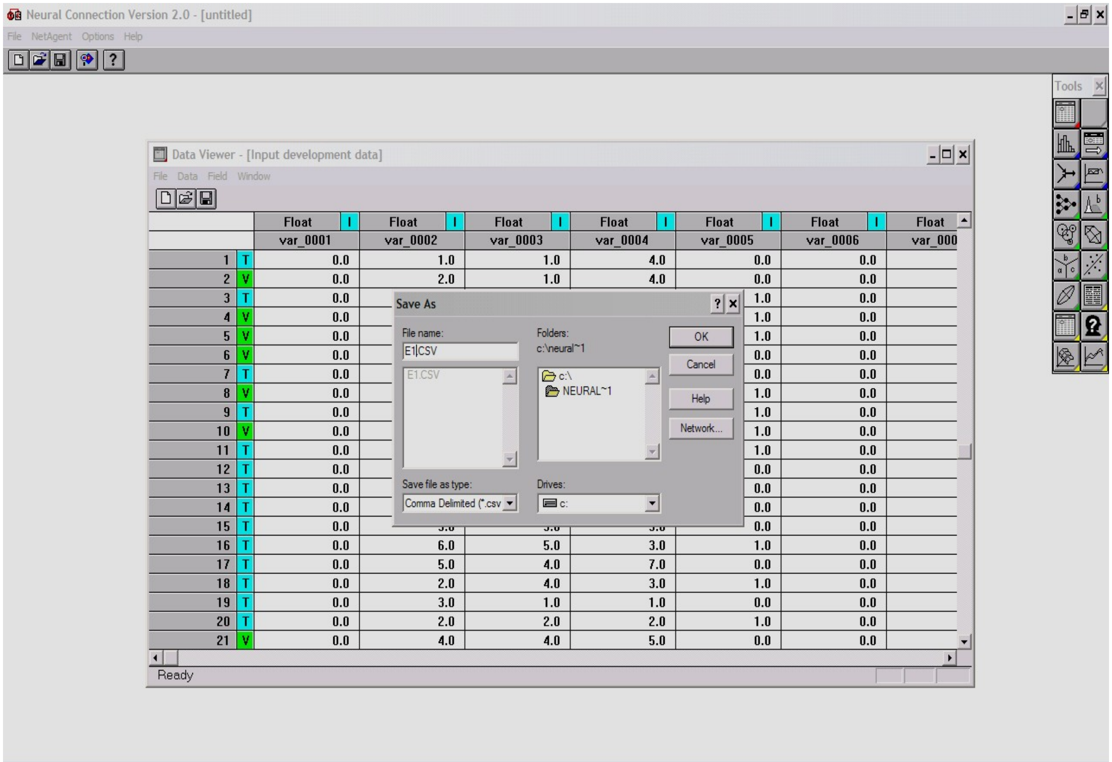


Figure (4-6) Saving the Program Data File

10. Right click on the **MLP 1** icon on the program main screen and choose **Dialog**, then choose the number of **hidden layers**, the **number of hidden nodes** (neurons) in each layer, and the function type that the program will use; Figure (4-7)

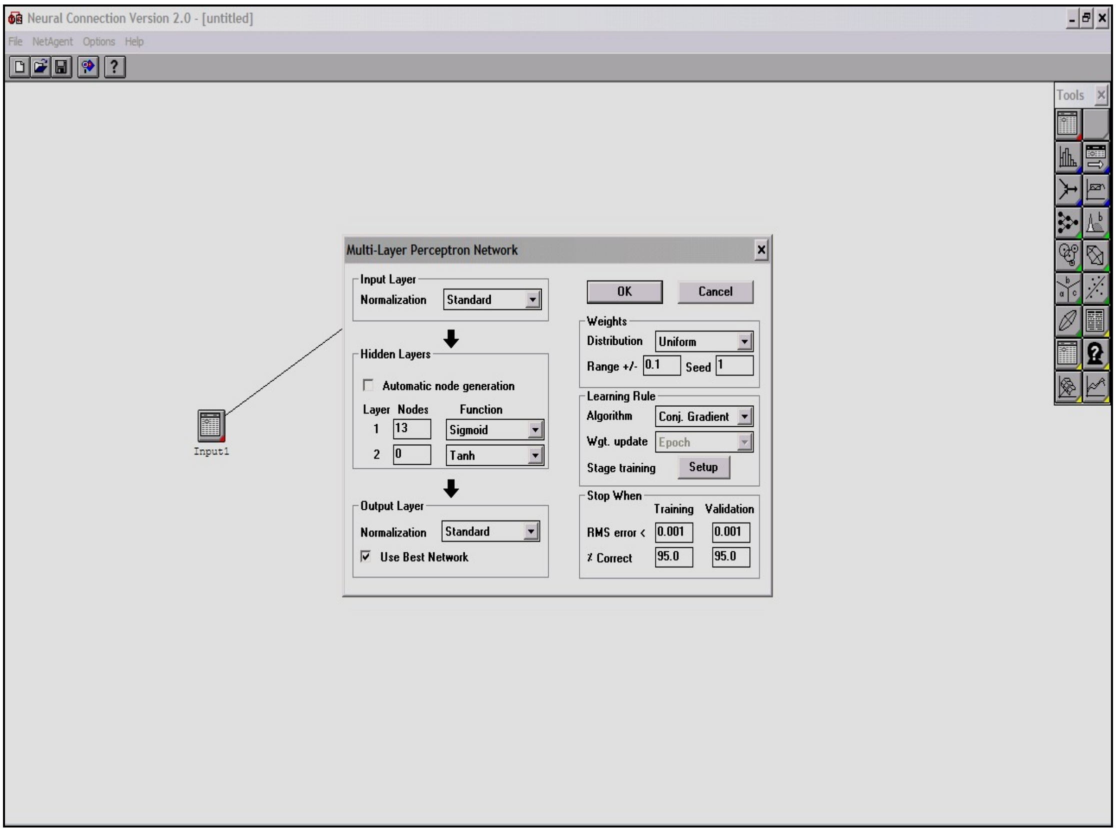


Figure (4-7) Designing the Model Parameters

11. Right click on **Text 1** icon on the main screen and choose **Dialog**, then mark the chick box next to the following: Figure (4-8)

    I. **Data Set (Test);**
    II. **Column Diameter (Spaces); and**
    III. **Destination**:
        A. **Output to screen**; and
        B. **Output to File**. (Choose the location desired to store the Results file). Example: partition **(C)** folder Neural Network and the format are set automatically.

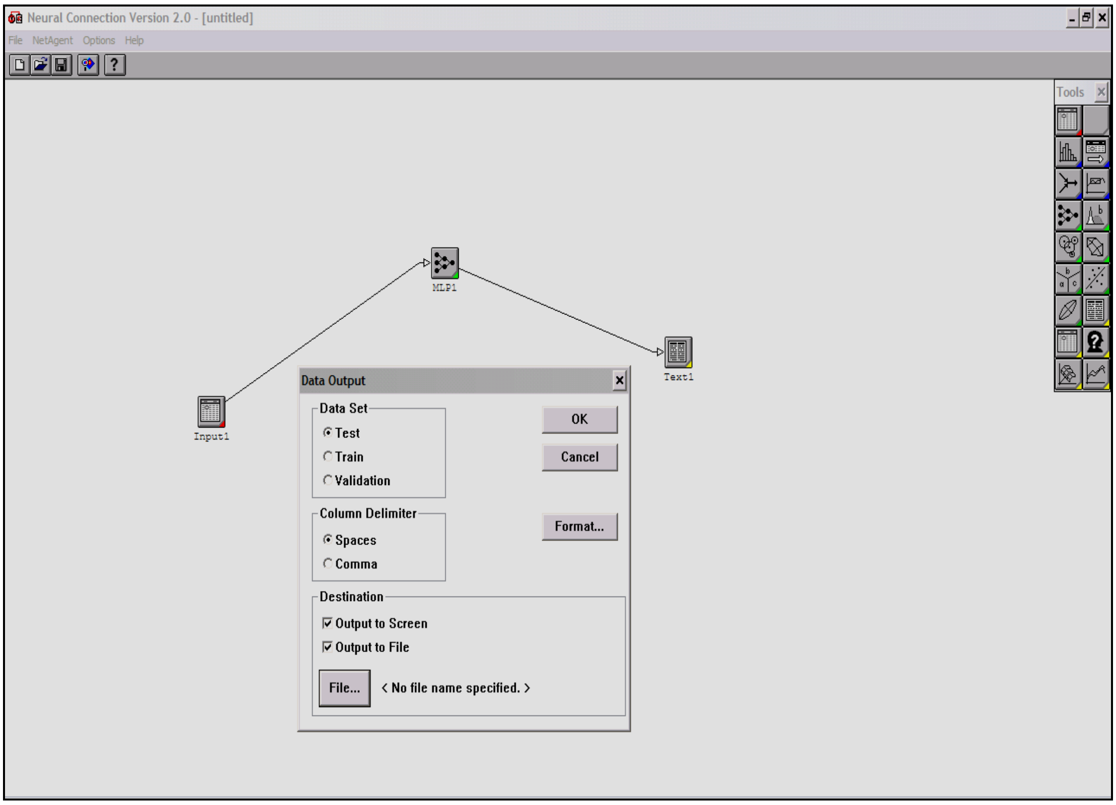


Figure (4-8) Choosing the Data Output Location.

12. Run the program by choosing the option (**Run**) from the icon titled (**Text 1**); Figure (4-9)

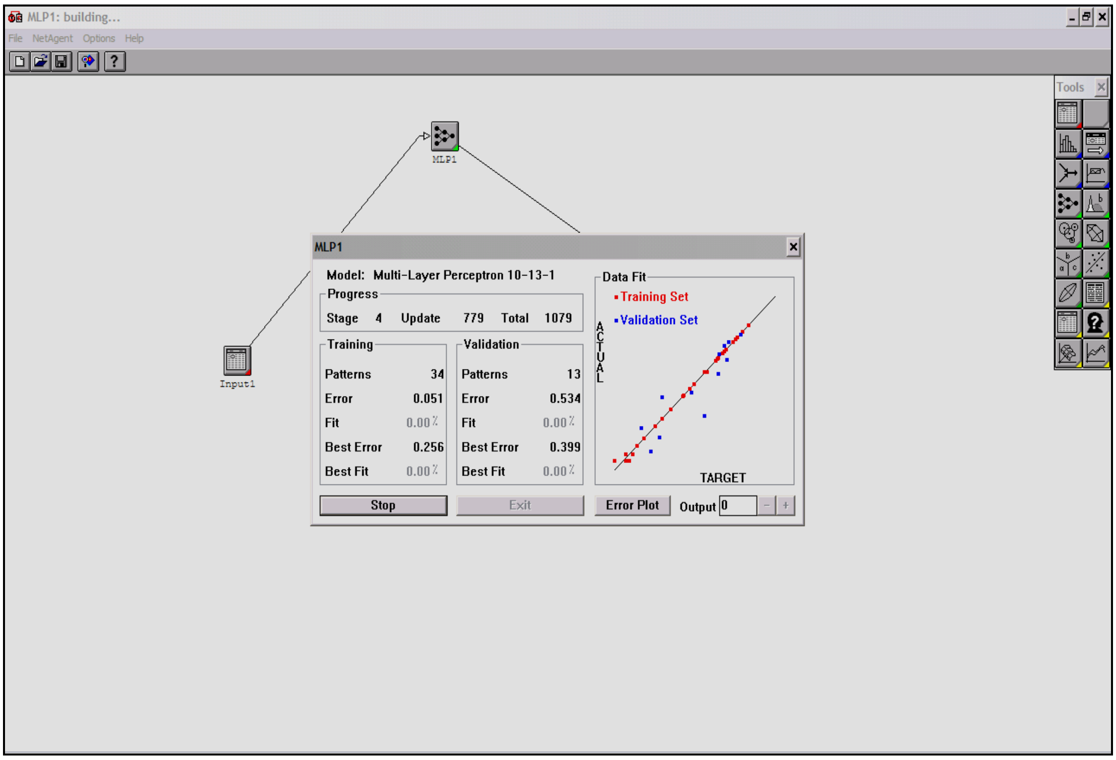


Figure (4-9A) Running the Program

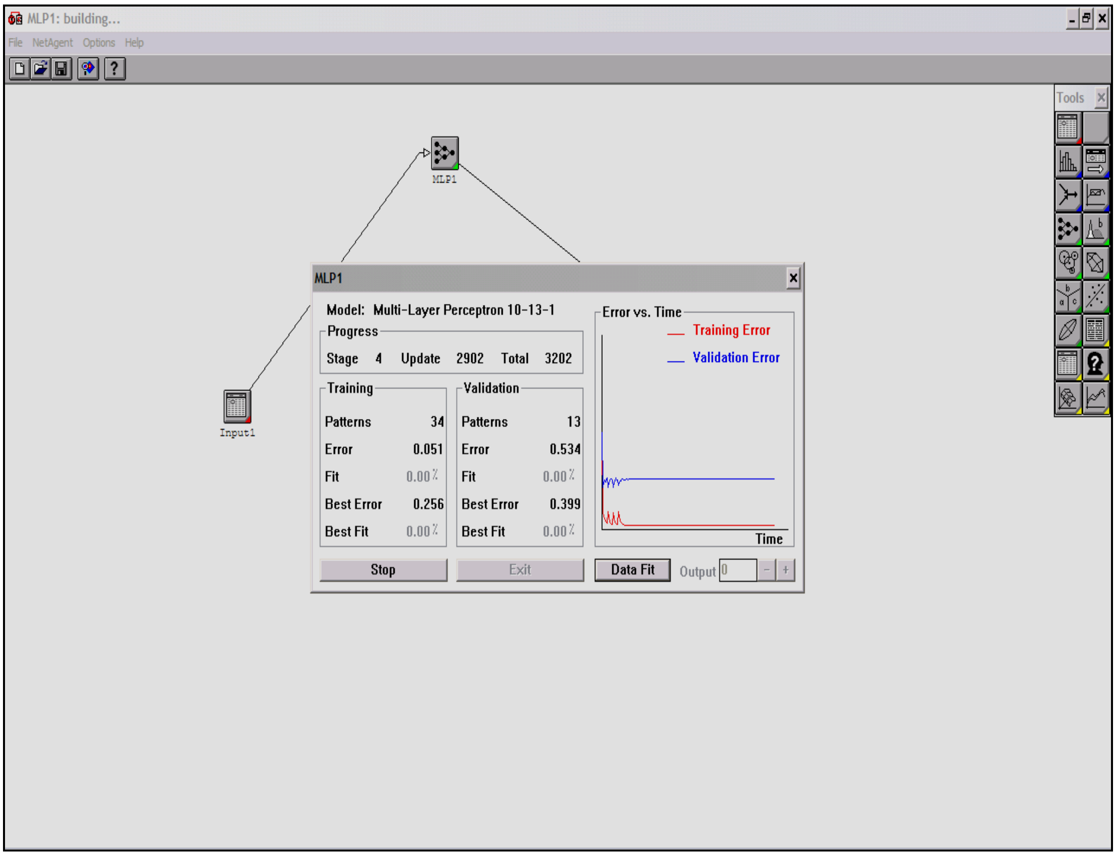


Figure (4-9B) Running the Program

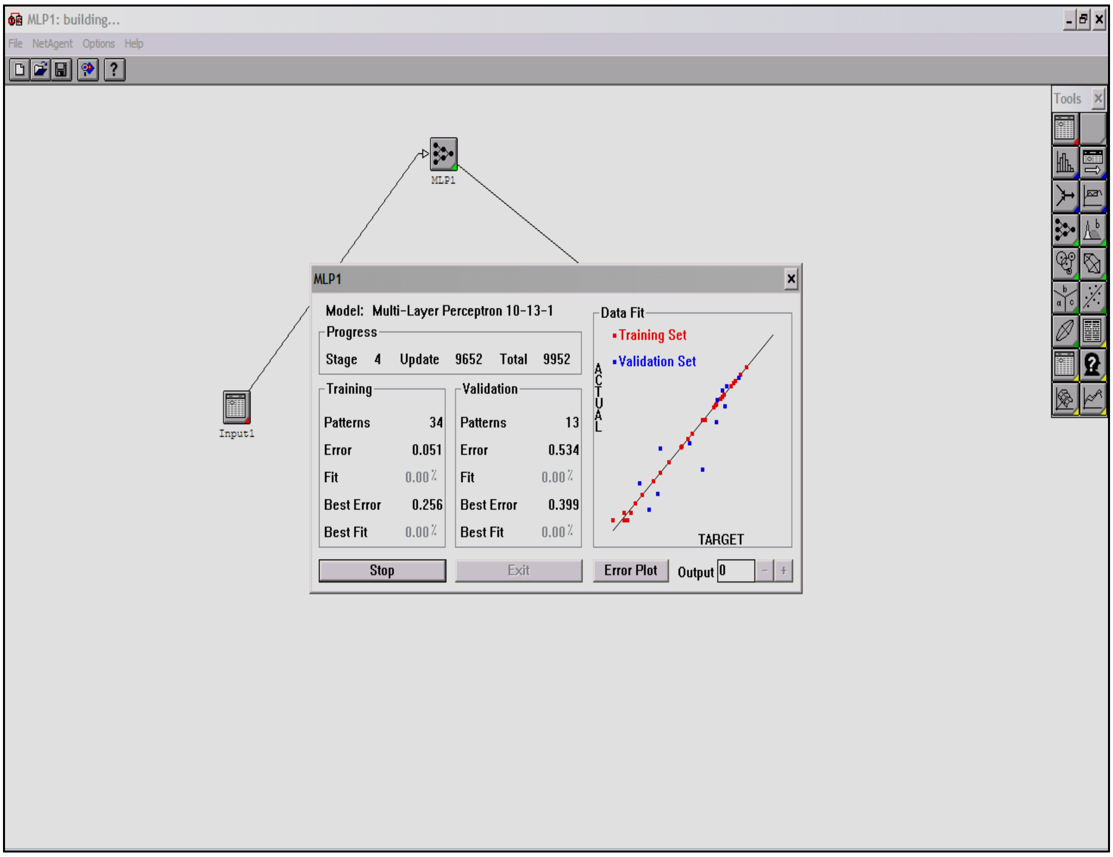
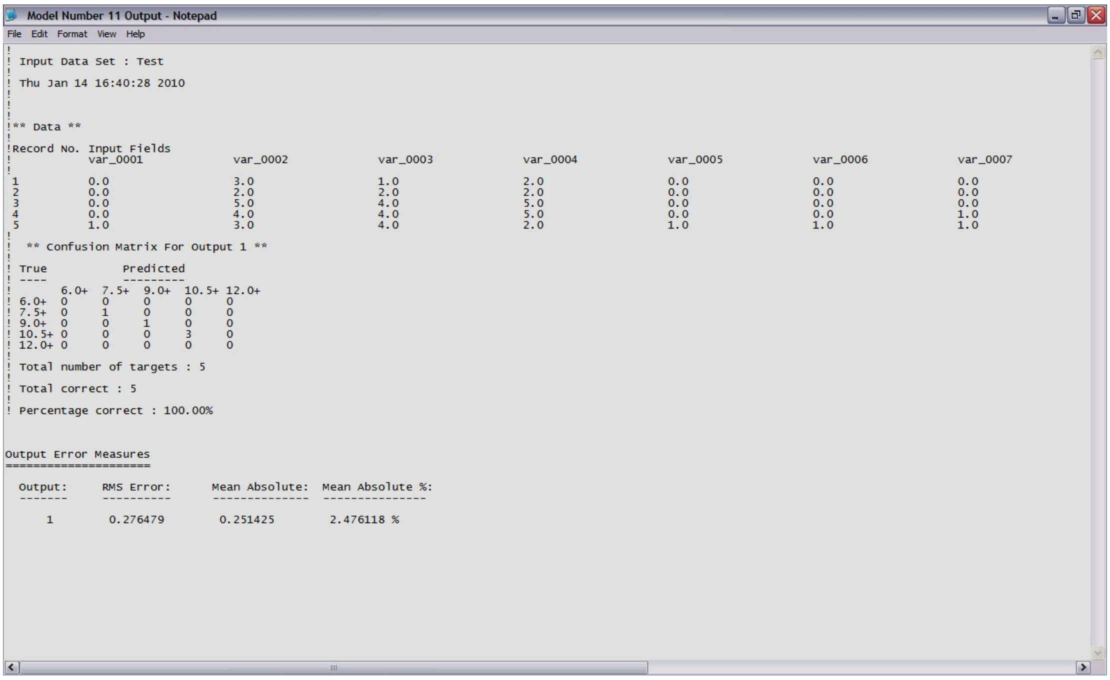


Figure (4-9C) Running the Program



```
Model Number 11 Output - Notepad
File Edit Format View Help
!
! Input Data Set : Test
!
! Thu Jan 14 16:40:28 2010
!
!
!
!** Data **
!
!Record No. Input Fields
!           var_0001      var_0002      var_0003      var_0004      var_0005      var_0006      var_0007
!
 1          0.0           3.0           1.0           2.0           0.0           0.0           0.0
 2          0.0           2.0           2.0           2.0           0.0           0.0           0.0
 3          0.0           5.0           4.0           5.0           0.0           0.0           0.0
 4          0.0           4.0           4.0           5.0           0.0           0.0           1.0
 5          1.0           3.0           4.0           2.0           1.0           1.0           1.0
!
!  ** Confusion Matrix For Output 1 **
!
! True          Predicted
! ----          ---------
!       6.0+  7.5+  9.0+  10.5+ 12.0+
! 6.0+  0     0     0     0     0
! 7.5+  0     1     0     0     0
! 9.0+  0     0     1     0     0
! 10.5+ 0     0     0     3     0
! 12.0+ 0     0     0     0     0
!
! Total number of targets : 5
!
! Total correct : 5
!
! Percentage correct : 100.00%


Output Error Measures
=====================

  Output:     RMS Error:      Mean Absolute:  Mean Absolute %:
  -------     ----------      --------------  ---------------

     1         0.276479        0.251425        2.476118 %
```

Figure (4-9D) Best Model Structure Output Screen

13. Record the output (RMS, Absolute difference, Absolute difference %), for this first trail, then carry out the trail in the same sequence but with different number of hidden layers, number of hidden nodes (neurons) and Transfer Function for each layer; and

14. After performing this sequence of steps on the program then choose the model structure (number of hidden layers, number of hidden nodes and Transfer Function) which leads to the minimum output (RMS) and record it's (Absolute difference %).

4.3 Data Encoding Scheme

This section describes the technique which was used to encode the input fields, in order to permit accurate modeling of the system Table (4-1). When used in conjunction with the techniques already described, these encoding technique enable the development of a robust Neural Network, assuming predictive information exists in the data **(42)**.

Table (4-1)

Real-Life Data Field Encoding Scheme

S/N	Factor	Subcategories	Category Coding
1	Construction Company Category		
		Category A	O
		Category B	1
2	Project Size (Total Contract Value)		
		≤ 15 (M.EGP.)	0
		≤ 30 (M.EGP.)	1
		≤ 60 (M.EGP.)	2
		≤ 250 (M.EGP.)	3
		≤ 500 (M.EGP.)	4
		≤ One Billion EGP.	5
		> One Billion E.G.P.	6
3	Project Duration (Month)		
		≤ 18	0
		≤ 24	1
		≤ 30	2
		≤ 36	3
		≤ 48	4
		> 48	5
4	Project Type		
		Sporting Clubs	0
		Multipurpose Housing Facility	1
		Office Buildings	2
		Schools and Universities	3
		Banks	4
		Restaurants & Hotels	5
		Villas Compounds	6
		Malls & Shopping Centers	7
5	Project Location		
		Inside the City	0
		Urbane Area's	1
6	Type-Nature of Client		
		Private	0
		public identities	1
7	Type of Contract		
		Fixed price contract	0
		Cost plus contract	1
8	Contractors-Joint Venture		
		Yes	0
		No	1
9	Special Site Preparation Requirements		
		Yes	0
		No	1
10	Projects Need for Extra-Man Power		
		Yes	0
		No	1

4.4 Determining the Best Model

The characteristics of the model learning rule, training and testing tolerance is set automatically by the program. The variables that the program requires setting during the design stage are **(42)**:

1. Number of Hidden Layers (N-Connection 2.0 Professional – Software accepts up to two Hidden Layers);
2. Number of Hidden Nodes in each Layer; and
3. Type of Transfer Function (Sigmoid or Tangent).

The program discussed in this research study is generated through the following sequence of alterations and the model structure that provides the minimum RMS value was then selected:

- **A.** One Hidden Layer with Sigmoid Transfer Function; (Table 4-2A)
- **B.** One Hidden Layer with Tangent Transfer Function; (Table 4-2B)
- **C.** Two Hidden Layers with Sigmoid Transfer Function in each; (Table 4-2C)
- **D.** Two Hidden Layers with Tangent Transfer Function in each; (Table 4-2D)

Table (4-2A)
Experiments for Determining the Best Model

Model No.	Input Nodes	Output Node	No. of Hidden Layers	No. of Hidden Nodes		Absolute Difference %	RMS
				In 1st Layer	In 2nd Layer		
1	10	1	1	3	0	7.589891	0.900969
2	10	1	1	4	0	5.491507	0.602400
3	10	1	1	5	0	8.939657	1.046902
4	10	1	1	6	0	7.766429	0.932707
5	10	1	1	7	0	4.979286	0.535812
6	10	1	1	8	0	5.818345	0.647476
7	10	1	1	9	0	4.947838	0.579932
8	10	1	1	10	0	8.887463	1.039825
9	10	1	1	11	0	4.858645	0.507183
10	10	1	1	12	0	5.352388	0.651948
11	**10**	**1**	**1**	**13**	**0**	**2.476118**	**0.276479**
12	10	1	1	14	0	2.857856	0.428663
13	10	1	1	15	0	4.074554	0.478028
14	10	1	1	20	0	8.065637	1.050137

i.e. Model trials from 1 to 14 has a Sigmoid transfer function.

The first fourteen model trails illustrated that the (RMS) and (Absolute Difference %) values changed as the number of hidden nodes in the single hidden layer increased in a nonlinear relationship, were the lowest RMS value of value **0.276479** and a corresponding Absolute Difference % value of **2.476118** were achieved in the eleventh trial, where there were thirteen hidden nodes in a single hidden layer with a sigmoid transfer function. While the highest RMS value of **1.050137** and the corresponding Absolute Difference value of **8.065637** were achieved in the fourteenth trial when there was twenty hidden nodes in the single hidden layer with a sigmoid transfer function. For the remaining twelve model trails the RMS and Absolute Difference values changed consecutively within the above mentioned ranges for each model trial.

Table (4-2B)

Experiments for Determining the Best Model

Model No.	Input Nodes	Output Node	No. of Hidden Layers	No. of Hidden Nodes		Absolute Difference %	RMS
				In 1st Layer	In 2nd Layer		
15	10	1	1	3	0	3.809793	0.490956
16	10	1	1	4	0	5.666974	0.703804
17	10	1	1	5	0	3.813867	0.425128
18	10	1	1	6	0	5.709665	0.709344
19	10	1	1	7	0	5.792984	0.634338
20	10	1	1	8	0	2.952316	0.343715
21	10	1	1	9	0	5.629162	0.655106
22	10	1	1	10	0	3.544173	0.387283
23	10	1	1	11	0	5.578666	0.686378
24	10	1	1	12	0	5.772656	0.701365
25	10	1	1	13	0	3.582526	0.380564
26	10	1	1	14	0	4.614612	0.515275
27	10	1	1	15	0	4.806596	0.641098
28	10	1	1	20	0	7.005237	0.826699

i.e. Model trials from 15 to 28 has a Tangent transfer function.

The model trails from **15** to **28** were there was one hidden layer, illustrated that the RMS and Absolute Difference values changed as the number of hidden nodes/hidden layer changed in a nonlinear relationship, where the lowest RMS value of 0.343715 and a corresponding Absolute Difference value of 2.952316 were achieved in the twentieth model trial when there was eight hidden nodes in a single hidden layer with a tangent transfer function. While the highest RMS value of 0.826699 and the corresponding Absolute Difference value of 7.005237 were achieved in the twenty eighth model trial when there was twenty hidden nodes in a single hidden layer with a tangent transfer function. While for the remaining twelve model trails the RMS and Absolute Difference values changed consecutively within the above mentioned ranges in each model trial.

Table (4-2C)

Experiments for Determining the Best Model

Model No.	**Input Nodes**	**Output Node**	**No. of Hidden Layers**	**No. of Hidden Nodes**		**Absolute Difference %**	**RMS**
				In **1st** Layer	In **2nd** Layer		
29	10	1	2	2	1	9.919941	1.519966
30	10	1	2	2	2	5.170748	0.581215
31	10	1	2	3	1	10.374248	1.413138
32	10	1	2	3	2	11.167767	1.687072
33	10	1	2	3	3	8.013460	1.140512
34	10	1	2	4	1	5.679721	0.643957
35	10	1	2	4	2	5.577789	0.617385
36	10	1	2	4	3	5.448696	0.598400
37	10	1	2	4	4	4.079718	0.492011
38	10	1	2	5	3	4.191063	0.574500
39	10	1	2	5	4	6.024062	0.723419
40	10	1	2	5	5	5.322466	0.654373
41	10	1	2	6	4	7.257790	0.804202
42	10	1	2	6	5	5.158298	0.567479
43	10	1	2	6	6	5.270355	0.545017

i.e. Model trials from 29 to 43 has a Sigmoid transfer function for both hidden layers.

The model trails from 29 to 43 illustrated that the RMS and Absolute Difference values changed as the number of hidden nodes per each hidden layer increased in a nonlinear relationship, where the lowest RMS value of 0.492011 and a corresponding Absolute Difference value of 4.079718 were achieved in the model trial number thirty-seventh model trial, when there were two hidden layers with four hidden nodes in each and having a sigmoid transfer function in each layer. Contrarily, the highest RMS value of 1.687072 and the corresponding Absolute Difference value of 11.167767 were achieved in the model trial number thirty-two when there were two hidden layers with three hidden nodes in the fist layer and two hidden nodes in the second hidden layer and having a sigmoid transfer function in each layer. While for the remaining thirteen model trails the RMS and Absolute Difference values changed consecutively within the above mentioned ranges for each model trial having a sigmoid transfer function in each layer.

Table (4-2D)

Experiments for Determining the Best Model

Model No.	Input Nodes	Output Node	No. of Hidden Layers	No. of Hidden Nodes		Absolute Difference %	RMS
				In 1st Layer	In 2nd Layer		
44	10	1	2	2	1	4.364562	0.499933
45	10	1	2	2	2	3.551318	0.380629
46	10	1	2	3	1	4.787220	0.493240
47	10	1	2	3	2	6.267891	0.852399
48	10	1	2	3	3	6.515138	0.829739
49	10	1	2	4	1	3.458081	0.481580
50	10	1	2	4	2	9.249286	1.158613
51	10	1	2	4	3	4.735680	0.552350
52	10	1	2	4	4	7.445228	0.991062
53	10	1	2	5	3	7.729862	1.105441
54	10	1	2	5	4	9.807989	1.180131
55	10	1	2	5	5	6.060798	0.657344
56	10	1	2	6	4	3.213154	0.355932
57	10	1	2	6	5	4.381631	0.490479
58	10	1	2	6	6	4.731568	0.502131

i.e. Model trials from 44 to 58 has a Tangent transfer function for both hidden layers.

The model trails from 44 to 58 illustrated that the RMS and Absolute Difference values changed as the number of hidden nodes per each hidden layer increased in a nonlinear relationship, where the lowest RMS value of 0.355932 and a corresponding Absolute Difference value of 3.213154 were achieved in the model trial number fifty-sixth, when there was two hidden layers with six hidden nodes in the first hidden layer and four hidden nodes in the second hidden layer and with a tangent transfer function in each layer. On the other side, the highest RMS value of 1.180131 and the corresponding Absolute Difference value of 9.807989 were achieved in the model trial number fifty-fourth, when there was two hidden layers with five hidden nodes in the fist layer and four hidden nodes in the second hidden layer and with a tangent transfer function in each layer. While for the remaining thirteen model trails the RMS and Absolute Difference values changed consecutively within the above mentioned ranges for each and with a tangent transfer function in each layer.

The recommend model structure for this complicated prediction problem is that with the least RMS value from all the fifty-eight, trail and error process **(69)**.

As a result, from training and validation phases the characteristics of the satisfactory Neural Network Model that was obtained through the trail and error process are presented in Table (4-3) and Figures (4-9D) and (4-10) respectively.

➢ Trial model number **11** with the following design parameters:

- Input layer with 10 neurons (nodes).
- One hidden layer with 13 neurons (nodes).
- Output layer with 1 neuron (node).
- Transfer function: Sigmoid transfer function.
- Learning rate automatically adjusted by the program.
- Training tolerance = 0.10.
- Root Mean Square Error (**RMS**) = 0.276479.
- Absolute Mean Difference % = 2.476118.

Table (4-3)

Characteristics of the Best Model

Model	No. of input nodes	No. of hidden layers	No. of nodes/ hidden layer	LR	TF	No. of output nodes	RMS
11	10	1	13	Back propagation	Sigmoid function	1	0.276479

LR: Learning Rule; TF: Transfer Function; RMS: Root Mean Square Error.

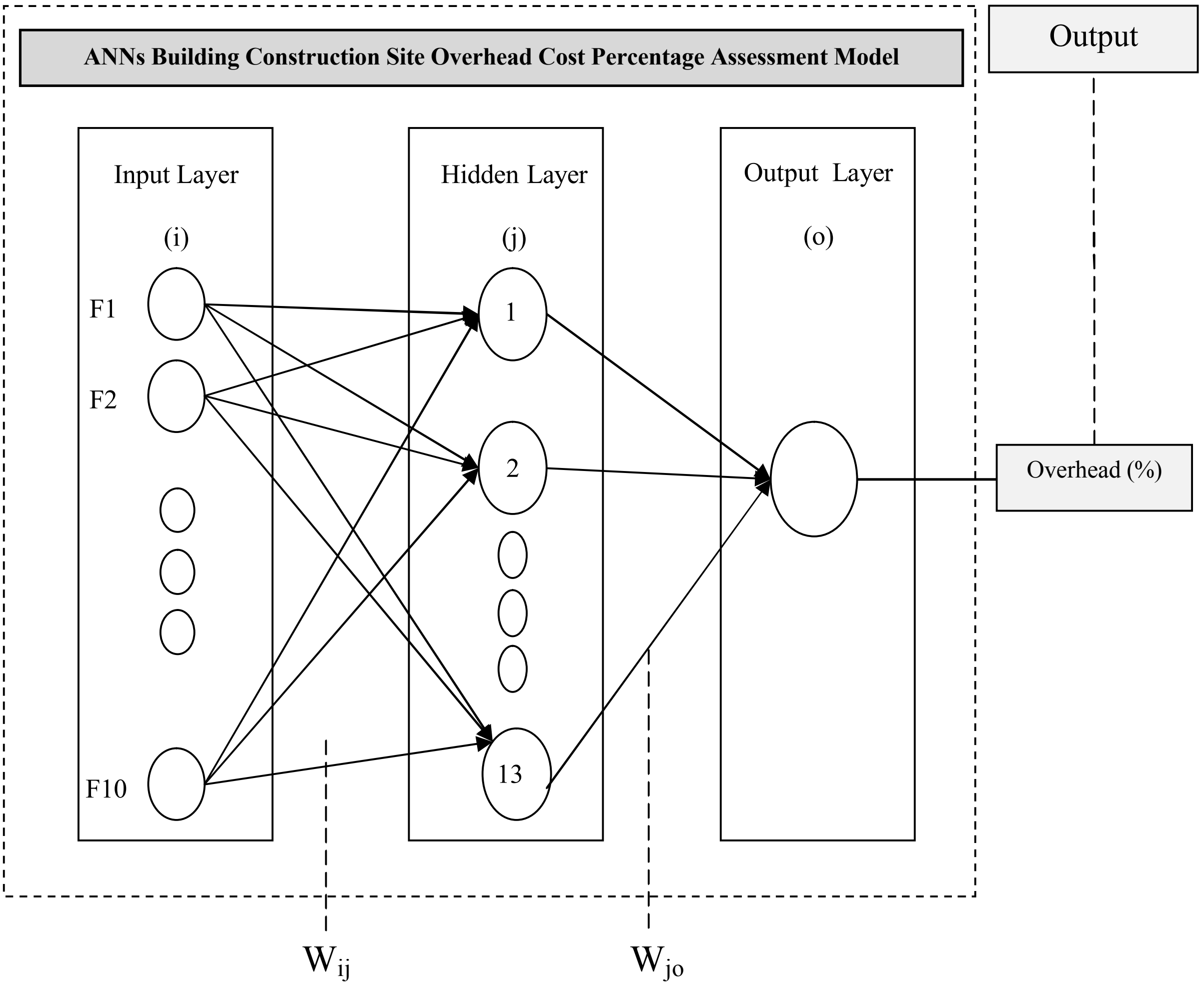


Figure (4-10) Structure of the Best Model, **(42).**

4.5 Testing the Validity of the Designed Model

To evaluate the predictive performance of the network, the five projects that were previously randomly selected and reserved for testing from the total collected projects are introduced to the final designed model without the percentage of their site overhead costs, for testing the predictive ability for that designed ANN-program.

The model will predict the percentage of building construction project's site overhead costs for projects constructed, in Egypt. The predicted percentage will be compared to the real-life projects percentage (stored outside the program) and the difference between them will be calculated if it equals or even under the value of the designed model's Absolute Difference %, then it is considered to be a correct prediction attempt. If it exceeds the value of the designed model's Absolute Difference then it is considered to be a wrong prediction attempt.

Table (4-4) presents the actual and predicted percentages for the test sample. The model correctly predicted four from the five testing projects sample which is equal to (**80**%) of the test sample. The wrongly predicted project had a positive difference between the value of predicted percentage from the model output and the real-life percentage for the same project equal to (+) **4.620294427**%. This means that the predicted outcome is greater than the actual real-life project value by this percentage. Such percentage is found to be acceptable; program user's manual, because the difference between the predicted program outcome for this project and the real-life project's outcome for the same project is less than five percent (**5**%) which is found by the program to be very small (under **10**%) and acceptable. And the program (user's manual) clearly dictates to regard small differences and accept any sample difference that small to be a correct sample. But even if, the model's still correctly predicted the outcome with an efficiency of (**80**%) that is still considered to be a very high and the model is accepted.

Table (4–4)

Actual and Predicted Percentage of Building Site Overhead for the Test Sample

Project no.	Actual real life percentage	Network output (predicted percentage)	Absolute difference %	Comments
1	8.13	8.32294	**(-) 2.373185732**	**Correct**
2	9.51	9.07061	**(+) 4.620294427**	**Wrong**
3	10.86	10.59704	**(+) 2.421362799**	**Correct**
4	10.84	11.11394	**(-) 2.427121771**	**Correct**
5	11.43	11.3421	**(+) 0.769028871**	**Correct**

As it is clear the correct predicted model outputs of the percentage of site overhead costs differ from the actual real-life project's percentage of site overhead costs value with a value under ± **2.476**%, which is the designed model's absolute difference%, this is acceptable.

This demonstrates a very high accuracy for the proposed model and the viability of the neural network as a powerful tool for modeling the assessment of building construction site overhead cost percentage for projects constructed in Egypt.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This research developed and tested a prediction model to assess the percentage of site overhead costs for building construction projects in Egypt, using the artificial neural network technique. A back-propagation network consisting of an input buffer with **10** input nodes, **one** hidden layer, with **13** hidden nodes, with a **sigmoid** transfer function, and **one** output node was developed. This model is based on the findings from a formal questionnaire through which key factors that affect the percentage of site overhead cost were identified. This chapter presents the major conclusions from the results obtained, and recommendations for future works.

5.1 Summary

Construction firms should carefully examine contract conditions and perform all the necessary precautions to make sure that project site overhead costs factors are properly anticipated for and covered within the total submitted tender price. The researcher conducted a survey that investigated the factors affecting project site overhead cost for building construction projects in the first and the second categories of construction companies, in Egypt. An ANN-Based model was developed to predict the percentage of site overhead cost for building construction projects, in Egypt, during the tendering process. A sample of building projects was selected as a test sample for this study. The impacts of different factors on the percentage of projects site overhead costs were deeply investigated. The survey results illustrated that site overhead costs are greatly affected by many factors. Among these factors come project type, size, location, site conditions and the construction technology. All of these factors make the detailed estimation of such overhead costs a more difficult task. Hence, it is expected that a lump-sum assessment for such cost items will be a more convenient, easy, highly accurate, and quick approach. Such approach should take into consideration the different factors that affect site overhead cost. It was found that an ANN-Based Model is a suitable tool for the percentage of site overhead cost assessment, in Egypt.

The research study was performed in the following sequence:

1. Review of all previous studies conducted in the field of site overhead cost;
2. Identifying a list of overhead cost factors for building projects from the literature review study;
3. Comparison is be made between that list and the factors that contribute to site overhead costs in Egypt, from the experts point of view, with the help of a questionnaire;
4. The collection of real-life building construction projects from different construction companies all within Egypt;
5. Impact analysis was performed to understand the effect of each site overhead factor on the percentage of site overhead costs for building projects, in Egypt;
6. Preparation of an ANN-Based Model to predict the overhead costs percentage for building construction projects, in Egypt; and
7. A sample of building projects from Egypt was selected to act as demonstrative examples to investigate the validity of the designed ANN Model.

5.2 Conclusions

The following conclusions may be drawn from this study:

1. Through literature review potential factors that influence the percentage of site overhead costs for building construction projects were identified. Ten factors were identified;

2. The analysis of the collected data gathered from fifty two real-life building construction projects all from Egypt illustrated that project duration, total contract amount, project type, type of the contract, special site preparation needs, and project location are identified as the top six factors that affect the value of the percentage of site overhead costs for building construction projects, in Egypt;

3. Nature of the client and contractor-joint venture are the least affecting factors in the percentage of site overhead costs for building construction projects, in Egypt;

4. A satisfactory neural network model was obtained through fifty-eight experimental (Trial and Error) for predicting the percentage of site overhead costs for building construction projects in Egypt for future projects. This model consists of input layer with ten neurons (nodes), one hidden layer having thirteen hidden nodes with a sigmoid transfer function and one output layer. The learning rate of this model is set automatically by the N-Connection 2.0 software (1997), while the training and testing tolerance are set to **0.1** also automatically by the program;

5. The results of testing for this designed model indicated a testing root mean square error (**RMS**) value of **0.276479**; and

6. Testing was carried out on five new facts that were still unseen by the network. The results of the testing phase indicated an accuracy of (**80**%). As the model wrongly predicted the percentage of site overhead costs for only one project (**20**%) from the testing sample.

5.3 Recommendations for Future Work

1. The model should be augmented to take into consideration the other different types of Construction projects. For example: the infrastructure construction projects and heavy construction projects; and

2. The development of artificial neural network models requires the presence of structured database for the finished projects in the construction companies. Unfortunately most Egyptian construction companies have no structured database system that can provide researchers with the required information. It is recommended that a standard database system for storing information regarding the finished projects should be developed and applied by the construction companies working, in Egypt.

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Appendix A

<u>Questionnaire</u>

For

Determination and Verification

Of

Egyptian Building Construction Projects Site Overhead Cost Factors

A- Information:

1.	**General Information:**				**Date**	**:**	**/ / 20** DD / MM / YY
-	**Company**	**:**		**-**	**Category**	**:**	
-	**Illumination Date**	**:**	**/ /** DD / MM / YY	**-**	**No. of Employees**	**:**	
2.	**Personal Information:**						
-	**Name**	**:**					
-	**Qualifications**	**:**					
-	**Job Title**	**:**					
-	**Area of specialty**	**:**					
-	**Years of Work Experience**	**:**					

B- The purpose for this questionnaire is to help in the preparation of a model for the assessment of the percentage of site overhead cost for building construction projects adaptable in Egypt, as a target during the fulfillment of the requirements for the degree of master of science in construction project management at the Arab academy for science and technology and maritime transport, (Cairo branch), besides to the great and very helpful efforts that any of the participants will give to this research study, and the proper alliance between the construction industry market with the research and development sector in the form of universities and national research centers that this will represent, this model will be available upon request after having the final approve, free of charge for all the participating construction firm's in Egypt.

C- The Questionnaire:

(All inputs is to be made in capital characters)

➢ FIRST SECTION			
S/N	**FACTOR**	Contributing to Project Overhead Cost Estimation	
		YES	**NO**
1	**The need for specialty contractors.**		
2	**Percentage of sub-contracted works.**		
3	**Consultancy and supervision.**		
4	**Contract type.**		
5	**Firms need for work.**		
6	**Type of owner/client.**		
7	**Site preparation needs.**		
8	**Projects tight time schedule.**		
9	**The need for special construction equipments.**		
10	**The delay in projects duration.**		
11	**The firms previous expertise with the same projects type.**		
12	**Legal environment and public policy in the home country.**		
13	**The projects cash-flow plan.**		
14	**Projects size.**		
15	**Projects location.**		
16	**Constructions Firm Category.**		

➢ SECOND SECTION (Factors currently accounted for by construction firms in Egypt)	
S/N	**FACTOR**
17	
18	
19	
20	
21	

➢ THIRD SECTION (Factors that are not accounted for and should be from the expert's experience)	
S/N	**FACTOR**
22	
23	
24	
25	
26	

D- Comments

A List of the Participating Construction Industrial Experts

	Name	Company	Job Title	Y. Experience
➢ Industrial Experts with Years of Experience over 20 years:				
1	Eng. Hatem EL-Gamal	Dar AL-Handasah	Project Manager	25 Years
2	Eng. Hany Shokry Tawfik	Orascom Constructions	Project Manager	27 Years
3	Eng. Yousef Soliman	Orascom Constructions	Construction Manager	28 Years
4	Eng. Hesham Mahran	Orascom Constructions	Design Manager	30 Years
5	Eng. Tarek Hashem	Orascom Constructions	Construction Manager	30 Years
6	Eng. Hassan Eltohamy	ECG	Construction Manager	30 Years
7	Eng. Amr El-Sarrag	ECG	Principle Structure Engineer	28 Years
8	Eng. Steve Ronald	Alfauttaim Carillion	MEP Senior Project Manager	30 Years
9	Eng. Tom B. Young	Alfauttaim Carillion	Project Director	38 Years
10	Eng. R. A. Jones	Alfauttaim Carillion	Construction Director	32 Years
11	Eng. Ahmed Atta	EHAF	Construction Manager	30 Years
12	Eng. Billy Ogilby	Mivan	S. Construction Manager	40 Years

A List of the Participating Construction Industrial Experts (Continue)

	Name	Company	Job Title	Y. Experience
➢ **Industrial Experts with Years of Experience under 20 years:**				
1	Eng. Mark Heneen	Accor	Senior Site Engineer	15 Years
2	Eng. Hesham Abed Elrahman	CCC	Construction Manager	18 Years
3	Eng. Nader Henry Azer	Orascom Constructions	Senior Site Engineer	19 Years
4	Eng. Essam Eldesouky	ECG	Construction Manager	19 Years
5	Eng. Diaa Shawky Mikhail	Orascom Constructions	Construction Manager	18 Years
6	Eng. Mohamed M. Magdy	Arab Contractors Co.	Project Manager	18 Years
7	Eng. Amr Hussein M.	ENPI, Project Management Department	Project Manager	14 Years

A List of the Participating Academician Experts

	Name	Company	Job Title	Y. Experience
➢ **Academician Experts with Years of Experience over 20 years:**				
1	Prof. Dr. Refaat Abd ELRazek	Zagazig University.	Professor	25 Years
2	Prof. Dr. Amr Zahir	Ain Shams University.	Professor	25 Years
3	Prof. Dr. Mohamed Nagibe	AUC, University.	Professor	30 Years
4	Prof. Dr. Amr Hassanein	AUC, University.	Professor	22 Years
➢ **Academician Experts with Years of Experience between 10 to 20 years:**				
6	Dr. Nabile Amir	Military Technical College.	Ass. Professor	12 Years
7	Dr. Wael Montasir	6th October University.	Ass. Professor	11 Years
8	Prof. Dr. Mohamed M. EL-Attar	AUC, University.	Professor	15 Years
9	Prof. Dr. Ossama Hosny	AUC, University.	Professor	15 Years
10	Dr. Eiad Zahran	6th October University.	Ass. Professor	10 Years
11	Prof. Dr. Aly Darwish	AAST, Academy, Alex.	Professor	12 Years
12	Prof. Dr. Ehab EL-Asas	AAST, Academy, Alex.	Ass. Professor	11 Years
➢ **Academician Experts with Years of Experience under 10 years:**				
13	Eng. Mohamed EL-Dayasty	AAST, Academy, Cairo.	Lecturer	5 Years
14	Eng. Tarek Glal Fauzy	6th October University.	Lecturer	4 Years
15	Eng. Mohamed Abassy	AAST, Academy, Cairo.	Lecturer	3 Years
16	Eng. Sherif Moustafa	6th October University.	Lecturer	4 Years

A Sample from the Replied Questionnaires

Sample # 1

The Arab Academy for Science and Technology and Maritime Transport

Faculty of Engineering – Cairo branch

Graduate Studies Department

Name	:	ISMAAIL YEHIA ALY EL-SAWY
Company	:	Egyptian Electricity Holding Company (EEHC)
Department	:	Central Research and Studies Sector
Job Title	:	Management and Environmental Engineer
Telephone	:	02 - 22616535
Fax	:	02 - 38365828
Mobile	:	010 - 39 39 39 9

Date: / /2009

1

Questionnaire

A- Information

1.	General Information's :				Date	:	23 / 5 / 2009 DD / MM / YY	
-	Company	:	DAR- AL Handasah.	-	Category	:	Consultant	
-	Illumination Date	:	/ / 1957 DD / MM / YY	-	No. of Employees	:	≃ 9000	
2.	Personal Information's :							
-	Name	:	Hatem ELgamal					
-	Qualifications		Bsc Civil Engineer.					
-	Job Title	:	Project manager					
-	Year of Experience	:	≃ 25 Years	-	Age	:	48	Years

B- The purpose for this questionnaire is to help in the preparation of a model for the assessment of overhead cost for building construction projects adaptable in Egypt, as a target during the fulfillment of the requirements for the degree of master of science in construction project management at the Arab academy for science and technology and maritime transport, (Cairo branch), besides to the great and very helpful efforts that any of the participants will give to this research study, and the proper alliance between the construction industry market with the research and development sector in the form of universities and national research centers that this represents, this model will be available upon request after having the final approve free of charge for all the participating construction firm's in Egypt.

2

C- **The Questionnaire :**

(All inputs to be made in capital characters)

➢ **FIRST SECTION**

S/N	FACTOR	Factor contributing to Project Overhead Cost Estimation		Factor's weight to total overhead cost
		YES	NO	(0 – 100 %)
1	project's size	✓		70
2	project's duration	✓		100
3	project's type	✓		50
4	project's location	✓		100
5	project's construction technology	✓		80
6	special equipment required	✓		90
7	probability of change order		✓	—
8	firm's need for work	✓		70
9	Project's Impact on surrounding Environment		✓	—
10	Delay in time	✓		100
11	project importance (contribution) to society		✓	—

➢ **SECOND SECTION**

(factors currently accounted for by construction firms in Egypt)

S/N	FACTOR	Factor's weight to total overhead cost (0 – 100 %)
10	* Type - Nature of Client.	100
11	* Project Cash flow Stratgy.	90
12		
13		
14		
15		
16		
17		
18		
19		
20		

➢ **THIRD SECTION**

(Factors that are not accounted for and should be from the expert's experience)

S/N	FACTOR	Factor's weight to total overhead cost (0 – 100 %)
21	* Type of Contract	100
22	* Contractor(s) - Joint venture	70
23	* subcontractor(s) nature	70
24		
25		
26		
27		
28		
29		
30		

3

Comments

* First section:-

- the point # 5 and 6 are almost the same.

- the point # 10 is almost covered in point # 2

* Second Section.

- Nature of client, is governmental entity of private entity.

- the cash flow of the project is guaranteed or not.

* third section.

- Type of contract, is it Lump sum contract (Fixed price) or remeasured.

- the contractor(s) is one contractor or several as joint venture.

- the subcontractor(s) is the local or international.

Sample # 2

Questionnaire

A- Information

1.	General Information's :			Date	:	/ /20 . DD / MM / YY
-	Company	:	Dar For Trading & Contracting (DETAC)	- Category	:	Construction
-	Illumination Date	:	/ / 1994 DD / MM / YY	- No. of Employees	:	450
2.	Personal Information's :					
-	Name	:	HELAL ABD ELSALAM			
-	Qualifications		Bsc Civil Engineering			
-	Job Title	:	Technical office			
-	Year of Experience	:	19	- Age 43	:	Years

B- The purpose for this questionnaire is to help in the preparation of a model for the assessment of overhead cost for building construction projects adaptable in Egypt, as a target during the fulfillment of the requirements for the degree of master of science in construction project management at the Arab academy for science and technology and maritime transport, (Cairo branch), besides to the great and very helpful efforts that any of the participants will give to this research study, and the proper alliance between the construction industry market with the research and development sector in the form of universities and national research centers that this represents, this model will be available upon request after having the final approve free of charge for all the participating construction firm's in Egypt.

2

C- The Questionnaire :

(All inputs to be made in capital characters)

➢ **FIRST SECTION**

S/N	FACTOR	Factor contributing to Project Overhead Cost Estimation		Factor's weight to total overhead cost
		YES	NO	(0 – 100 %)
1	project's size	✓		
2	project's duration	✓		
3	project's type	✓		
4	project's location	✓		
5	project's construction technology	✓		
6	special equipment required	✓		
7	probability of change order		✓	
8	firm's need for work		✓	
9	Project's Impact on surrounding Environment		✓	
10	Delay in time	✓		
11	project importance (contribution) to society	✓		

➢ **SECOND SECTION**

(factors currently accounted for by construction firms in Egypt)

S/N	FACTOR	Factor's weight to total overhead cost (0 – 100 %)
10		
11	Project Man Power	
12		
13	Engineer requirments	
14		
15	Maintenance requirments	
16		
17	Head office over Heads	
18		
19		
20		

➢ **THIRD SECTION**

(Factors that are not accounted for and should be from the expert's experience)

S/N	FACTOR	Factor's weight to total overhead cost (0 – 100 %)
21		
22		
23		
24		
25		
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27		
28		
29		
30		

3

Appendix B

PROJECT DATA COLLECTION SHEET

- The adapted construction technology is :

S / N	FACTOR	PROJECT # ( )
1	**Category of the Construction Company**	
2	**Project(s) Total Contract Amount (EGP.)**	
3	**Project(s) Duration (Month)**	
4	**Project(s) Type**	
5	**Project(s) Location**	
6	**Type-Nature of Client**	
7	**Type of Contract**	
8	**Contractor(s) - Joint Venture**	
9	**Special Site Preparation Requirements**	
10	**Project need for Extra-man Power**	
*	**Project Site Overhead Cost**	
*	**Project Site Overhead Cost Percentage (%)**	

- I Here by declare that;
  - This is not considered to be an official document and it cannot be used as a legal document.

Best Regards,

ENGINEER,

Ismaail Yehia EL-Sawy.

Appendix C

THE COLLECTED PROJECTS DATA

The following section presents the data used during the analysis and the model development stages, which were collected from real life projects constructed in Egypt by many construction firms gathered from the Egyptian Building and Construction Union, during the seven year period 2002-2009. The data collected contained the percentage of projects site overhead costs and the ten overhead cost factors affecting that percentage in each project. Table (C-1)

Table (C-1)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Tanta Central Bank	NSGB Head Quarter	Bloom Head Quarter	HSBC Head Quarter
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	29,465,819.00	41,936,225.00	146,422,865.00	130,760,520.00
3	**Project(s) Duration (Month)**	22 months	23 months	50 months	39 months
4	**Project(s) Type**	Bank Project	Bank Project	Bank Project	Bank Project
5	**Project(s) Location**	Tanta City	Cairo Governorate	New Cairo	New Cairo
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	No	No	Yes	Yes
9	**Special Site Preparation Requirements**	No	No	Yes	Yes
10	**Project need for Extra-man Power**	No	No	Yes	No
⇒	**Percentage of Site Overhead Costs (%)**	**9.347**	**9.429**	**11.706**	**10.892**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Piraeus Bank of Egypt	Bank of Alexandria	Mall of Africa	Maadi City Center-Extension
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	135,544,399.00	81,311,666.00	1,172,906,643.00	88,423,556.00
3	**Project(s) Duration (Month)**	37 months	24 months	42 months	54
4	**Project(s) Type**	Bank Project	Bank Project	Super Mall	Mall
5	**Project(s) Location**	Industrial Zone, 6th of October	Alexandria City	Cairo City	Ring Road, New Maadi Zone
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Lump-Sum Contract	Lump-Sum Contract
8	**Contractor(s) - Joint Venture**	Yes	No	No	No
9	**Special Site Preparation Requirements**	Yes	No	No	Yes
10	**Project need for Extra-man Power**	Yes	No	Yes	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**11.63**	**8.13**	**10.9**	**13.5**

Table (C-1) **(Continue)**

The Data Used During the Analysis and the Modeling Phases

S/N	**Site Overhead Factors**	**Project (s)**			
		Bonyan Mall	Zamalek Residence	Beltone Financial New Head Office	EFG Hermes New Head Quarters
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	125,123,983.00	79,544,801.00	98,888,147.00	219,180,470.00
3	**Project(s) Duration (Month)**	42 months	22 months	24 months	18 months
4	**Project(s) Type**	Mall	Office Building	Office Building	Office Building
5	**Project(s) Location**	Cairo City	Cairo City	Smart Village, 6th of October	Smart Village, 6th of October
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	No	Yes	Yes
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	Yes	No	No	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**12.0**	**8.13**	**10.0**	**9.1**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Office Park	Sultanate of Oman Embassy	Arrura Restaurant	Mena House Extension
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	77,963,995.00	131,236,412.00	70,750,030.00	62,908,151.00
3	**Project(s) Duration (Month)**	22 months	18 months	26 months	36 months
4	**Project(s) Type**	Office Building	Office Building	Restaurant	Hotel
5	**Project(s) Location**	Cairo City	Cairo City	Cairo City	Giza City
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	No	Yes	No	Yes
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	No	Yes	No	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**8.5**	**8.1**	**9.54**	**11.0**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		A.U.C New Campus	Nile City Towers	Smart Village School	Raya Head Quarters
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	1,650,000,000.00	853,200,000.00	40,000,000.00	60,000,000.00
3	**Project(s) Duration (Month)**	60 months	42 months	42 months	27 months
4	**Project(s) Type**	University	Office Building	School	Office Building
5	**Project(s) Location**	New Cairo Zone	Cairo City	Smart Village, 6th of October	Cairo City
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	Yes	No	No
9	**Special Site Preparation Requirements**	Yes	Yes	No	No
10	**Project need for Extra-man Power**	Yes	Yes	Yes	No
⇒	**Percentage of Site Overhead Costs (%)**	**11.0**	**11.0**	**10.82**	**9.51**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Surice Complex	Core & Shell	Fermon Heliopolise	Conrad
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	80,000,000.00	45,000,000.00	512,000,000.00	421,200,000.00
3	**Project(s) Duration (Month)**	20 months	30 months	42 months	42 months
4	**Project(s) Type**	Multi Purpose Facility	Office Building	Hotel	Hotel
5	**Project(s) Location**	Cairo City	Smart Village, 6th of October	Cairo City	Cairo City
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Cost Plus Contract
8	**Contractor(s) - Joint Venture**	No	Yes	No	Yes
9	**Special Site Preparation Requirements**	No	No	Yes	No
10	**Project need for Extra-man Power**	Yes	Yes	Yes	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**9.06**	**10.64**	**10.86**	**11.09**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		First Residence	San Stefano Complex	Fermon Nile City	City Stars (Extension)
1	**Category of the Construction Company**	First Category	First Category	First Category	First Category
2	**Project Size (Contract Value) (EGP.)**	120,000,000.00	1,350,000,000.00	297,000,000.00	3,132,000,000.00
3	**Project(s) Duration (Month)**	34 months	60 months	38 months	60 months
4	**Project(s) Type**	Multi Purpose Facility	Multi Purpose Facility	Hotel	Mega Super Mall
5	**Project(s) Location**	Cairo City	Alexandria City	Cairo City	Cairo City
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Cost Plus Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	No	Yes	Yes	Yes
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	Yes	Yes	Yes	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**10.65**	**11.02**	**10.84**	**11.3**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Ceti Bank Head Quarter	Future University	EL-Sid Club	Modern Heliopolis
1	**Category of the Construction Company**	First Category	First Category	First Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	169,472,700.00	380,000,000.00	180,000,000.00	73,000,000.00
3	**Project(s) Duration (Month)**	42 months	36 months	30 months	24 months
4	**Project(s) Type**	Bank	University	Social and Sporting Club	School
5	**Project(s) Location**	New Cairo Zone	New Cairo Zone	Ring Road, New Maadi Zone	Cairo City
6	**Type-Nature of Client**	Private Client	Private Client	Public Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Cost Plus Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	Yes	No	Yes
9	**Special Site Preparation Requirements**	Yes	No	No	No
10	**Project need for Extra-man Power**	Yes	Yes	No	No
⇒	**Percentage of Site Overhead Costs (%)**	**11.41**	**10.68**	**7.8**	**8.5**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Enpi Office Building	Touristy village	Residential Building	Residential Building
1	**Category of the Construction Company**	Second Category	Second Category	Second Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	53,408,000.00	144,450,000.00	8,000,000.00	23,000,000.00
3	**Project(s) Duration (Month)**	19 months	35 months	14 months	16 months
4	**Project(s) Type**	Office Building	Housing Villas Compound	Multi Purpose Facility	Multi Purpose Facility
5	**Project(s) Location**	Cairo City	North Coast (Alexandria)	AL-Haram	AL-Haram
6	**Type-Nature of Client**	Public Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Cost Plus Contract	Lump Sum Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	Yes	No	No
9	**Special Site Preparation Requirements**	No	Yes	No	No
10	**Project need for Extra-man Power**	No	No	No	No
⇒	**Percentage of Site Overhead Costs (%)**	**7.3**	**10.5**	**6.0**	**6.5**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	**Site Overhead Factors**	**Project (s)**			
		Students Housing Facility	Students Housing Facility	Students Housing Facility	Students Housing Facility
1	**Category of the Construction Company**	Second Category	Second Category	Second Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	23,000,000.00	21,133,000.00	6,000,000.00	7,500,000.00
3	**Project(s) Duration (Month)**	24 months	18 months	12 months	12 months
4	**Project(s) Type**	Multi Purpose Facility	Multi Purpose Facility	Multi Purpose Facility	Multi Purpose Facility
5	**Project(s) Location**	6^{th} October City	6^{th} October City	6^{th} October City	6^{th} October City
6	**Type-Nature of Client**	Private Client	Private Client	Private Client	Private Client
7	**Type of Contract**	Cost Plus Contract	Cost Plus Contract	Cost Plus Contract	Cost Plus Contract
8	**Contractor(s) - Joint Venture**	No	No	No	No
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	No	No	No	No
⇒	**Percentage of Site Overhead Costs (%)**	**7.0**	**6.8**	**6.5**	**6.65**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Administration Building	Administration Building	Residential Building	AL-Amrikia Center
1	**Category of the Construction Company**	Second Category	Second Category	Second Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	55,000,000.00	24,000,000.00	12,000,000.00	47,864,500.00
3	**Project(s) Duration (Month)**	18 months	18 months	20 months	38 months
4	**Project(s) Type**	Office Building	Office Building	Multi Purpose Facility	Multi Purpose Facility
5	**Project(s) Location**	Cairo City	Cairo City	Cairo City	6^{th} of October
6	**Type-Nature of Client**	Public Client	Public Client	Private Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	Yes	No	Yes
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	No	No	No	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**7.8**	**7.2**	**7.6**	**10.98**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Seven Stars	AL-Ahly Social and Sporting Club	Misr for Central Clearing, Depositing and Registry	PARIBAS Egypt
1	**Category of the Construction Company**	Second Category	Second Category	First Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	38,853,000.00	58,000,000.00	184,731,000.00	163,694,000.00
3	**Project(s) Duration (Month)**	40 months	36 months	30 months	34 months
4	**Project(s) Type**	Mall	Club	Office Building	Bank
5	**Project(s) Location**	New Cairo	New Cairo	New Cairo	New Cairo
6	**Type-Nature of Client**	Private Client	Public Client	Public Client	Private Client
7	**Type of Contract**	Lump Sum Contract	Unit Rate Contract	Cost Plus Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	Yes	No	No	No
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	Yes	No	No	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**11.5**	**8.0**	**8.5**	**10.58**

Table (C-1) (Continue)

The Data Used During the Analysis and the Modeling Phases

S/N	Site Overhead Factors	Project (s)			
		Development & Agricultural Insurance Egypt	Ahli United Bank of Egypt	Development & Housing Bank of Egypt	BNP PARIBAS Egypt Head Quarters
1	**Category of the Construction Company**	First Category	Second Category	First Category	Second Category
2	**Project Size (Contract Value) (EGP.)**	138,621,600.00	171,500,000.00	194,638,500.00	139,700,000.00
3	**Project(s) Duration (Month)**	30 months	42 months	30 months	28 months
4	**Project(s) Type**	Bank	Bank	Bank	Bank
5	**Project(s) Location**	New Cairo	New Cairo	New Cairo	New Cairo
6	**Type-Nature of Client**	Public Client	Public Client	Public Client	Private Client
7	**Type of Contract**	Unit Rate Contract	Cost Plus Contract	Unit Rate Contract	Unit Rate Contract
8	**Contractor(s) - Joint Venture**	No	No	No	Yes
9	**Special Site Preparation Requirements**	No	No	No	No
10	**Project need for Extra-man Power**	No	Yes	No	Yes
⇒	**Percentage of Site Overhead Costs (%)**	**10.13**	**11.43**	**10.0**	**10.53**

بسم الله الرحمن الرحيم

الـمـلــخـــص الـعـربـــى

يعتمد بقاء شركات المقاولات و إستمرارها بالمنافسة بدرجة كبيرة على قدرتها فى تقييم أسعار المشروعات بدقة عالية اثناء الاعداد لتقديم العطاءات. فالمشاركة فى مشروعات البناء يتطلب إحتساب جميع البنود و التنبؤ بأدق العناصر الخاصة بالمشروع من خلال تطويع القدرات المتاحة لدى الشركة من خبرات و كفاءت العاملين بالشركة بالاضافة الى إيجاد برامج هندسية دقيقة يمكن الاعتماد عليها لتوفير الوقت و الموارد و ضمان أعلى نسبة دقة أثناء حساب جميع بنود المشروع لكى تضمن الشركات أن العرض المقدم قد حدد و فحص جميع التأثيرات الناتجة من العوامل و الخصائص المختلفة للمشروع على نسبة التكلفة النهائية للمشروع لضمان أعلى نسبة ربحية للشركة من هذا المشروع. و بذلك يمكن تجنب التأثير على مشاركة الشركة بالمشروعات القائمة و الجديدة، و بالتالى رفع فئة الشركة فى السوق و إكتساب علاقات و ثقة العملاء القائمين و الجدد.

يهدف هذا البحث الى تصميم نموذج بإستخدام الشبكات العصبية الصناعية كأحدى تطبيقات الذكاء الصناعى لدعم شركات المقاولات ذات الفئة الاولى و الثانية لتقييم نسبة تكلفة نفقات المشروع العامةِ لتشييد مشروعات البناءِ في جمهورية مصر العربية.

و ذلك باستخدام برنامج يعرف بإسم (Neural Connection 2.0 Professional)، و لتحقيق هدف البحث تم تحديد جميع العناصر التى تؤثر على نسبة تكلفة النفقات العامة لمشروعات البناء داخل جمهورية مصر العربية لكى تؤخذ فى الإعتبار أثناء القيام بإنشاء البرنامج و لقد تم التنفيذ على النحو الاتى:

1. تم مراجعة جميع الابحاث السابقة بنفس المجال فى البلدان المختلفة، تم تجميع ١٦ عاملاً مؤثراً على نسبة تكلفة النفقات العامة لمشروعات البناء.
2. تم تحديد حجم العينة المطلوبة من المشروعات و التى يمكن أن تعبر عن المشكلة المراد حلها من خلال البرنامج المختار و قد تم الاستعانة بسجلات الاتحاد المصرى للتشييد و البناء لشركات المقاولات ذات الفئة الاولى و الثانية، تم تطبيق المعادلات الخاصة ببرنامج Neural (Connection 2.0 Professional, User's Manual) و كانت النتيجة ٣٤ مشروعاً كحد أدنى.

٣. تم تصميم إستبيان و من ثم عمل مقابلات و إتصالات مع مديرى إدارات التكاليف بالشركات المختلفة و كانت خبراتهم تتراوح بين ١٥-٢٥ سنة فى مجال إعداد التكاليف لمشروعات التشييد و البناء بمصر. و كان الهدف من هذا الإستبيان هو حصر للعناصر المؤثرة على تكلفة النفقات العامة لمشروعات البناء لإجراء التعديل بقائمة العناصر السابق حصرها من الإبحاث السابق جمعها للعناصر المؤثرة على تكلفة النفقات العامة لمشروعات البناء فى البلدان المختلفة عالمياً.

٤. بعد الإنتهاء من تحديد العناصر المؤثرة على نسبة تكلفة النفقات العامة لمشروعات البناء داخل جمهورية مصر العربية، وجد أن عددهم ١٠ عناصر هى التى تؤثر فى نسبة تكلفة النفقات العامة لمشروعات البناء بمصر، تم تصميم إستبيان ثانى لجمع هذة العناصر من مشروعات تم الإنتهاء منها فعلياً و التى تم تنفيذها من قبل شركات مقاولات ذات فئة الاولى أو ثانية داخل مصر. هذة الشركات تم الإسترشاد عنها من خلال سجلات الاتحاد المصرى للتشييد و البناء.

٥. لقد تم جمع بيانات عن العشر عناصر المطلوبة لعدد ٥٢ مشروعاً لكى يكون العدد أكبر من الحد الادنى المطلوب للبرنامج لضمان أعلى نسبة دقة لناتج البرنامج.

٦. لقد تم إستخدام بيانات ٤٧ مشروعاً من إجمالى ٥٢ الذين تم جمعهم من الشركات و ذلك لإستخدامها فى تدريب و تصميم نموذج الشبكات العصبية الصناعية.

٧. و بعد الإنتهاء من تدريب نموذج الشبكات العصبية من خلال ٥٨ تجربة و ذلك للوصول الى أفضل نموذج يعطى أقل نسبة خطاء، تم إختبار النموذج بواسطة بيانات لم يسبق للبرنامج التعامل معها أثناء مرحلتى التدريب و التصميم للبرنامج و كان عددها خمسة مشاريع.

و لقد تبين من خلال التجارب المختلفة التى أجريت على الشبكات العصبية المختلفة أن أفضل نموذج يمكن الاعتماد علية فى تقييم نسبة تكلفة النفقات العامة لمشروعات البناء فى مصر يتكون من: طبقة المدخل (Input Layer) و بها عشرة خلايا عصبية، و طبقة متوسطة (Hidden Layer) و بها ثلاثة عشر خلايا عصبية (Hidden Neurons) بالإضافة الى طبقة المخرج (Output Layer) و بها خلية واحدة.

وللتأكد من قدرة النموذج على تقييم نسبة تكلفة النفقات العامة لمشروعات البناء فى مصر فقد تم إختبار النموذج على خمسة مشروعات جديدة و كانت نسبة الخطأ 20%، حيث إتخذ القرار السليم فى أربعة مشروعات من إجمالى الخمسة مشروعات تم إختبارها.

و تعتبر هذة النسبة جيدة جداً بالرجوع الى (N-Connection 2.0 Professional, User's Manual).

الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحرى

كلية الهندسة والتكنولوجيا

قسم التشييد و البناء

تقييم الكلفة العامةِ لتشييد مشاريع البناءِ

رسالة مقدمة لاتمام متطلبات الحصول على درجة ماجستير

فى

هندسة التشييد و البناء

مقدمة من:

المهندس/ إسماعيل يحيى على الصاوى

تحت إشراف

أ.د/ محمد إمام عبد الرازق

قسم التشييد و البناء

كلية الهندسة والتكنولوجيا

الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحرى

د/ حسام الدين حسنى محمد

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كلية الهندسة

جامعة الزقازيق

أكتوبر ٢٠١٠