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Artificial Neural Network (ANN) for Estimating of Overhead Cost for School Construction Projects Gaza Strip

استخدام الشبكات العصبية الاصطناعية لتقدير التكاليف الإدارية لمشاريع المدارس – قطاع غزة

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إقــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Artificial Neural Network (ANN) for Estimating of Overhead Cost for School Construction Projects Gaza Strip

استخدام الشبكات العصبية الاصطناعية لتقدير التكاليف الإدارية لمشاريع المدارس – قطاع غزة

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بناءً على موافقة عمادة البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحثة/ ريـا محمـد أحمـد عـوض لنيل درجة الماجستير في كلية *الهندسة* قسم الهندسة المدنية- إدارة المشروعات الهندسية وموضوعها:

استخدام الشبكات العصبية الاصطناعية لتقدير التكاليف الإدارية لمشاريع المدارس في قطاع غزة

Artificial Neural Network (ANN) for Estimating of Overhead Cost for School Construction Projects in Gaza Strip

وبعد المناقشة العلنية التي تمت اليوم الأحد 16 صفر 1439هـ، الموافق 2017/11/05م الساعة الثانية عشر والنصف مساءً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحثة درجة الماجستير في كلية *الهندسة*/ قسم الهندسة المدنية- إدارة المشروعات الهندسية.

واللجنة إذ تمنحها هذه الدرجة فإنها توصيها بتقوى الله ولزوم طاعته وأن تسخر علمها في خدمة دينها ووطنها.

والله ولي التوفيق،،،

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Abstract

Purpose: There are two main objectives of this research. First is to determine the affect factor on OH. Second is to establish a Neural Network Model that will provide any construction firm the ability to assess its overhead costs for any school project. This may improve the construction industry's performance and the ability to overcome the national and international market difficulties.

Methodology: The research generates a questionnaire to select the top ten factors that affect the construction market in Gaza Strip and develop and test the model using the artificial neural network (ANN) technique. Matlab R2013a Software was chosen to generate the Model for predicting the percentage of school projects overhead costs from the total projects costs. This model consists of an input layer with eight input neurons, and one hidden layer with twenty neurons and one output neuron. Data on 70 real-life school construction projects from Gaza were used in the training and validation processes. To verify the generalization ability of the best model, testing with 11 projects (facts) that were still unseen by the network was performed.

Results: The top ten factors that result from questionnaire analysis, are company's experience, closure and the inability to obtain materials, intensity of competition from other contractors, number of projects, existence of documentation for implemented projects, management system for overhead cost, project size, mechanism of company financial dues (payments), firms need for work, and economic inflation. The selected model has 20 hidden neurons, where MSE equal 0 and R = 1 for training phase, MSE equal 0.13 and R = 0.989 for Validation phase and MSE equal 0.13 and R = 0.987 for test phase. The performed sensitivity analysis shows that the firm need for work, existence of documentation for implemented projects, No. of similar projects in the same year and contract amount, have significant influence on the output of the network.

Recommendation: 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 overhead costs decision-making process. In addition, it encourages all parties involved in construction industry to pay more attention for developing ANN in cost estimation by archiving all projects data, and conducting more studies and workshops to obtain maximum advantage of this new approach and join more outputs in a model.

الملخص

الهدف: هناك هدفان رئيسيان لهذا البحث. الأول هو تحديد عامل التأثير على التكاليف الادارية. والثاني هو إنشاء برنامج الشبكة العصبية التي من شأنها أن تقدم لأي شركة مقاولات القدرة على تقييم تكاليفها الادارية لأي مشروع مدرسة الموالية. وهذا قد يحسن أداء صناعة البناء والتشييد وان يكون لها قدرة التغلب على صعوبات السوق الوطنية والدولية.

المنهجية: قام الباحث بعمل استبانة لاختيار افضل عشرة عوامل والتي تؤثر على سوق البناء في قطاع غزة وتطوير واختبار النموذج باستخدام تقنية الشبكة العصبية الاصطناعية (ANN). تم اختيار برنامج Matlab R2013a لعمل نموذج للتنبؤ بنسبة التكاليف العامة للمشاريع المدرسية من التكاليف الإجمالية للمشروع. يتكون هذا النموذج من طبقة المدخلات مع ثمانية خلايا عصبية، وطبقة خفية واحدة مع عشرين خلية العصبية وخلية واحدة لطبقة المخرجات. البيانات المستخدمة هي 70 مشروع لبناء مدارس من غزة والتي استخدمت لعمليتي التدريب والتحقق. وللتحقق من قدرة أفضل نموذج، أجري اختبار مع 11 مشاريع (من وقائع) والتي كانت نتائجها لا تزال غير مرئية من قبل الشبكة.

النتائج: أعلي عشر عوامل الناتجة عن تحليل الاستبانة كانت كالتالي تجربة الشركة في تنفيذ مشاريع مماثلة، الاغلاق وعدم القدرة علي الحصول علي المواد، شدة المنافسة مع المقاولين اخرين، عدد المشاريع المتاحة في السوق، وجود وثائق للمشارع المنفذة، ادارة الشركة للتكاليف الادارية، حجم المشروع، الية الشركة غي المستحقات المالية (المدفوعات)، حاجة الشركة للعمل و التضخم الاقتصادي. النموذج المختار يتكون من طبقة مخفية تحتوي علي 20 خلية عصبية وكانت نتائج مرحلة التدريب تحتوي MSE تساوي 0 و R تساوي 1 ومرحلة المصداقية تحتوي MSE تساوي 0.13 و R تساوي 0.989. اخير مرحلة الاختبار تحتوي MSE تساوي 0.13، وR تساوي 0.987. وتبين أن أكثر العوامل المؤثرة على إنتاج الشبكة هي الحاجة الشركة إلى العمل ووجود وثائق للمشاريع المنفذة وعدد المشاريع المماثلة في نفس السنة ومبلغ العقد وذلك من خلال تحليل كل عامل وايجاد مدي تأثيره على المخرجات.

التوصيات: هذا النموذج هو أداة بسيطة وسهلة الاستخدام جدا والتي يمكن أن تساعد المقاولين / الشركات من خلال النظر في متغيرات تكاليف النفقات العامة المؤثرة وتحسين النسبة المئوية للتكاليف النفقات العامة لعملية صنع القرار. وبالإضافة إلى ذلك، فإنه يشجع جميع الأطراف المشاركة في مجال المقاولات على ابداء المزيد من الاهتمام لتطوير استخدام الشبكات العصبية الاصطناعية لتقدير التكلفة من خلال أرشفة جميع بيانات المشاريع، وإجراء المزيد من الدراسات وورش العمل للحصول على أقصى قدر من الاستفادة من هذا النهج الجديد وربط نماذج الشبكات العصبية باكثر من مخرج.

Dedication

I would like to dedicate this thesis

To My parents “Prof. Dr. Mohammed” and “Noha” for their endless support and unlimited encouragement,

To my handsome husband “Ahmed” and my loving Son “Ibrahim” who were missing my direct care during my study.

To my dearest sister “Eman” and brothers “Ahmed Abdullah and Abdulrahman”, my in laws, my colleagues and my friends for their infinite support.

Eng. Ruba Mohammed Awad

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Also, I wish to thank the consultants, UNRWA and academics who gave me all the needed answers about my questions and allowed me to collect the actual real life projects data.

Last but not the least I express my special gratitude to my parents for their support and prayers. Also, I am especially grateful to my husband for his encouragement and patience,

Thank you.

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AACE:	American Association of Cost Engineering
ANN:	Artificial Neural Network
BPNN:	Back Propagation Neural Network
GRNN:	Generalized Regression Network
HOOH:	Home Office Overhead
MAPE:	Mean Absolute Percentage Error
NN:	Neural Network
OH:	Overhead
PNN:	Probabilistic Neural Network
R:	Regression
RII:	Relative Importance Index
UK	United Kingdom
UNRWA:	United Nations Relief and Works Agency
U.S	United States

Chapter 1

Chapter One: Introduction

This chapter is aimed to outline the theoretical part of the study. The problem statement was presented through highlighting the need for Artificial Neural Network application in the estimating of overhead cost for school construction projects in Gaza Strip. In addition, this chapter included Problem statement, aim, objectives, research importance, study methodology and Thesis organization were included in this chapter.

1.1. Background

In this modern world, daily life was maintained and enhanced by an impressive array of construction, awesome in its diversity of form and function. As long as there were people on earth, structures would be erected to serve them (Assaf et al., 2001).

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 continuously increased.

Construction firms overhead costs can be approached through dividing construction costs into two classifications which are direct and indirect costs. (ElSawy et al., 2011)

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 have two categories: general overhead costs and overhead costs (Pratt, 1995; ElSawy et al., 2011).

General overhead costs could not be identified readily with a project. General overhead costs were items that represent the cost of doing business and often were considered as fixed expenditures that have to be paid by the constructor. General overhead expenditures include the general business expenditures that were included by the home-office in support of the company's construction program. They were intended to include all those expenditures incurred by the home-office that could not be tied directly to a given project such as (Richard et al., 1991; ElSawy et al., 2011):

- 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.

1.2. Rationale of Research

After the outbreak of the Intifada in Gaza Strip in year 2000, the construction industry faced a very critical stage as a result of different reasons; such as an increase in the competition between contractors where the number of projects is declining, very low bids against high probability of risk, shortage of building materials, and disturbance of works due to security conditions etc. (ElSawy et al., 2011)

After the economic situation in the Gaza Strip has created an environment in which construction companies are forced to submit their bids at lowest profit levels in an effort to not be excluded without very strong causes. the clients numerously face contractual problems with contractors who are unable to execute the works on schedule with the desired quality. These problems are mainly due to the bankruptcy of the contractor, mismanagement of project, insufficient experience, or inability to finance the project smoothly. Hence, the inability to execute the works on schedule will increase the cost of overhead and losses.

The percentage of overhead cost estimation is considered a principal parameter in estimating the financial value of a bid offer, where overhead costs are those charges that cannot be attributed exclusively to single product or services (Assaf et al., 2000; El-Sawalhi and El-Riyati, 2015).

Many contractors take the risk and do not consider the actual cost of overhead, especially the home office overhead in order to win the tender. Hence, neglecting overhead costs has forced some contractors out of business because these costs constitute a fair amount of total construction costs (Dagostino, 2002). In construction industry any incremented overhead costs will include both home-office and overhead overhead (Abdul-Malak et al., 2002; El-Sawalhi and El-Riyati, 2015).

The construction industry in Gaza Strip became in need of judicious management to be able to face all obstacles and to minimize the disputes between the parties. Minimization of these disputes need tight and fair contract clauses in addition to presenting guidance for the risks which should be in consideration within any contractual process regarding the overhead cost. On the other hand, the contractor should be aware about the importance of accurate estimation of overhead in their projects to avoid any damages which may occur. (El-Sawalhi and El-Riyati, 2015)

1.3. Problem Statement

The construction industry in Gaza Strip is carried out under exceptional circumstances rarely found in other countries owing to the unstable political and security situations. There are always big problems such as availability of building materials, closures, and the absence of a secure environment most of the time. Hence, the volume of construction projects varies according to the political situations and donors' interests.

The events in Gaza Strip since June 2007 have forced most owners to suspend their contracts for variant periods. Accordingly, there are disputes in most cases where every party has a different perspective to determine the liabilities of overhead in suspension periods. When construction is delayed by owner-caused actions, contractors request compensable delay. It is difficult to reach agreement on causes and extent of delay and even tougher to agree on the cost of delay (Zack, 2001; El-Sawalhi and El-Riyati, 2015). The increment in overhead expenses is easier to quantify. The contractor is required to discover its buildup of preliminaries, showing detailed expenditures for all items considered as general items (infrastructure, cranes, and other general equipment) (Abdul-Malak et al., 2002; El-Sawalhi and El-Riyati, 2015). On the other hand, it is not very clear how home-office costs are affected by site delays.

Overhead cost constitutes a major cost element for any construction project. Identifying the expected 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 led the detailed calculation of overhead cost to be hard and tedious mission. For example, some items of overhead cost are directly related to the project time. Such cost items greatly increase with any extension in the project's time. Another 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 overhead cost are very difficult to be identified or estimated. However, overhead costs are greatly affected by numerous factors such as project size, type, location, client nature, and the project conditions. Hence it was expected that a lump-sum estimation for such cost items will be a easier, convenience, quick approach, and highly accurate. Such approach must take into consideration the various factors that affect overhead cost. It is expected that an artificial neural network Model will be a suitable tool for school projects overhead costs estimation.

1.4. Research Aim and Objectives

The Main aim is to develop ANN Model. The developed ANN Model use to predict OH cost percentage. The Main of this research has two objectives. First objective is to identify the most affected overhead cost factor in school construction project in Gaza Strip. Second objective is to develop an ANN Model. This Model will provide any construction firm the ability to predict overhead cost for any UNRWA School project. This model may improve the construction industry's performance and the ability to compete in the different national and international market (the ability of competing with the international construction firms). This will also improve the bids' accuracy which will lead to a decrease time, effort and money spent during overhead cost prediction. In achieving this aim, two main objectives have been outlined which includes:

- Identifying the top ten overhead cost factors that effect on the school construction projects. This objective will be achieved by using a questionnaire.
- Develop a comprehensive model based on ANN technique. The Output of this model will be OH cost percentage. The top ten factor that concluded from questionnaire analysis, use as input for a model. A data collection of UNRWA school projects in Gaza Strip will use as a sample for a model.

1.5. Research Importance

The estimation of OH costs is a central issue in the planning and management of construction project. In Gaza Strip, methods of estimation are poor and traditional due to lack of historical data and high competitiveness between the companies. It's important to develop a computer model to estimate OH costs and that is why this research is important.

1.6. Study Methodology

The overhead cost estimating model for buildings construction projects is a prediction technique for any school project, in order to assess its overhead cost as a percentage from the overall projects contract value. The model will be developed for the identification or anticipation of all overhead cost factors for school building projects in Gaza for the **first A and B and second categories** of contracting 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 overall project contract value.

This research study will be performed in the following sequence: Figure (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 overhead costs in Gaza from the **expert's opinions** (with the aid of a factors identification and verification questionnaire);
4. **Design the questionnaire**. Then a questionnaire will Distributed on contractor companies that have the **first A and B categories**.
5. **Analysis the questionnaire**. Depend on the **top ten factor** that will be found, the real-life school projects collection sheet will be design.
6. C**ollection of real-life school projects** for the last 5 years from UNRWA in Gaza. The data include companies that have **first A, B and second categories**;
7. Impact analysis to understand the effect of each **overhead cost factor** on the percentage of overhead costs for school projects and also to understand whether a weighting of the factors is **needed or not** before the Model is designed;
8. **Designing of an ANN-based Model** to predict the percentage of overhead costs for school construction projects in Gaza; The sample of school projects from Gaza will be selected to act as demonstrative examples to **investigate the validity** of the developed ANN model;
9. The **sensitivity analysis** will be applied on the selected Model. This will identify the significant input of model on output; and
10. Research **conclusions and recommendations** will be derived from this study to help for future research and studies works.

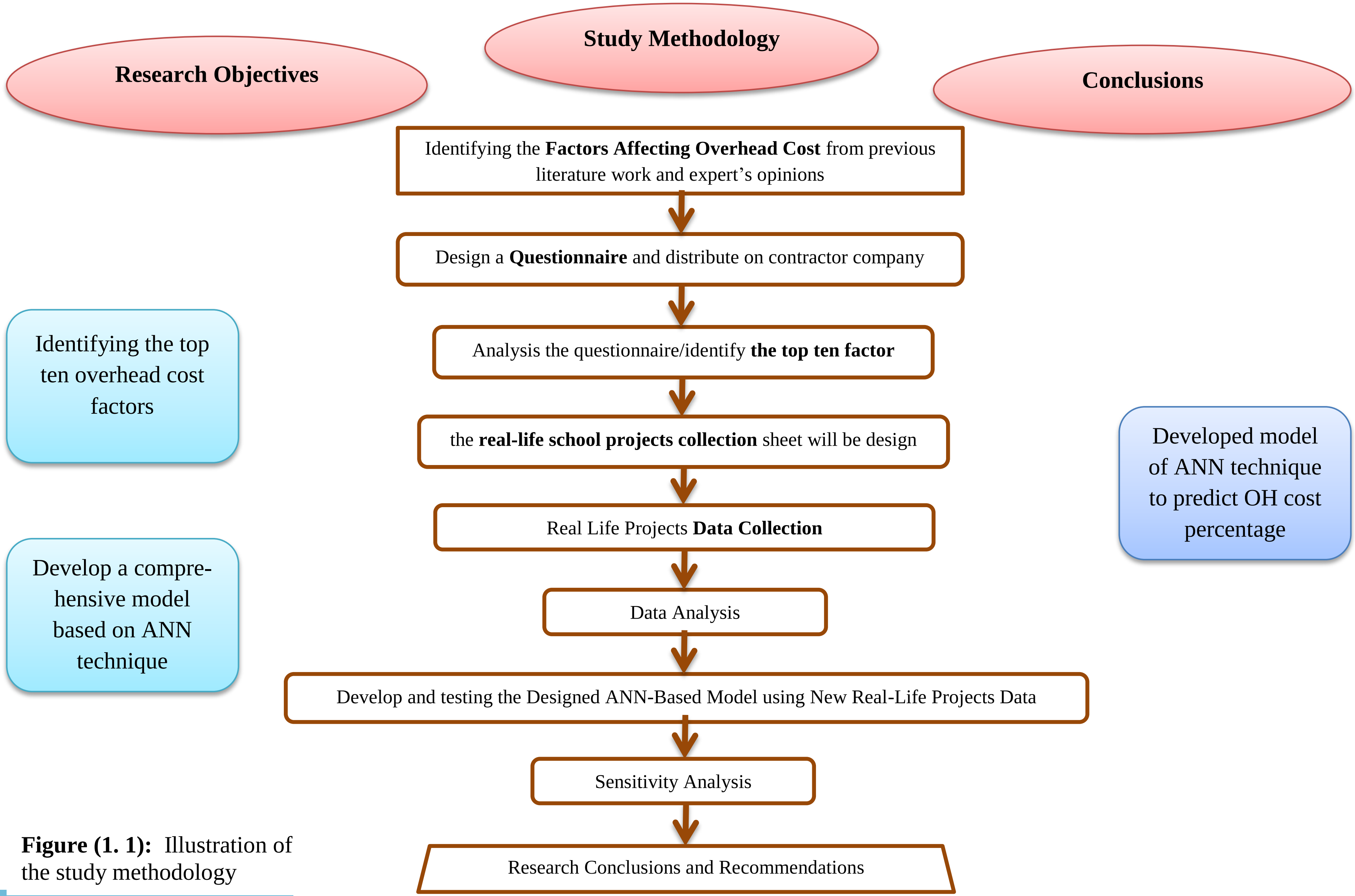

Figure (1. 1): Illustration of the study methodology

1.7. Thesis Organization

The thesis is organized in five different chapters, three appendixes and a list of references.

Chapter one (introduction): The background, Rationale of research, problem statement, aim and objectives, methodology and Research importance are defined.

Chapter two (Literature Review): The definition of various type of OH costs, artificial neural network and previous researches and studies are presented.

Chapter three (Research methodology): The adopted methodology will include problem identification, questionnaire design, analysis of questionnaire and OH cost of NN model.

Chapter four (Modeling and analysis): The collected real-life projects data are presented and analyzed, the ANN model is designed and tested and Sensitivity analysis is made.

Chapter five (Summary, conclusion and recommendations**):** It is the summary and the conclusions are derived from the thesis.

Appendix (A) is a questionnaire for determination and verification of school building construction projects overhead costs factors in Gaza Strip.

Appendix (B) is the real-life school projects collection sheet.

Appendix (C) is a table of the real life collected school projects data.

Chapter 2

Chapter Two: Literature Review

This chapter aims to establish a theoretical understanding of the concept of overhead cost in construction projects. The areas of interest for literature review are: firstly, related definitions to OH: Construction Company General Overhead Cost, Indirect costs, and office overhead costs, Cost estimate, Illustrate the items and factors that affect site overhead, Summary of indirect costs, An Artificial Neural Network. Finally the Previous Work and study summarized in the end of this chapter. The sources have mainly been passed on judicially academic research journals, refereed conferences, theses, reports/occasional paper, government publications, and books.

2.1. Introduction

The literature study was one of the most important stage in the methodology of this research. The first aim of this detailed literature research was to obtain the comprehensive knowledge about the subject under study, "Artificial Neural Network (ANN) for Estimating of Building Construction Overhead Cost". The overall study in this chapter would attempt to answer the following inquiries:

- What is meant by Construction Company General Overhead Cost؟
- What is the differentiate between Site and Office Overhead Costs؟
- What is the Cost Estimate meaning؟
- What is Illustrate the items and factors that affect Site Overhead؟
- What is Artificial Neural Networks (ANNs)?

2.2. Definitions

2.2.1. Construction Company General Overhead Cost

The Council of the Institute of Cost and Works Accountants of India on "Overheads" (2009) defined overheads – Overheads comprise indirect materials, indirect employee costs and indirect expenses which are not directly.

Emerging Professional's Companion (2013) said that overhead costs associated with construction are usually referred to as general conditions. These costs include those for field supervisory staff, additional professional services staff, engineering consultants, as well as temporary facilities and utilities, small tools, and a variety of safety and security equipment. Also included in this category are bonds, permits, and insurance costs allocated to the project. Contractors and subcontractors also incur general conditions costs.

El-Sawalhi and El-Riyati (2015) summarized the construction, field and home office overhead

- ❖ Construction Overhead General costs of the project are defined as the additional, indirect costs that are important for the simplification of the project. However, this definition inadvertently causes confusion by linking indirect costs and general expenses (Holland and Hobson, 1999).
- ❖ OH cost define as cost that could not be identified with or charged to a construction project or to a unit of construction production (Coombs and Palmer, 1995). Therefore, OH costs generally have two categories: general overhead costs and job overhead costs (Peurifoy and Oberlender, 2002).
- ❖ Overhead cost is defined as the costs are those charges that cannot be attributed exclusively to single product or services (Zack, 2001), another definition says that ―those costs that is not a component of actual construction work but is incurred by the contractor to support the work (Cilensek, 1991).
- ❖ Industrial overheads consist of all manufacturing expenses other than direct labor, direct expenses and direct materials. Indirect labor and material and indirect manufacturing expenses are thus included. Examples of indirect manufacturing expenses in a multi-product company are factory rent and machinery depreciation (Drury, 2004; Horngren et al., 2007).
- ❖ In construction industry, general overhead expenses are those expenses that could not be identified readily with a project. General overhead expenses are items that represent the expense of doing business and often are considered as fixed expenses that should be paid by the contractors (Dagostino, 2002).
- ❖ In the survey of Eksteen and Rosenberg (2002) the Respondents contractors says that overhead was included all company expenses that could not directly be allocated or recovered from or attributed to sites. Other terms used by respondents were: expenses of centralized and support functions; basic fixed expenses of opening the front door every day; expenses incurred to run the firm; site preliminaries and general office expenses; expenses of head office and site management;

office and plant yard running expenses; unproductive people or non-productive staff.

- In the context of construction, the term "overhead" often has alternate references as explained by El-Sawalhi & El-Riyati (2015), such as:
  - Home Office overhead؛
  - Home Office general & administrative costs؛
  - Jobsite overhead costs؛
  - Jobsite general & administrative costs؛
  - Jobsite general conditions costs؛
  - Jobsite general requirements costs؛
- In the survey of Eksteen and Rosenberg (2002), there was an overhead cost elements classification which depended on internal accounting and costing systems and on individual business models. Where a respondent contractor classify the overhead as:
  - Administration and management: Head office and site managers' space rentals, salaries, services, computers, IT, office equipment, cleaning, security, water, electricity, printing, refreshments and stationery.
  - Travelling: Vehicles (cars, trucks, LDVs), accommodation, a cross-border activities, transportation of staff.
  - Communication: Telephones, cell phones, faxes, postage.
  - Financial: Auditing, asset ownership, subscriptions, legal fees, depreciation, bank and finance charges, corporate insurances, professional membership fees, sponsorships, donations, group fees.
  - Human resources: Training, skills development, occupational health and safety, salaries, medical aid, pension, etc., industrial relations, holding costs of monthly and some hourly paid site staff, retrenchment packages, protective clothing.

2.2.2. Indirect Costs

Commonwealth of Massachusetts (Division of Capital Asset Management) (2006) said OH costs are those costs which could not be attributed to a single task of construction work. Costs that can be applied to a special item or work may be considered direct cost to which item and not be included in OH costs. The overhead costs are customarily had two categories:

- OH & P (Home Office Overhead), covering Overhead, Administrative costs, and Profit. OH & P expenses are those incurred by the Contractor in the overall management of business.
- General Conditions, including all Job Overhead, General Site Costs and Field Office Overhead. When estimating items costed over the entire duration of construction, the Cost Estimator should utilize the job schedule.

The Cost Estimator should be certain that costs are not duplicated between the two categories. Special considerations should be predestined for each project. The Cost Estimator should use considerable judgment and care in assessment OH costs. The Cost Estimator should rely on historical data, judgment, and current labor market conditions to evaluate OH costs.

Stolz (2010) began by briefly amplifying that construction estimates have direct costs, indirect costs, and profit. Direct costs are those costs which may be directly ascribed to the performance of a specific construction mission and are classified into direct cost items. On the other hand, Indirect costs are costs expended in support of the project and are often referred to as "OH" costs. As can be expected, sometimes the different between direct and indirect costs can get hazy, but indirect costs usually are not estimated til such time as a draft estimate is made of the direct costs، including a preliminary construction schedule. The following categories of indirect costs are typically always used when preparing a tunnel cost estimate.

2.2.3. Site and Office Overhead Costs:

General OHs, Clough (1986) defined general OH includes general business costs like office insurance, office rent, heat, office supplies, electricity, furniture، telephone, and the salaries of executives and office employees. Generally, contractors are using percentage for these expenses. However, Hinze (1999) says that the general costs like an element of costs which cover the company-particular costs of running the business, like those for corporate office personnel, office services and supplies, and administration. These costs continue even if only one job is being conducted by the company.

Asaaf (2001) stated there are two types of OH costs in construction, company OH costs and project OH costs. This research is limited to the company overhead. Company OH is also called general and administrative OH and includes all costs incurred by the construction firm in maintaining the firm in business and supporting the production process, but are not directly related to a specific project (Adrian, 1982). Company OH may be one of the major reasons why so many contractors are unable to realize a profit, or even to continue in business (Lew, 1987). Clearly, a failure in recovering these costs will result in financial collapse if the company does not know its true OH costs. Company OH costs vary considerably from period to period however range from 8 to 15% of the overall construction volume (Pulver, 1989).

The best way in dealing with company OH expenses are to directly charge each project the actual expenses which would be incurred, provided an accurate assessment is reachable (Pulver, 1989). The commonly used allocation technique is to overall company OH costs for a given accounting period and scale them against the whole direct costs for the same time, that gives the percentage of company OH costs which could be applied to forthcoming projects (Lew 1987; Franks 1984). After the OH rate is calculated, it is added to the whole evaluated direct costs of the project in hand. Although this method lacks accuracy, it is widely used among contractors because it is easily applicable to almost all types of projects. The reason accuracy is not obtained is that the amount of OH costs added to a given project does not take into account the efforts exerted by the company's main office to win and manage different projects, which differ considerably from one project to another. Accuracy is also negatively affected because the allocated costs depend on parameters that are determined only through estimation. It must be noted, however, that in deciding the final amount of company OH that has to be added to project direct costs, contractors may not exactly use figures emerging from the calculation. Instead they sense other factors such as the complexity of the project, the com- petition level, or the payment schedule. Major company OH costs include: head office expenses, head office staff wages, insurance, taxes and social security, warehouses, workshops and camps, fees, automobile expenses, uncollected receivables and miscellaneous.

Shaat and Al-Shanti (2003) divided overhead cost to Site (Project) Overheads and General (Company) Overheads. Site OHs based on McCaffer and Baldwin (1991) states that the site OHs as the costs that could be directly attributable to a contract and broadly include: site staff; transport costs; welfare and site office costs; insurances and bonds. In addition site OHs are not specifically identified as being associated with especial work item. These costs are generally incurred whether or not productive work is actually accomplished (Hinze 1999 and Forster 1981).

Patil and Bhangale (2014) illustrated there are two types of OH costs in construction Company OH costs and Project OH costs. Company OH cost is also called general and administrative OH, includes all costs incurred by the construction firm in maintaining the firm in business and supporting the production process, but are not directly related to a specific project. Company OH costs differ significantly from time to time but vary from 8 to 15% of the total construction volume. Project OH cost is also called job site overhead or general condition are It is the cost specific to a project, but not specific to a trade or work item. Project OH costs comprise the contractor's expenses in managing the project at the job site.

2.2.3.1. Home Office Overhead (HOOH)

General overhead costs (main-office or home-office expenses) are intended to include all those expenses incurred by the home office that cannot be tied directly to a given project such as home-office building rental, clerical, or utilities (Neil, 1982). Therefore, these costs are distributed over all company projects by some basis (Holland and Hobson, 1999).

It should be made clear that general and administrative costs are also referred to an overhead and in fact are part of the contractor‘s total overhead (Shelton and Brugh, 2002).

HOOH is generally described as company costs incurred by the contractor for the benefit of all projects in progress. This is the actual cost, which is an essential part of the cost of doing business. These costs cannot be directly allocated to a project. Contractors are reasonably free to account for such costs in whatever manner they choose. They must, however, use the same system at all times and on all contracts (Zack, 2001).

Shelton and Brugh (2002) explained that indirect job costs (field overhead) are related to contract performance, meanwhile general and administrative costs are related to the functioning of the company as a whole. They also gave examples of these types of costs are advertising, dues and subscriptions, office supplies, office salaries, salesman salaries, legal and accounting fees, taxes and licenses, office rent, building maintenance, depreciation on software, office equipment and furniture, owner‘s salary, and utilities.

Examples of such home office overhead costs include but are not limited to the following as specified by Lowe et al. (2003):

- Rent؛
- Utilities؛
- Furnishings؛
- Office equipment؛
- Executive staff؛
- Support and clerical staff not assigned to the field؛
- Estimators and schedulers not assigned to field staff؛
- Mortgage costs؛
- Real estate taxes؛
- Automobile maintenance and travel costs for home office personnel؛
- Non-project-related bond or insurance expenses؛
- Depreciation of equipment and other assets؛
- Advertising؛
- Marketing؛
- Office supplies (paper, staples, etc.).
- Interest؛
- Legal services؛
- Accounting and data processing; and
- Professional fees/registrations.

Irwin (2005) explained that Contractor‘s accounting system does not distribute these costs directly to specific projects. For example, an accounting clerk may work on several projects during a day but on the time card enters all 8 hours on one line item called ―accounting.‖ Therefore, home office overhead costs are usually posted to accounts that are not project related, and lumped together, they are called the home office overhead "pool".

Home office overhead normally consists of costs such as auto travel, professional trade licenses and fees, employee recruitment, relocation, training and education, photocopying, entertainment, contributions, donations, postage, cost of preparing bids, review of submittals, taxes, advertising, insurance premiums, interest costs, and data processing/computer costs (Taam and Singh, 2008).

EL-Sawalhi and Shehatto (2013) represented that overheads cost are construction costs of any kind that cannot be attributed to any specific item of work. In general, Overheads are a significant item of expense and will generally run from (5% to 15 %) of the total project cost, depending somewhat on where certain project costs are included in the cost estimate.

El-Sawalhi and El-Riyati (2015) declared the general overhead expenses include the general business expenses that are incurred by the home office in support of the company construction program (Clough et al., 2000). In other words, home office overhead represents the costs of the activities of the Contractor‘s home, or corporate, office necessary to run the business and to support the projects in the field (Irwin, 2005).

2.2.3.2. Field overhead

El-Sawalhi and El-Riyati (2015) defined field overheads as the general cost or direct cost of the project for providing general plant and site-based services like insurance, site accommodation, etc (Chan and Pasquire, 2002). It mainly consists of the costs expended to manage and administer a specific project (e.g., the cost of providing a job site office) (Lowe et al., 2003). In other words, it is used to quantify overhead costs that are incurred in the field (Ruf, 2007).

The following Table (2-1) shows items that might qualify as field overhead costs as specified by Ruf (2007).

Table (2. 1): Field overhead items.

Possible Field Overhead Items	
Office Trash Removal	Airfare - Home Office Personnel
Office/Field Water	Ice Builders Risk Insurance
Portable Toilets	Cell Phones
Postage & Shipping	Engineers' Office Rent
Safety Supplies	Field Office Expenses
Telephones	Insurances Required by contract
Utilities	Lodging - Home Office Personnel
Yard Rent	Miscellaneous Expenses
Yard Tools & Supplies	Office Security
Office Trailer Rental	

Source: Ruf (2007).

Field overhead costs include items that can be identified with a particular job, but are not materials, labor, or production equipment. Job overhead includes expenses that cannot be charged directly to a particular branch of work, but are required to construct the project (Dagostino, 2002). Job overhead (field overhead) is similar to general overhead but it must be distributed over the associated project, since it cannot be allocated to specific work packages (Neil, 1982).

Lowe et al. (2003) refers to very important details for a part of site overhead, which is Labor Overhead. Overhead on direct salary costs includes sick leave, vacation, and holiday pay; unemployment, excise and payroll taxes; contributions for social security, employment compensation insurance, retirement benefits, and medical insurance benefits; and any other benefits customarily paid to or available to all employees.

An increase in site overhead expenses is usually easier to quantify. It requires the contractor to disclose its buildup of site preliminaries, showing detailed costs for all items considered as general site items (site infrastructure, cranes, and other general site equipment) (Abdul-Malak et al., 2002).

According to Shelton and Brugh (2002), Indirect costs allocable to contracts include the costs of indirect labor, contract supervision, tools and equipment, supplies, quality control and inspection, insurance, repairs and maintenance, depreciation and amortization, and, in some circumstances, support costs, such as central preparation and processing of payrolls.

2.3. Cost estimate

Shaat and Al-Shanti (2003); Clough (1986) stated that the construction assessment as the compilation and analysis of the various items which influence and contribute to the project cost. Steward (1991) definite the cost evaluating from the Society of Cost Estimating and Analysis (SCEA), as "the art of approximating the probable worth or cost of an activity based on information available at the time". Ritz (1994) gives another definition which is, "the project cost estimate is the predicted cost of executing the work."

Ahuja, et al, 1994 define cost estimate is "the Estimate at best is an approximation of the expected cost of the project".

Kim, An and Kang (2004) divided cost estimating to three models, first the Multiple regression model that have been used for estimating cost since the 1970s because they have the advantage of a well-defined mathematical basis as well as measures of how well a curve matches a given data set. Second Neural network model which is a computer system that simulates the learning process of the human brain. NNs are widely applied in many industrial areas, including construction. Third Case-based reasoning model is an alternative to an expert system, which is based on rule-based reasoning. Reasoning in CBR is based on experience or memory (Chen and Burrell, 2001). A case-based reasoner solves new problems by adopting solutions that were used to solve old problems.

EL-Sawalhi and Shehatto (2013) represented that association for the Advancement of Cost Engineering (AACE) International defines the cost estimation as it provides the basis for project management, business planning, budget preparation and cost and schedule control (cited in (Marjuki, 2006)). Dysert in (2006) defined a cost estimate as, "the predictive process used to quantify cost, and price the resources required by the scope of an investment option, activity, or project". Moreover, Akintoye & Fitzgerald (2000) defined cost estimate as, "is crucial to construction contact tendering, providing a basis for establishing the likely cost of resources elements of the tender price for construction work". Another definition was given by Smith & Mason (1997) which is "Cost estimation is the evaluation of many factors the most prominent of which are labor, and material“. The Society of Cost Estimating and Analysis (SCEA) defined the cost estimation as "the art of approximating the probable worth or cost of an activity based on information available at the time" (Stewart, 1991).

2.4. Illustrate the Items and Factors that Affect Site Overhead

Elhag and Boussabaine (1998) described the cost factor as following: Type of project, Type of contract, Market conditions, Site slope, Start conditions, Ground conditions, Excavation conditions, Site access, Work space in site, Number of stories, Gross floor area (m^2), Duration (months) and Lowest tender price (£).

Asaaf, Bubshait, Atiyah and Al-Shahri (2001) studied factors that affecting on company (general) OH and say "In many instances, decision-makers in contracting firms do not adhere to figures coming from project estimators but change company OH rates to higher or lower values. Contractors may choose to do so because of the nature of the contract, the size and complexity of the project, the contractor’s need for work, financial causes, the contractor’s experience with the client, the degree to which subcontractors services are needed, or the number of contractors competing to win the project, that may not be known at bidding time." his factors are type of contract, project complexity, location & size, need for work, payment schedule, contractor’s cash availability, client’s strictness in supervision, percentage of subcontracted work, number of competitors.

The project's duration, overall contract value, projects type، special site preparation needs and project's location are identified as the top five factors that affect the value of the percentage of site overhead costs for building construction projects in Egypt (ElSawy, 2011)

El-Sawalhi and El-Riyati (2015) showed the estimation of overhead percentage as presented by (Eksteen and Rosenberg, 2002) was influenced by historical data of the projects; a prediction of future activity, the ratio between contractors and subcontract work, competitive conditions, the nature, size and duration of the project and an evaluation of risk. Furthermore، reference (Lowe, et al. 2003) added that the profit potential of individual projects is driven by many factors, including the contract terms and the level of competition.

2.5. Summary of Overhead Costs Factors

After reviewing the previous noted literature and asking experts' opinion, as well as, 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 1998-2015.

Table (2. 2): Factors Contributing to Construction Site OH Cost from previous study

NO.	Factor	Referrance
G 1	Firm Factor (Construction Firm Category.)	
1.1.	Expertise in the determination of the overheads costs percentage during the pricing of tenders.	(ElSawy, 2011)
1.2.	Setting up system for monitoring, follow-up, and evaluation of company overheads costs.	
1.3.	Using of computerized systems	
1.4.	Doing financial auditing for expenses and revenues in periodic and continuous manner	
1.5.	Company's ability to cope with the problems during the implementation	
1.6.	The company's ability to identify and expect risks	
1.7.	The company's ability to adhere to the implementation of projects according to the specification within the contractual period	
1.8.	Separation between the home office overhead and field overhead costs	
1.9.	Diversity in the company's business (works other than construction, such as trade, for example)	
1.10.	The existence of documentation and records for information on projects that have been implemented already	
1.11.	A tendency towards claims and rigorism in contractual matters	
1.12.	Company response in finding solutions for claims and disputes	
1.13.	The company's experience in implementing similar projects	
1.14.	Banking facilities obtained by the company	
1.15.	Financial liquidity of the company	
1.16.	Value and number of projects that are contracted annually (financially)	
1.17.	Mechanism of contractor financial dues (payments)	
G 2	Project Factor	
2.1.	Project Size.	(ElSawy, 2011); (Asaaf, 2001)

NO.	Factor	Referrance
2.2.	Project Duration.	(ElSawy, 2011); (Al-Shanti, 2003); (ElSawalhi, 2015); (Asaaf, 2001)
2.3.	Project Type.	(ElSawy, 2011); (Shehatto, 2013); (AlShanti, 2003); (ElSawalhi, 2015)
2.3.1.	Costs of value-added tax	
2.3.2.	Project Income tax	
2.3.3.	Project vehicles and fuel required	
2.3.4.	Survey instruments	
2.3.5.	Electrical and mechanical necessary equipment	
2.3.6.	Field offices rental costs	
2.3.7.	Furniture of field offices	
2.3.8.	Computers and printers	
2.3.9.	Stationery and publications	
2.3.10.	First aid kit	
2.3.11.	Cost of connecting water, electricity, phone to the work field	
2.3.12.	Cost of access roads	
2.3.13.	Cost of fence for protection	
2.3.14.	Cost of demobilization	
2.3.15.	Guarantees (good performance and maintenance)	
2.3.16.	Salary of project engineer	
2.3.17.	Site engineer salary	
2.3.18.	Mechanical and electrical engineers salaries	
2.3.19.	Surveyor Salary	
2.3.20.	Forman salary	
2.3.21.	Quantities surveyor salary	
2.3.22.	Office boy salary	
2.3.23.	Drivers salaries	
2.3.24.	Project accountant salary	
2.3.25.	Bills of water, electricity, telephone, mobiles and Internet	
2.3.26.	Hospitality and drinks	
2.3.27.	Miscellaneous	
2.3.28.	Project insurances (labors and contactor all risks)	
2.4.	Project Location.	(ElSawy, 2011); (Al-Shanti, 2003); (ElSawalhi, 2015)

NO.	Factor	Referrance
2.5.	Type-Nature of Client.	(ElSawy, 2011); (Asaaf, 2001)
2.5.1.	owner's commitment toward payments as scheduled	
2.5.2.	The company's experience with the owner (the previous relationship between the company and the owner)	
2.5.3.	Strictness of owner in supervision	
2.5.4.	Owner response towards financial claims	
2.6.	Type of Contract.	(ElSawy, 2011); (Shehatto, 2013); (ElSawalhi, 2015); (Asaaf, 2001)
2.6.1.	Contractual terms of the project	
2.7.	Contractor-Joint Venture.	(ElSawy, 2011); (Asaaf, 2001)
2.7.1.	Project need for Extra-man Power.	
2.7.2.	The proportion of sub contracted works	
2.7.3.	Relation with subcontractors	
2.8.	Special Site Preparation Requirements.	(ElSawy, 2011); (ElSawalhi, 2015)
2.8.1.	Closure and the inability to obtain materials	
2.8.2.	Economic inflation	
2.9.	Direct cost	(Asaaf, 2001)
G 3	Market Factor	
3.1.	Intensity of competition from other contractors Marketing	(ElSawalhi, 2015); (Asaaf, 2001)
3.2.	Number of projects	(Asaaf, 2001)
3.3.	Project bid value	(Asaaf, 2001)

2.6. An Artificial Neural Network

Elhag and Boussabaine (1998) illustrated that the artificial neural network (ANN) is an analogy-based process, which best suits the cost prediction domain. The main advantages of ANNs is their ability to learn by examples (past projects), and to generalise solutions for forthcoming applications (future projects). ANNs do not require a prerequisite establishment of rules and reasoning which govern relationships between a desired output and its significant effective variables. Two ANN models have been developed to predict the lowest tender price of primary and secondary school buildings.

Rumelhart and McClelland (1986), an ANN is presented as a set of operators or neurons, with a small amount of storage capacity, connected numerically one-way by links called axons. Nodes operate with local data supplied through the axons, weighted with some parameters, wij, linking neurons i and j. A propagation rule establishes how inputs to a neuron are valued and processed. The basic model has an input layer, one or several hidden layers formed by non-observable variables, and an output layer containing the dependent variables. Like any model, the specification is the core task when using ANN: it is necessary to define the network topology (number of hidden layers، and the neurons in each of them), the propagation rule, the transformation of explanatory input variables, and so on. The activation function and the learning rule should also be specified. An excessive number of neurons can originate a lack of forecasting power, due to over parameterization. Computer time to estimate the ANN parameters, learning process, is becoming less relevant with the evolution of the speed in the equipment. There are several learning procedures to estimate the parameters; a widely used technique is the back-propagation method.

An ANN is like a non-linear regression or a multivariate regression model, with no observable linking variables. Once the topology and the parameters of the network are specified، it can be presented as an ordinary statistical or econometric model. Neural networks are used with different purposes, such as the estimation of models, classification, forecasting, and so on. (Núñez Tabales et al., 2013)

2.7. Previous Work

Bastian (1994) illustrated that an effective way to dynamically determine the number of hidden units in a three-layer feedforward neural network for function approximation is proposed.

Elhag and Boussabaine (1998) demonstrated the development of a cost assessment model using ANN and a back-propagation algorithm. Determinants of building project costs were identified, and their pertaining data was extracted from the BCIS database. Two ANN models were developed, model I & II, for predicting the lowest tender price of primary and secondary school projects. Thirteen cost-influencing factors were involved in model I, whereas only 4 input variables contributed to model II.

Siqueira (1999) presented a neural network-based cost estimating method. Developed for the generation of conceptual cost estimates for low-rise prefabricated structural steel buildings. A PC-based software system (ACE) is then developed to automate the conceptual cost estimating process, using the neural network models for direct cost estimating. The ability of NNs to capture real life experiences encountered on actual projects (Le. actual costs), generalize and utilize that knowledge for estimating the cost of new projects makes it a very powerful tool to the application at hand. Data used in this study (75 building projects) were collected from a large manufacturer of prefabricated structural steel buildings in Canada (Canam Manac) over a 3-month period. The performance of developed cost models was tested against costs incurred by projects not used in training of those models، and costs predicted by regression. Results indicate that the proposed models, when used for projects with parameters within the range for which the models were trained, outperform regression.

Kavzoglu (1999) determined the optimum network structure for the classification of land-cover classes are investigated. The structure of the network has a direct effect on training time and classification accuracy. Investigations of the relationship between the network structure and the accuracy of the classification are reported, using a MATLAB tool-kit to take the advantage of scientific visualization. All the analyses carried out are based on the combination of visual and mathematical analyses. Five important conclusions can be drawn from the results. These are:

- magnitudes of the network weights increase more in the first part (between input and hidden layer section) in the training stage،
- accuracy does not increase gradually when the size is increased.
- large networks learn tasks more quickly, but not necessarily better,
- large networks do not give considerably better results.
- scientific visualization can provide valuable insights for understanding the behavior of ANNs.

The most important conclusion derived is that large networks do not always improve the accuracy of the classification A network that is large enough to learn the characteristics of the data is usually sufficient. However, several factors, such as learning parameter, number of iterations, transfer function and the characteristics of the data, play very important role to get a network with high generalization capabilities. Investigating the effects of these factors would be very useful to understand the behavior of artificial neural networks.

Fang and Froese (1999) employed neural networks to predict automatically the costs of concrete and formwork required for a wall-frame structure system of tall commercial buildings using high strength concrete. The structural elements involve solid slabs, beams, columns and shear walls. Design parameters such as grid sizes، numbers of story and grades of concrete have been considered in the models to assess their effect on quantities/costs of the high performance concrete HPC structures. Two strategies of cost estimation based on neural networks have been proposed. From the training and validation results, it can be concluded that all the neural models, no matter of the hybrid or hierarchical strategies, can provide a promising cost estimation. The two strategies are compared and it is confirmed that the hybrid model is less accurate but easy to be trained, while the hierarchical models are more accurate but more complicated in implementation.

Asaaf et al. (2001) investigated the overhead cost practices of construction companies in Saudi Arabia. The 61 large building construction were investigated via questionnaire. Results show that average OH cost is slightly higher than the ratio reported in the literature. The average percentage of company OH costs to project direct cost is greater than 10%. Reasons of high OH costs are delayed payments, Lack of new projects, cost of inflation and governmental regulations. Factors affecting company overhead costs include the following: automobile and equipment costs, head office expenses, labor related costs and financing costs. The unstable construction market makes it difficult for contractors to decide on the optimum level of OH costs that enables contractors to win and efficiently administer big projects.

Eksteen and Rosenberg (2002) showed the progress on current research into managing OHs in South African construction enterprises. Its objective is to promote productivity through optimal management of OHs.

Kim and Ballard (2002) reviewed traditional overhead control and critiques problems thereof through literature review which are:

1. Cost Distortion Hinders Profitability Analysis
2. Little Management Attention to Activities or Processes of Employees

Odeyinka et al (2002) attempted to model the variation between predicted and actual cost flow due to inherent risks in construction. Data were obtained through questionnaire survey and empirical data collection. Contractors on individual projects were requested to score on a Likert type scale, the extent of occurrence of each identified risk variable that resulted in the variation between the predicted and actual cost flow profiles. An analysis of the responses, using ranking of the mean response enabled the study to focus on the most significant risk variables. The impact of these risk variables on cost flow forecast was then investigated by collecting data on predicted and actual cost flow from completed construction projects in order to determine their variation.

Shaat and Al-Shanti (2003) explored the local practice in construction cost assessment and develop a cost estimating system to facilitate the local estimating practice mainly in building construction.

Kim et al. (2004) examined the performance of three cost estimation models for estimating construction costs of Korean residential buildings. The examinations are based on multiple regression analysis (MRA), neural networks (NNs), and case-based reasoning (CBR) of the data of 530 historical costs. Although the best NN estimating model gave more accurate estimating results than either the MRA or the CBR estimating models because of the trial and error process, the CBR estimating model performed better than the NN estimating model with respect to long-term use, available information from result, and time versus accuracy tradeoffs and the clarity of explanation should be considered in cost estimating model. The CBR model was more effective with respect to these tradeoffs, especially its clarity of explanation in estimating construction costs, than the other models. The CBR and NN models were appropriate for estimating construction costs. However, further research is required to develop a hybrid model integrating the various tools, such as NNs, case-based reasoning, and genetic algorithms. In particular, a NN model incorporating genetic algorithms for obtaining both the optimal NN architecture and its parameters will be developed in the future.

Šiškina and Apanavičiene (2009) presented a relevant and innovative methodology for evaluating the competitiveness of construction company overhead costs and preliminary selection of overhead costs optimization strategies. By applying the correlation-regression analysis the dependences between the relative values of construction company overhead costs and their components - administration and building facilities' costs, and company's infrastructure parameters - number of administration employees and buildings' area were defined. These models can be applied in practice in order, to forecast overhead expenses in accordance with different parameters of a construction company's management system and evaluate possible overhead costs optimization strategies.

Luu and Kim (2009) employed the application of artificial neural networks(ANNs) in estimating Total construction cost TCC of apartment projects in Vietnam. Ninety-one questionnaires were collected to identify input variables. Fourteen data sets of completed apartment projects were obtained and processed for training and generalizing the neural network(NN). MATLAB software was used to train the NN. A program was constructed using Visual C++ in order to apply the neural network to realistic projects. The results suggest that this model is reasonable in predicting TCCs for apartment projects and reinforce the reliability of using neural networks to cost models.

Stolz (2010) reviewed briefly, the contractor consensus that cost evaluates for heavy civil and tunnel projects should be based on a "bottom-up" approach. He said that three factor which are indirect cost categories, project schedules, and evaluated uncertainty, not only helps owners establish criteria for preparing cost estimates, but also guides them to the cost elements that might suggest when it is beneficial to make changes to the standard contract language. Understanding the categories of indirect costs helps owners better comprehend how contractors price their work for these costs and why these costs are so much higher than the standard allowances for OH an markup in the Standard Specifications. It also explains why having a detailed project schedule is key because so many of these indirect costs are time dependent. Finally, understanding base uncertainty in an estimate gives owners a better idea about how confident they can be in the numbers when establishing a project budget. Supplied with these tools, owners can review a cost estimate with more confidence and greater effectiveness.

Attal (2010) attempted to develop a consistent model of forecasting early design construction cost of highway and the project's duration based on statistical analysis. Consequently, the statistical techniques used to represent Artificial Neural Networks (ANN) and step wise regression analysis to identify the influential parameters and forecast the early design phase of highway construction cost and duration. The input data used to develop the mathematical models were compiled and maintained by the Virginia Department of Transportation. The data used in these modeling was extracted from two sources within VDOT: Data Warehouse Management Information Portal (DWMIP) and Project Cost Estimating System (PCES)". The parametric stage data were maintained in Project Cost Estimating System (PCES) by VDOT. In addition, for the identification of effective parameters used in these models, two separate techniques were used; sorting and identifying the effective parameters used in traditional techniques, the trial and elimination method of ANNs, and sensitivity analysis. Consequently, the chosen parameters were analyzed by two distinct statistical techniques: linear regression analysis and nonlinear ANN.

ElSawy et al. (2011) used Artificial Neural Network (ANN) way to develop a parametric cost-evaluating model for site overhead cost in Egypt. Fifty-two actual real-life cases of building projects constructed in Egypt during the seven-year period 2002-2009 were used as training materials. The study conducted a survey that investigated the factors affecting project's site overhead cost for building construction projects in the first and second categories of construction companies. The neural network architecture is presented for an assessment of the site overhead costs as a percentage from the overall project coat during the tendering process. The model consists of one 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 the model is set automatically by the N-Connection V2.0 while the training and testing tolerance are set to 0.1.

Arafa and Alqedra (2011) developed an efficient model to evaluate the cost of building construction projects at early stages using ANNs. A database of 71 building projects is collected from the construction industry of the Gaza Strip. Several significant parameters were identified for the structural skeleton cost of the project and yet can be obtained from available engineering drawings and data at the pre-design stage of the project. The input layer of the Artificial Neural Networks (ANN) model comprised seven parameters, namely which area ground floor area, typical floor area, number of story's, number of columns, type of footing, number of elevators and number of rooms. The developed ANN model had one hidden layer with seven neurons. One neuron representing the early cost estimate of buildings formed the output layer of the

ANN model. The results obtained from the trained models indicated that neural networks reasonably succeeded in predicting the early stage cost estimation of buildings using basic information of the projects and without the need for a more detailed design. The performed sensitivity analysis showed that the ground floor area, number of story's, type of foundation and number of elevators in the buildings are the most effective parameters influencing the early evaluate of building cost.

Aibinu et al. (2011) constructed and trained a three- layer ANN model of feed- forward type with one output node to generalise nine characteristics of 100 completed projects and the cost data from those projects. The nine input variables of the model are project size (measured by number of story's and gross floor area), principal structural material, procurement route, project type، location, sector, estimating method, and estimated sum. Estimate accuracy (bias) was used as the output variable. The prediction power stands at 73% correlation coefficient, 3% of Mean Absolute Error and 0.2% Mean Squared Error. It was found that in more than 73% of the test cases the predicted estimate bias did not differ by more than 8.2% from the expected) Maximum Absolute Error). This means that amount of estimate bias predicted by the ANN are similar to what actually occurred. The trained ANN model can be used as a decision-making tool by cost advisors when forecasting building cost at the pretender stage. The model can be queried with the characteristics of a new project in order to quickly predict the error in the estimate of the new project. The predicted error represents the additional contingency reserve that must be set aside for the project in order to cater for possible cost overruns. The model can also be extended to forecast the likely cost of a project.

Ahiaga-Dagbui1 and Smith (2012) showed that the knowledge acquisition, generalization and forecasting capabilities of Artificial Neural Networks (ANN) to build final cost estimation models. Data was collected on ninety-eight water-related construction projects completed in Scotland between 2007-2011. Separate cost models were developed for normalized target cost and log of target costs Ten input variables, all readily available or measurable at the planning stages for the project, were used within a Multilayer Perceptron Architecture and a Quasi-Newton training algorithm.

Kaushik et al. (2013) investigates the use of Back-Propagation neural networks for software cost estimation. The model is designed in such a manner that accommodates the widely used COCOMO model and improves its performance. It deals effectively with imprecise and uncertain input and enhances the reliability of software cost estimates. The model is tested using three publicly available software development datasets. The test results from the trained neural network are compared with that of the COCOMO model.

Tony (2013) illustrated that the cost of building work is important to the vast majority of construction clients and outlined the principle factors affecting the cost of building work within the Irish context. The study identified that the client's priorities in relation to quality, cost and time constraints are key factors in forming an effective brief. The appointment of the design team is shown to be a key decision in the process of developing this brief and determining the nature, and hence the cost of the project. Design factors affecting the cost of buildings include their function, geometry، specifications, emphasis on whole life costs, legislative constraints and socioeconomic factors. The location, physical and environmental conditions of the site also exert a considerable bearing on costs. The study also examined the impact of procurement choices, and market conditions and concluded with an overview of the factors affecting the contractor's site production costs.

El-Sawalhi and Shehatto (2014) developed a model to evaluate the cost of building construction projects with a high degree of accuracy and without the need for detailed information or drawings by using Artificial Neural Network (ANN), through developing a model that is able to help parties involved in construction projects (owner, contractors, and others) in obtaining the total cost information at the early stages of project with limited available information. ANN is new approach that is used in cost estimation, which is able to learn from experience and examples and deal with nonlinear problems. It can perform tasks involving incomplete data sets, fuzzy or incomplete information and for highly complex problems. In order to build this model, quantitative and qualitative techniques were utilized to identify the significant parameters for the building project costs including skeleton and finishing phases. A database of 169 building projects was collected from the construction industry in Gaza Strip. The ANN model considered eleven significant parameters as independent input variables affected on one dependent output variable "project cost." Neurosolution software was used to train the models. The results of the trained models indicated that neural network reasonably succeeded in estimating the cost of building projects without the need for more detailed drawings. The average error of test dataset for the adapted model was largely acceptable (less than 6%). The performed sensitivity analysis showed that the area of typical floor and number of floors are the most influential parameters in building cost.

El-Sawah and Moselhi (2014) presented a study on the use of artificial neural networks (ANNs) in preliminary cost estimating. The choice and the design of the ANN model significantly affect the results obtained from the model and, hence, the accuracy of the estimated cost. The study considered Back Propagation Neural Network. Models were developed for order of magnitude cost estimating of low-rise structural steel buildings and short-span timber bridges. The study was conducted on actual data for 70 low-rise structural steel buildings and their respective cost was estimated using the developed regression and ANN models. These models were also applied to estimate the cost of a timber bridge extracted from the literature. The results showed that the mean absolute percentage error for the neural network models ranges from432q 16.83% to 19.35% whereas was equal to 23.72% for the regression model. Moreover, the linear regression model was more sensitive to the change of the number of the training data and that the PNN network was the most stable network among all the other estimating models as the maximum difference in MAPE percentage was only 2.46%. Whereas, the maximum difference in MAPE was 19.47%, 17.91%, and 61.45% for BPNN, GRNN and regression models respectively.

Lyne and Maximino (2014) developed an artificial neural network (ANN) model which could estimate the overall cost of building projects in the Philippines. Data which was thirty building projects, were collected and randomly divided into three sets: 60% for training, 20% for validating the performance and 20% as a completely independent test of network generalization. Six input parameters, namely: number of story's, number of basements, floor area, volume of concrete, area of formworks، and weight of reinforcing steel. These inputs were entered into the ANN architecture and simulated in MATLAB. The feedforward backpropagation technique was used to generate the best model for the overall structural cost. The best ANN architecture consists of six input variables, seven nodes in the hidden layer and one output node. The resulting ANN model also reasonably estimated the overall structural cost of building projects with favorable training and testing phase outcomes.

Patil and Bhangale (2014) discusseed the actual definition of overhead cost, contractor awareness about overhead cost, percentage of OH costs, changes in overhead cost, causes of increased overhead cost in construction industry, contractors perception about overhead cost, control of overhead cost. As a result of research, the unstable construction market makes it difficult for contractors to decide on the optimum level of OH costs that enables contractors to win and administer large projects and at the same time does not financially drain the company. Reason of increased OH costs include shortage of new projects, delayed payments, cost of inflation and government regulations. Factors affecting company OH costs include the following: automobile and equipment costs, head-office expenses, labor related costs and financing costs. Results of survey show that average overhead cost is slightly higher than the ratio reported in the literature.

El-Sawalhi and El-Riyati (2015) stated that the majority of contractors in Gaza Strip are aware towards overheads concept and they have good knowledge about the components of overheads. Accordingly, companies' owners or senior managers usually estimate overhead costs during the pricing of tenders. Around one third of contracting companies in Gaza Strip do not depend on historical data during pricing process. The OH cost is calculated based on detailed calculation for all items required by contractual conditions. No specific amount or percentage could be applicable to be added. Furthermore, during the bidding stage the overheads costs is equally distributed within each item proportionally to the total contract value. High competition in Gaza construction industry may force the contractors to reduce the HOOH percentage. Most contractors believe that submission of overhead breakdown within their bids will give them opportunity to review the overheads accurately before submission.

Janani et al.(2015) discussed about overheads, overhead percentage on contractual value, factor affecting the overhead costs, major issues faced by contractors, how overhead costs affects the income, Engineers/Contractors view on overheads, investigation and control of overhead costs, creating cost awareness among employees, lists out the major items which affects the overheads, interviews with professionals and data collection from the projects and hence creates awareness while bidding and plan the financial resources effectively. They said In order to control the overhead costs in project, the initiated project has to be completed on time without any delay، delayed arrival of materials to project site has to be controlled or it must be eliminated at any reasons, regular review on reports, and regular supervision of project work، delayed payments of wages to employees, proper monitoring and control on costs must be performed.

Olufolahan et al. (2015) developed an Artificial Neural Networks (ANN) model to estimate operating and maintenance costs of existing buildings. Historical data were gathered from an Office Block, Penllergaer Business Park. The resulting ANN model reasonably predicted the total cost of the building with favorable training and testing phase outcomes. The study improves the confidence in life cycle costing (LCC) modelling.

Jiang and Shi (2016) investigates the different roles of entry cost and overhead cost in the productivity-based selection of firms into production. It also discusses the implications for the resource allocations of the aggregate economy. Using an analytically tractable model with entry and exit, we show that reducing entry cost will increase average firm productivity by encouraging more entries of firms, whereas reducing overhead cost will decrease it by adversely lowering the selection standard. The perspective of improving the allocation of production resources. They apply the model to infer these two costs and to quantify their potential effects, using six-digit U.S. manufacturing data. The quantitative results show that a 1% reduction in entry cost increases output by 0.27%, whereas the same percentage of reduction in overhead cost increases output by only 0.048%. Their findings suggest that the various policies designed to reduce the costs of setting up new businesses are more important than the policies designed simply to reduce operation costs.

Yadav et al. (2016) develop a cost estimation technique by using an artificial neural network (ANN) model that will be able to forecast the total structural cost of residential buildings by considering various parameters. In this study, data of last twenty-three years has been collected from Schedule of rate book (SOR) and general studies. Eight input parameters، namely, cost of cement, sand, steel, aggregates, mason، skilled worker, non-skilled worker and the contractor per square feet construction were selected. The parameters were simulated in NERO XL Version 2.1 for developing ANN architecture. The resulting ANN model reasonably predicted the total structural cost of building projects with correlation factor R—0.9960 and RSquared-0.9905 giving favorable training and testing phase outcomes.

2.8. Summary

This chapter reviewed the literature of different definitions of overhead cost, cost estimation, summary of overhead cost factor and an Artificial Neural Network. This chapter will be the first step for this research by identify the factor that effect on school construction projects. These factor will help to design the questionnaire.

Chapter 3

Chapter Three: Research Methodology

This chapter presents the methodology that used in this study. The research methodology was selected in a term to satisfy the research aim and objectives in help to accomplish this study. This chapter included information about the Literatures review, Questionnaire design, Limitation of the research, Population and sample, Analysis of questionnaire and ANN model for OH cost included ANN application

3.1. Introduction

This chapter discusses the methodology used in this research. The research conducted an extensive literature study. The key objective of this literature survey was to acquire in depth understanding and immense knowledge regarding the factors affecting the percentage of overhead costs for school building construction projects, in Gaza Strip, concerning the first A and B categories of construction companies.

The important information and required projects data are collected on two stages which are: -

1. Comparison between the list of OH factors collected from the previous literature, via a review study phase, and the applied site overhead assessment of factors technique's in Gaza Strip, from the participating expert's opinions; and
2. Collection of the required OH data for a number of school's projects in Gaza strip to be used during the analysis phase and the design of an overhead cost assessment model.

The selected methodology to complete this study uses the following stapes: review of literature related to overheads costs in the construction projects, design of research questionnaire, Analysis of Questionnaire and OH cost of ANN model. Figure (3.1).

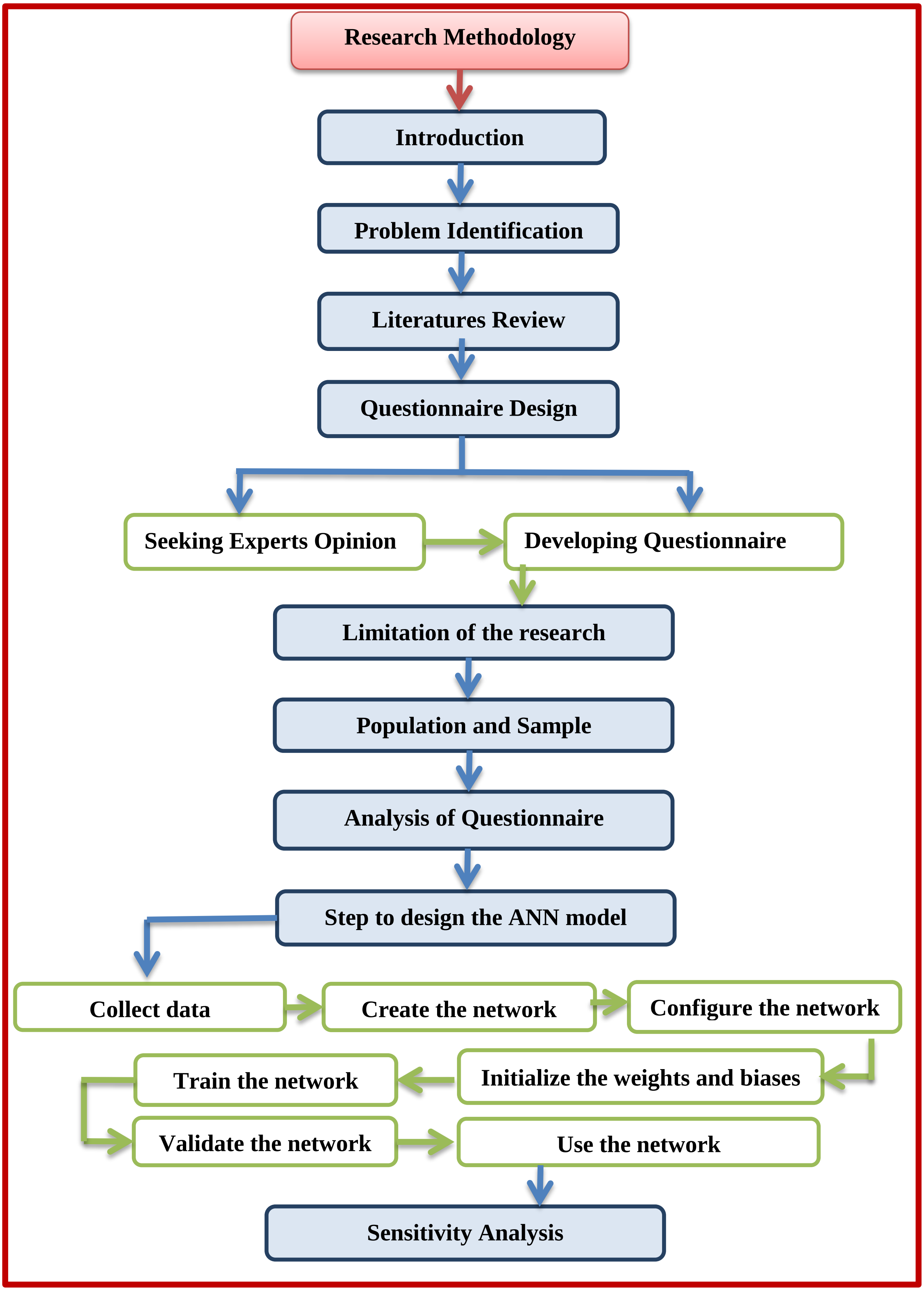

Figure (3. 1): The methodology step of research

3.2. Problem Identification

The first stage of the research was included in the thesis proposal which include identifying and defining the problem. Hence, the objectives and work plan of the thesis was established. In the first step of a school project in Gaza Strip, there is limited available database and a shortage of appropriate cost estimate methods, where most estimate techniques used in Gaza Strip are still inadequate and traditional methods. This study is intended to analyze overhead cost factors affecting the construction industry (schools) using Artificial Neural Network (ANN).

3.3. Literatures Review

The second step of the research was the literature review which involved reading and appraising what other researchers have written about the subject area (Naoum, 2007 and El-Sawalhi and El-Riyati, 2015). This step is to make a comparison between the OH cost factors from the comprehensive literature study and the Gaza construction industry for the identification of overhead costs factors for school construction projects, in Gaza. The previous chapter showed many studies regaring overhead cost factors and neural network analysis.

3.4. Questionnaire Design

Fourth stage is divided into two integrated steps, first step is seeking academics opinion for developing the second step of design questionnaire. A structured questionnaire has applied in this research for their advantages. The structured questionnaire tool is the most widely used for data collection. Questionnaires have been usually used in order to find out facts, opinions and views `(Naoum, 2007; El-Sawalhi and El-Riyati, 2015).

3.4.1. Experts Opinion

Experts opinion is the most important step of this research methodology, as it incorporates a detailed evaluation of the developed list for overhead cost factors in school 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 were mainly identified based on the expert's opinions from IUG University in Gaza. The principal objective of this survey study was to reinforce the potential model, based on the expert's opinions. This study will lately make the modification of the developed selected list of factors previously identified in Table (2-2) if required.

3.4.2. Developing Questionnaire

Establishing perfect design of the research questionnaire is crucial to get precise results. Therefore, the questions were deigned to be specific, measurable, and realistic.

The main sections of the questionnaire are constructed based on:

- First section: Definition of the concerned entity.
- Second section: (Yes or No) questions to confirm - Affecting factors in estimation of overhead costs in the construction of school buildings in Gaza Strip.
- Third section: Writing current factors that influence the estimation process and its degree of impact.

In order to get an appropriate method of analysis, the level of measurement must be understood and simple. Within the questionnaire in many questions, ordinal scales were used. Ordinal scale is a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned to the agreement or degree of influence (1, 2, 3, 4, and 5) does not indicate that the intervals between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels.

Based on Likart scale researcher has the following:

Table (3. 1): Lekart scale

Level	**Not Important**	**Low Importance**	**Medium Importance**	**Important**	**Very Important**
Scale	1	2	3	4	5

In this stage of the data collection process, a questionnaire was prepared to investigate the main factors affecting overhead cost for school construction projects, in Gaza. (**Appendix A questionnaire**)

3.5. Limitation of the Research

The research survey was limited to Gaza strip contracting companies. The company classified as first degree first (A and B), which have a valid registration in Palestinian contractor union PCU, will answer questionnaire. The data collection of School project has contracting companies of first (A and B) and second categories. Other categories will be neglected due to the low practical and administrative experience of their companies in school construction works.

3.6. Population and Sample

The studied population includes the contracting companies in Gaza Strip who have a contractor's union valid registration at 17th April 2017. The classification of company depends on every sector the company is working. So, you may find a company has classified as first degree in building. The total number of companies that company has classified as first degree are 77 company.

The formula shown below was used to determine the sample size of unlimited population (Creative Research Systems, 2005).

$$SS = \frac{Z^2 \times P \times (1-P)}{C^2} = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.5^2} = 384 \qquad E(3.1)$$

where SS = sample size

Z = Z value (e.g. for 95% confidence level)

P = percentage picking a choice, expressed as decimal (0.5used for sample size needed)

C = confidence interval (0.5)

The correction for finite population is:

New $SS = \frac{SS}{1+\frac{SS-1}{pop.}} = \frac{384}{1+\frac{384-1}{77}} = 64\ company$

This questionnaire was used to collect the required data in order to achieve the research objective. 70 questionnaires were distributed to the research population from the active companies in the Gaza strip, but **63 questionnaires** were received.

3.7. Analysis of Questionnaire

The returned questionnaire was numerically coded to enter the data systematically and efficiently. Data was analyzed using the Excel software program.

The respondents were asked to provide their opinions on the identification of factors that affect the estimation of overheads through the pricing process of tenders by scores 1 to 5, where "1" represent very low and "5" the very high. To determine the relative importance index (RII) of the factors, these scores were transformed to importance relative indices based on the formula:

$$\text{Relative importance index (RII)} = \frac{\sum W}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \qquad E(3.2)$$

Where W is the weight given to each factor by the respondent, ranging from 1 to 5, (n1 number of respondents for Very Important, n2 = number of respondents for Important، n3 = number of respondents for Medium Importance, n4 = number of respondents for Low Importance, n5 = number of respondents for No Importance). A is the highest weight (i.e. 5 in the study) and N is the total number of respondents. The RII equals ranges from 0 to 1.

A one respondents' t-test was used to test if the opinion of the respondents in the content of the sentences positive if RII ≥ 0.6 and the p-value less than 0.05, or neutral If the p-value greater than 0.05, or negative RII ≤ 0.6 and the p-value less than 0.05.

3.8. Design the ANN model

Neural computation is one of the inductive machines learning methodologies. It is most often used to learn, generalise and represent general knowledge. It extracts information from existing data by inductive learning. It is a fundamentally different approach to other information processing approaches. (Elhag and Boussabaine, 1998). The applications of ANN in construction management go back to the early 1980‟s. These applications of ANN cover a very wide area of construction issues. The early attempts to embed ANN techniques within the cost estimation area were conducted by Shtub and Zimerman (1993) who developed models for estimating the cost of assembly systems. Ehrlenspiel. (Shehatto, 2013).

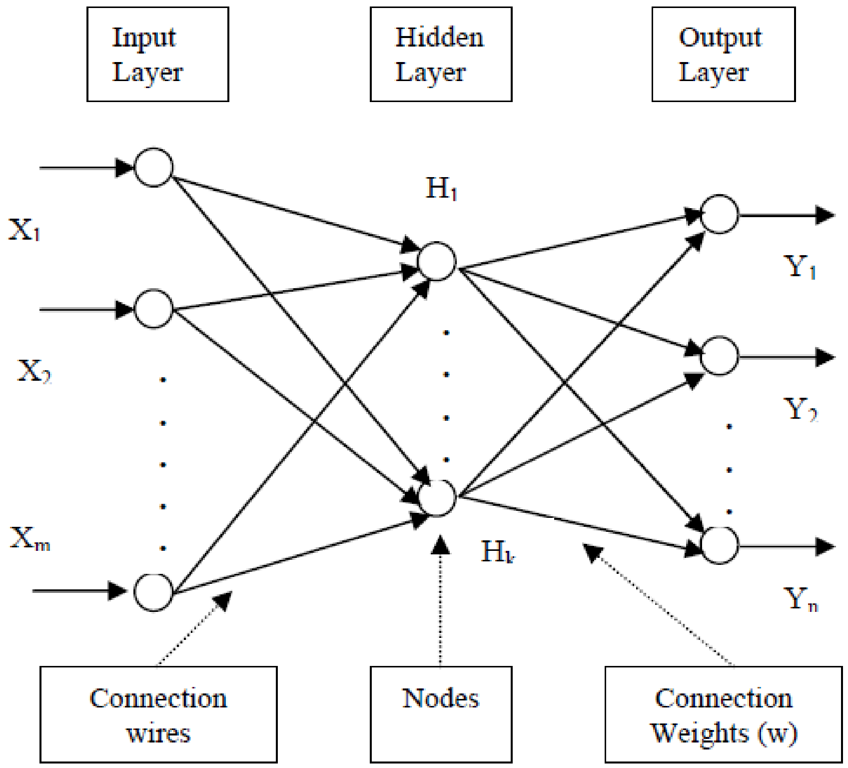

***Figure (3. 2)*:** A Simple Artificial Neural Network Structure
Source : (Elhag and Boussabaine, 1998)

The second stage is to collect data for many school projects from several construction companies that represent **the first A, B and second categories** of construction companies, in Gaza. This stage describes the design of an ANN model for predicting the percentage of overhead costs in school construction projects, in Gaza. The MATLAB program was selected to build the model. MATLAB provides Neural Network Toolbox that provides algorithms, pretrained models, and apps to create, train, visualize, and simulate both shallow and deep neural networks. MATLAB version R2013a was used to develop, train, test, and validate the designed neural network model structure.

Steps to Design the Artificial Neural Network Model

In this stage, hierarchy of OH categories, which are framed from the literature to analyze the OH in term of its factor. The model will build by MATLAB. The standard steps for designing neural networks to solve OH cost model the work flow for any of these problems has seven primary steps (Beale et al., 2011; MATLAB Guide):

1. Collect data
2. Create the network
3. Configure the network
4. Initialize the weights and biases
5. Train the network
6. Validate the network
7. Use the network

3.8.1. Data Collection

All factors that affect the percentage of overhead costs for school construction projects in Gaza will identified and demonstrated from questionnaire analysis (look to next chapter). These factors will help to know which information is important to collect in school projects. The data analysis of collected school project and pre-processing will do before building the model. 10 factors will be identified by the questionnaire, as well as, the data of 70 similar school projects collected from UNRWA and contractors. The data will prepare for the model as input and target data. The following figure (3.2) show how the data will be collected. see **Appendix C.**

Question	Pro. 1	Pro. 2	Pro. 3	Pro. 4	Pro. 5	…………	Pro. 70
OH %	5	4	4	10	4	…………	5
P1	4	4	2	4	2	…………	3
P2						…………	
P3	12	3	10	14	9	…………	13
P4	13	17	17	13	17	…………	8
P5	1	1	7	1	5	…………	5
P6	1	1	2	2	2	…………	2
P7	1.00	1.50	1.32	1.40	1.30	…………	1.50
P8						…………	
P9	4	4	1	2	12	…………	1
P10	5	4	4	5	4	…………	1

* **P:** Parameter which identify from questionnaire analysis, and convert to question for collecting of real life school projects.
* **OH%:** Overhead percentage that contractor companies use in school projects.
* **Pro. 1,2,3…70:** project No. 1,2,3….70 which selected to be used in ANN Model.

Figure (3. 3)**:** figure show how the data will be collected**.**

3.8.2. Data Encoding

Artificial networks only deal with numeric input data. Therefore, the raw data must often be converted from the external environment to numeric form (Kshirsagar & Rathod, 2012). This may be challenging because there are many ways to do it and unfortunately, some are better than others are for neural network learning (Principe, et al., 2010).

3.8.3. Developing of ANN Model

The Neural Network Toolbox is fitted with functions that are suitable for use in predicting the overhead percentage. This Toolbox is simple and will simplify the step of developing ANN Model that include create the network, configure the network, initialize the weights and biases, train the network and validate the network. **Appendix D** will show how this Toolbox can use.

3.8.4. Sensitivity Analysis

The influence of the input parameters on the performance of the trained ANN model will be evaluated using sensitivity analysis. This study will comment on the significance of each parameter to the network and whether any change in the size of the network is necessary. The sensitivity analysis will be carried out by varying one parameter at a time and the corresponding change in the cost as a percentage was reported. Look at **example (4.2).**

3.9. Summary

This chapter described the detailed adopted methodology of research. It included the problem identification for the research, literatures review, questionnaire design, limitation of the research, Population and Sample, analysis of questionnaire and design the ANN model. This chapter summarize the work that done through this research and will be help to understand the results in the next chapter.

Chapter 4

Chapter Four: Modeling and Analysis

This study, conducted in the Gaza Strip, is to evaluate the overhead cost in construction projects specially in school projects for contractors; to determine the main OH factors in school projects. This chapter included modeling, analysis and discussion of the results that have been collected from field surveys. A total of 63 retained questionnaire had been analyzed using (Excel program). Seventy completed school projects were founded and received from UNRWA and construction companies. Matlab R2013a program was used to develop a model for prediction of OH cost for school project in Gaza strip. All these topes were discussed in this chapter.

4.1. Introduction

An artificial neural network (ANN) is an analogy-based process, which best suits the cost forecasting domain. The primary advantages of ANNs include their ability to learn by examples (past projects), and to generalize solutions for forthcoming applications) future projects). ANNs do not require a prerequisite establishment of rules and reasoning which govern relationships between a desired output and its significant effective variables. Two ANN models have been developed to predict the lowest tender price of primary and secondary school buildings.

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

4.2. Analysis of the Data

Analysis of the data is an important section for understate the overhead cost of a school project. This part shows the relation between overhead factors and percentage of OH cost for school projects and also to understand whether a weighting of the factors is needed or not before the Model is designed.

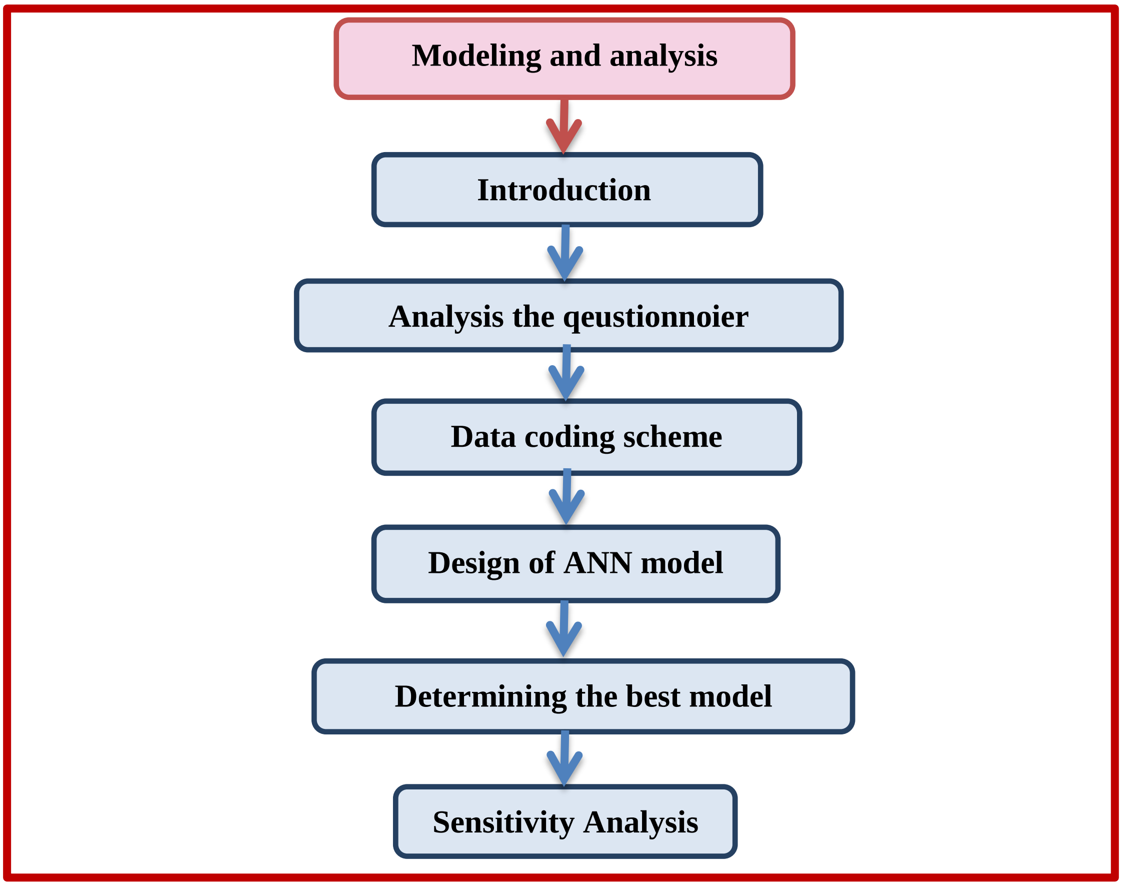

Figure (4. 1): The modeling and analysis flow chart has followed within the research

4.2.1. Analysis of Questionnaire:

In fact, one of the most significant keys in research is identifying the factors that have real impact on the cost of school projects. Seventy questionnaires were distributed to various contractor company, where sixty-three questionnaires have been reserved. The following table (4-1) show the total number of contractors for each degree of affected factor who agreed on the impact of this factor on the pricing process.

Table (4. 1): Analysis of questionnaire

No.	(Factor)	Mean	SD	RII	Rank
1	Setting up system for monitoring, follow-up, and evaluation of company overheads costs.	1.12	4.11	0.83	6
2	Using computerized systems	1.18	3.47	0.70	21
3	Separation between the home office and field overhead costs	1.13	3.50	0.71	19
4	The existence of documentation and records for information on projects that have been	0.97	4.08	0.84	5

No.	(Factor)	Mean	SD	RII	Rank
	implemented already				
5	Company response in finding solutions for claims and disputes	1.02	3.64	0.73	15
6	The company's experience in implementing similar projects	0.69	4.58	0.93	1
7	Mechanism of company financial dues (payments)	0.94	3.97	0.80	8
8	Legal environment and public policy in the home country.	1.05	3.75	0.75	12
9	Firms need for work.	0.97	3.83	0.77	9
10	Project Size.	0.74	4.03	0.82	7
11	Project Duration.	0.98	3.69	0.75	13
12	Projects tight time schedule.	0.96	3.64	0.74	14
13	Project Type.	0.93	3.61	0.72	17
14	Project Location.	1.13	3.75	0.76	11
15	Type-Nature of Client.	1.07	3.36	0.69	22
16	Type of Contract.	1.02	3.58	0.71	18
17	Contractual terms of the project	0.99	3.64	0.73	15
18	The need for specialty contractors	0.94	3.47	0.71	19
19	Percentage of sub-contracted works.	1.04	3.06	0.6	23
20	Special Site Preparation Requirements.	0.95	2.89	0.59	24
21	Closure and the inability to obtain materials	0.84	4.39	0.89	2
22	Economic inflation	0.95	3.81	0.77	10
23	Intensity of competition from other contractors	0.86	4.33	0.88	3
24	Number of projects	0.91	4.25	0.86	4

4.2.2. Results of questionnaire

After reading the analysis of questionnaire, the top ten factors that have high effect on estimation process were the company's experience, closure and the inability to obtain materials, intensity of competition from other contractors, number of projects, the existence of documentation and records for information on projects that have been implemented already, setting up system for monitoring, follow-up, and evaluation of company overheads costs, project size, mechanism of company financial dues (payments), firms need for work, and economic inflation.

A. Company's Experience Factors

This factor was ranked high by the respondents, with one of the top ten factors of importance of OH cost. The results show mean = 0.69, SD = 4.58 and RII=0.93, which was considered the top factor (from 24 factors) of overhead cost factor. Obviously, the expertise in the determination of the overhead cost percentage during the pricing of tender is necessary to inspect the progress of implementation of school projects.

B. Closure and the Inability to Obtain Materials Factors

One of most factor that has high effect in the construction industry in Gaza Strip, was closure and the inability to obtain materials in suitable time for project. It is clear from questionnaire analysis that this factor has mean = 0.86, SD = 4.39 and RII = 0.89. So It is important to store all necessary material that project construction needed.

C. Intensity of Competition from other Contractors Factor

The understanding of bid condition is very important for estimation OH cost percentage. One of these condition is No. of contractor inter to the bid. The questionnaire analysis show that the mean = 0.89, SD = 4.33 and RII = 0.80. If the No. of contractor increase in the bid, each contractor will decrease the OH cost percentage to win.

D. Number of Projects Factor

Supply and demand in market effect on contractor decision. Number of projects in the same year also becomes an important factor; The questionnaire analysis show that the mean = 0.91, SD = 4.25 and RII = 0.86. After reading the analysis of project, the percentage of overhead approximately decrease with increase the number of project in the same year.

E. Existence of Documentation for Implemented Projects Factor

The existence of documentation and records for information on projects that have been implemented already help in estimation of overhead percentage and new project implemented smoothly with minimum problems. The successful resolution of a construction dispute depends on the quality of information and documentation maintained from the project. The quality of the records maintained by the parties of a construction project is paramount to a successful claim calculation and presentation (Kaplan and Jarek, 2002), whereas the Contractors often give up potential claim dollars simply because they did not prepare or maintain documentation sufficient to support a claim (Mckibbin and Stokes, 2005; El-Sawalhi and El-Riyati, 2015). The questionnaire analysis show that the mean = 0.97, SD = 4.08 and RII = 0.84.

F. Management System for Overhead Cost Factor

The system for monitoring, follow-up, and evaluation of company overheads costs must exist to help the contractor to minimize problems during the implementation phase. The questionnaire analysis show that the mean = 1.12, SD = 4.11 and RII = 0.83.

G. Project Size Factor

The projects were characterized by the total projects contract amount. The questionnaire analysis show that the mean = 0.74, SD = 4.03 and RII = 0.82.

H. Mechanism Of Company Financial Dues (Payments) Factor

The Mechanism Of Company Financial Dues was eighth factor that have effect on school construction project. The questionnaire analysis show that the mean = 0.94, SD = 3.97 and RII = 0.8.

I. Firms Need for Work Factor

The questionnaire analysis show that the mean = 0.97, SD = 3.83 and RII = 0.77.

J. Economic Inflation Factor

The questionnaire analysis show that the mean = 0.95, SD = 3.81 and RII = 0.77.

4.2.3. Analysis of Projects

After analyzing the questionnaire, the top ten factors were taken to continue the research, and 70 school construction projects' data was collected from UNRWA. Factors 2 & 8 (closure and the inability to obtain materials, and mechanism of company financial dues (payments) respectively) were not included in the analysis of the school projects since all projects have the same answer. Analysis of the school projects was done by comparing each factor with the overhead percentage. The range and average were calculated for each factor.

I. The Influence of Contractor/Firm Category on the Percentage of OH Cost

Alter and Sims (2001), 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:

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

This research study (Modeling Section) focused only on the first(A & B) and second categories of construction companies, in Gaza. The following table and chart show the relation between overhead percentage and contractor category,

Table (4. 2): Contractors Firms Category and the Percentage of Overhead Cost

SN	Category of the Construction Company	OH %	
		Range (Min-Max)	Average
1	1-A	4-10	5.8
2	1-B	4-10	7.8
3	2	5-7	5.3

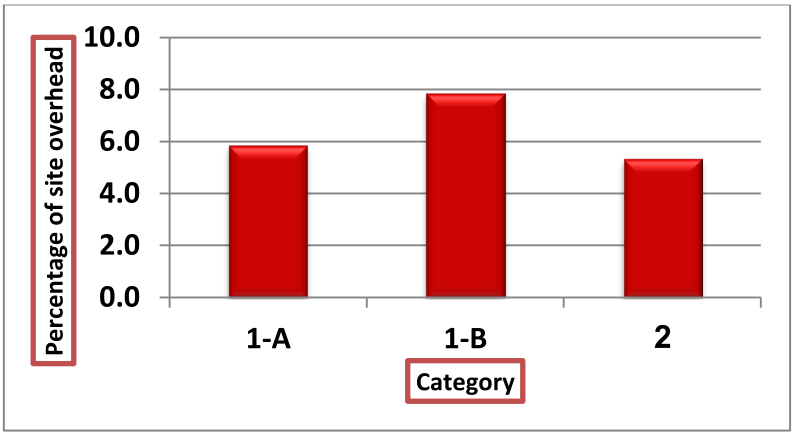

Figure (4. 2): Overhead Percentage vs. Construction Firm Category.

The way of analysis the collected date will explain in this example:

Example (4.1) from table (4.2) first row **(SN 1):** Category of the construction company is 1-A. This Group contain 12 value of OH% as follow (4,10,5,5,5,6,4,10,5,5,5 & 6%).

Analysis is as follow:

1. Range of construction company category for 1-A has minimum value that is 4& and maximum value that is 10%.
2. The average = $\frac{4 + 10 + 5 + 5 + 5 + 6 + 4 + 10 + 5 + 5 + 5 + 6}{12} = 5.8\ \%$

After careful inspection of Figure (4-2) Astonishingly, the results ,that were revealed by the data analysis for the (70) collected school construction projects, as the following, seventeen percent of the projects that had been constructed by a 1 - A category construction company had average mean value for the percentage of overhead costs reach 5.3 % from the total projects contract amount. And sixty six percent of the projects that had been constructed by a 1 - B category construction company had average mean value for the percentage of overhead costs reach 7.8 % from the total projects contract amount. While the remaining seventeen percent of the projects were constructed by a second category construction company and after calculating their average mean value for the percentage of overhead costs it was found to be 5.3 % from the total projects contract amount. This illustrates the extent of contractor company contribution in school construction project which depend on their category.

II. The Influence of Project Location on the Percentage of Overhead Cost

The project location is a strong influencing factor on the percentage of overhead cost for construction building projects in Gaza (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?). The results of this analysis are shown in Table (4-3) and Figure (4-3).

Table (4. 3): Project Location and the Percentage of Overhead Cost

SN	***Location of project***	***OH %***	
		Range (Min-Max)	***Avarage***
1	North Gaza	5-10	5.8
2	Gaza	4-10	7.4
3	Middle Area	5-10	6.7
4	Khan Younes	5-10	6.9
5	Rafah	4-10	5.6

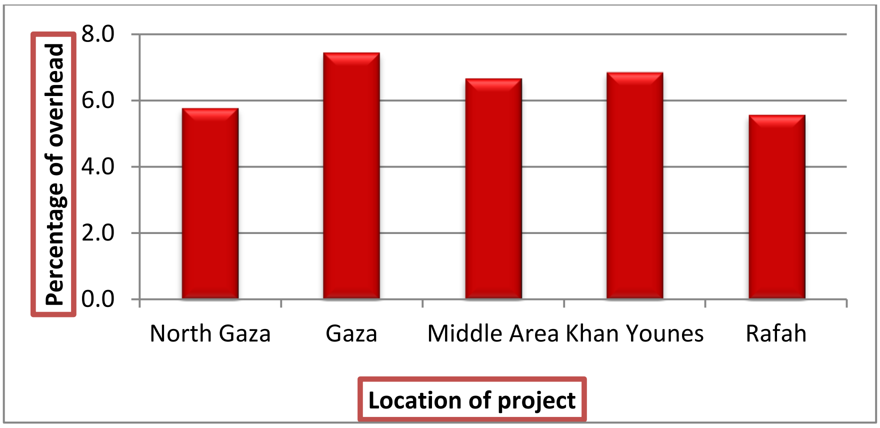

Figure (4. 3): Overhead Percentage vs. Project Location.

The results of the analysis for the collected data shown in Figure (4-3) which were gathered from different locations, and the opinions of the experts from the field differentiated. The results show the average mean value for the percentage of overhead cost which is 5.8 % in North Gaza and the average mean value for the percentage of overhead cost which is 7.4 % in Gaza (6.7 % in Middle Area, 6.9 in Khan youns and 5 % in Rafah). This differentiated in the average mean value relate to other reason like economic inflation, influence of participant contractors….etc.).

III. The Experience of Contractor in Implementing Similar Projects on The Percentage of Overhead Cost

Historical information is an essential element in successful implementation of construction projects. The following table and chart show the relation between overhead percentage and company's experience (no. of similar project).

Table (4. 4): The experience of contractor and the Percentage of Overhead Cost

SN	***The company's experience***	***OH %***	
		Range (Min-Max)	***Avarage***
1	1	5-6	5.5
2	2	4-10	6.7
3	3	5-10	7.4
4	4	4-10	7.2
5	5	10	10.0
6	7	10	10.0
7	20	7	7.0
8	30	5	5.0

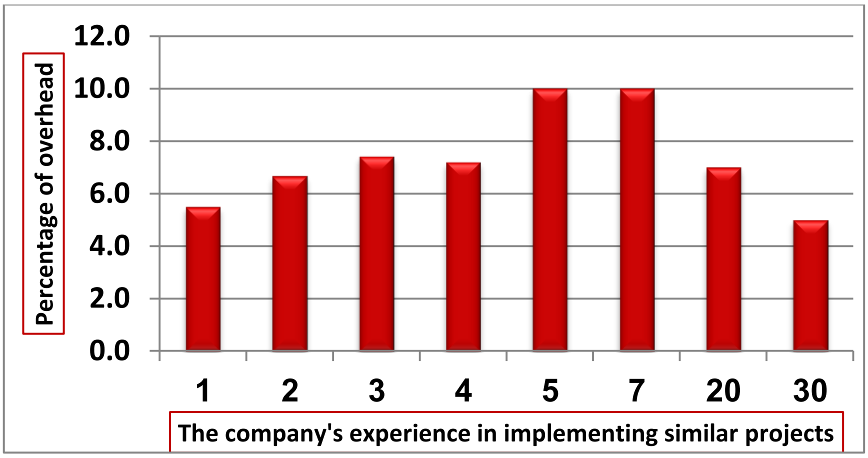

Figure (4. 4): Overhead Percentage vs. experience of contractor

As seen from data, figure (4-4), the overhead cost percentage start with 5.5 %then increases with increased experience of the contractor (No. of schools that contractor implemented). After 7 schools, the overhead decreases with increased number of implemented schools. The discrepancies of overhead costs may be due to different ways of OH cost management.

IV. The Influence of Participant Contractors on the Percentage of Overhead Cost

In an environment of intense competition, declining profit margins, and shrinking market shares, the only way to stay competitive is to control costs while maintaining quality products (Assaf et al., 2001).

Table (4. 5): No. of Participant Contractors and the Percentage of Overhead Cost

SN	***No. of Participant Contractors***	***OH %***	
		Range (Min-Max)	***Avarage***
1	3	4-7	5.5
2	5	5-10	8.3
3	6	5	5.0
4	7	7	7.0
5	8	6	6.0
6	9	4-10	7.3
7	10	4-10	6.0
8	11	5-10	7.2
9	12	5-10	7
10	13	5-10	7.0
11	14	10	10.0

SN	No. of Participant Contractors	OH %	
		Range (Min-Max)	Avarage
12	17	10	10.0
13	18	5	6.0
14	19	6-10	8
15	20	5	6.0

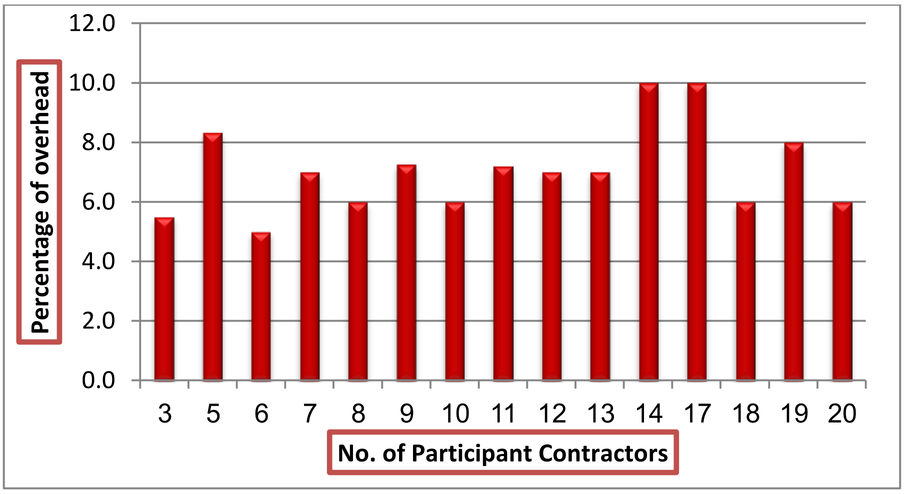

Figure (4. 5): Overhead Percentage vs. No. of Participant Contractors.

As seen from data, figure (4-5) and table (4-5), the overhead cost percentage isn't related with the increase of No. of Participant Contractors. OH percentage increases sometimes and decreases other times due to the effect of other factor on OH percentage.

V. The Influence of No. Of Similar Projects in the Same Year on The Percentage of Overhead Cost

Supply and demand in market effect on contractor decision

Table (4. 6): No. of similar projects in the same year and the percentage of overhead Cost

SN	No. of similar projects in the same year	OH %	
		Range (Min-Max)	Avarage
1	2	10	10.0
2	3	5-10	6.7
3	8	5-10	8.8
4	13	5-10	6.5
5	17	4-10	6.5

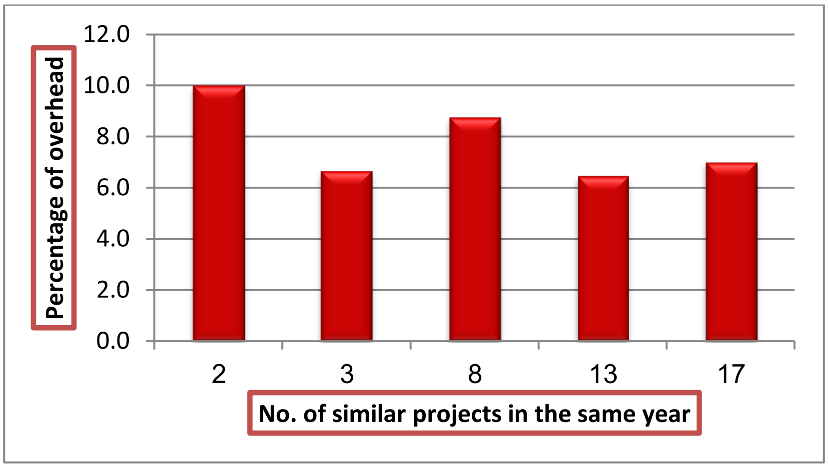

Figure (4. 6): Overhead Percentage vs. No. of similar projects in the same year.

Number of projects in the same year also becomes an important factor; it begins with two projects up to seventeen projects as shown Table 4.6. In which, the samples that have 2 projects in the year is about 3% from the total sample, 9% of sample of 3 projects in the year is 9% from the total sample, 12% of sample is 13 projects. After reading the analysis of project, the percentage of overhead approximately decrease with increase the number of project in the same year.

VI. The Influence of Existence of Documentation for Implemented Projects on the Percentage of Overhead Cost

The existence of documentation and records for information on projects that have been implemented already help in estimation of overhead percentage and new project implemented smoothly with minimum problems. The successful resolution of a construction dispute depends on the quality of information and documentation maintained from the project. The quality of the records maintained by the parties of a construction project is paramount to a successful claim calculation and presentation (Kaplan and Jarek, 2002), whereas the Contractors often give up potential claim dollars simply because they did not prepare or maintain documentation sufficient to support a claim (Mckibbin and Stokes, 2005; El-Sawalhi and El-Riyati, 2015).

Table (4. 7): Existence of Documentation for Implemented Projects and the Percentage of Overhead Cost

SN	Existence of Documentation for Implemented Projects	OH %	
		Range (Min-Max)	Avarage
1	No	4-10	6.6
2	Yes - 1 year	5-10	7.8
3	yes - 3 year	6	6.0
4	Yes - 5 year	4-10	7.6
5	yes - 7 year	4	4

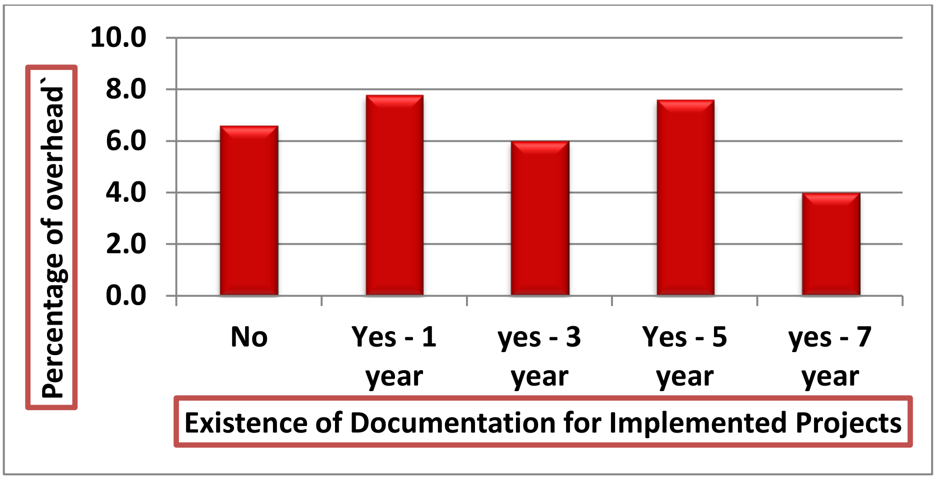

Figure (4. 7): Overhead Percentage vs. Existence of Documentation for Implemented Projects.

Table 4.7 shows that 34% from the contractor says that there were no historical data to estimate the overhead percentage, while 26% says they save data for two years for implemented projects, 9% of contractor for 3 years, 28% of contractor for 5 years and 3% of contractor for 7 years. The OH was 6.6%, 7.8%, 6%, 7.6% and 4% for each answer respectively.

VII. The Influence of Management System for Overhead Cost on the Percentage of Overhead Cost

The system for monitoring, follow-up, and evaluation of company overheads costs must exist to help the contractor to minimize problems during the implementation phase.

Table (4. 8): Management System for Overhead Cost and the Percentage of Overhead Cost

SN	Management System for Overhead Cost	OH % Range (Min-Max)	Avarage
1	No	4-10	6.9
2	Yes	4-10	7.2

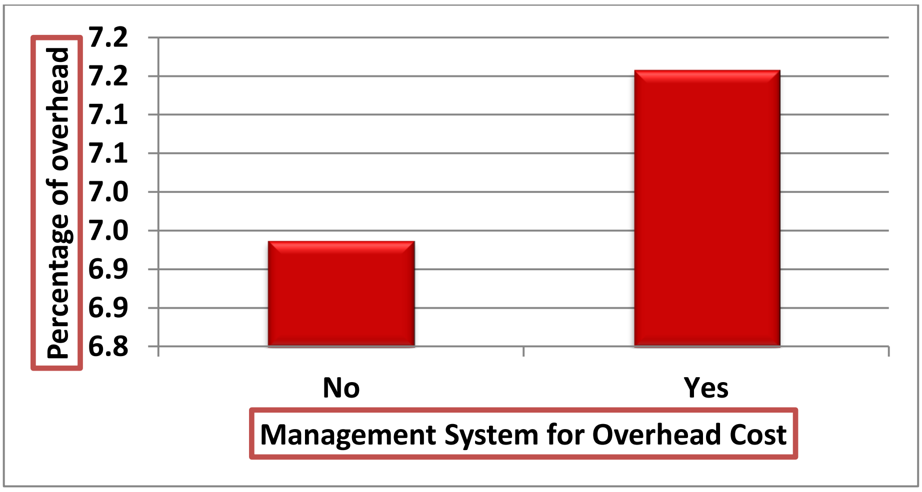

Figure (4. 8): Overhead Percentage vs. Management System for Overhead Cost.

After the inspection of Figure (4-8) it is clear that, the existence of a management system for overhead cost has influence over the percentage of OH more than the absence of management system for overhead cost. 54% of contractor had management systems for overhead cost while 46% of contractor had not.

VIII. The Influence of Project Size on the Percentage of Overhead Cost

The projects were characterized by the total projects contract amount ($US). That gave us six classification groups, starting with a group of twelve projects with total contract amount under one million dollars, three projects with total contract amount under 1.2 million dollars, five projects with total contract amount under 1.3 million dollars, five projects with total contract amount under 1.4 million dollars, eight projects with total contract amount under 1.5 million dollars, and two projects with total contract amount under 1.6 million dollars. For each group the average mean value for the percentage of overhead was calculated in-order to represent the percentage of 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 (4-9) and Figure (4-9).

Table (4. 9): Contract Value and the Percentage of Overhead Cost

SN	Contract Amount M $US	OH %	
		Range (Min-Max)	Avarage
1	1	5-10	5.83
2	1.15	10	10
3	1.2	5-10	7.5
4	1.25	10	10
5	1.3	4-10	8.5
6	1.35	4-10	7
7	1.4	10	10
8	1.5	4-10	6.38
9	1.6	6-10	8

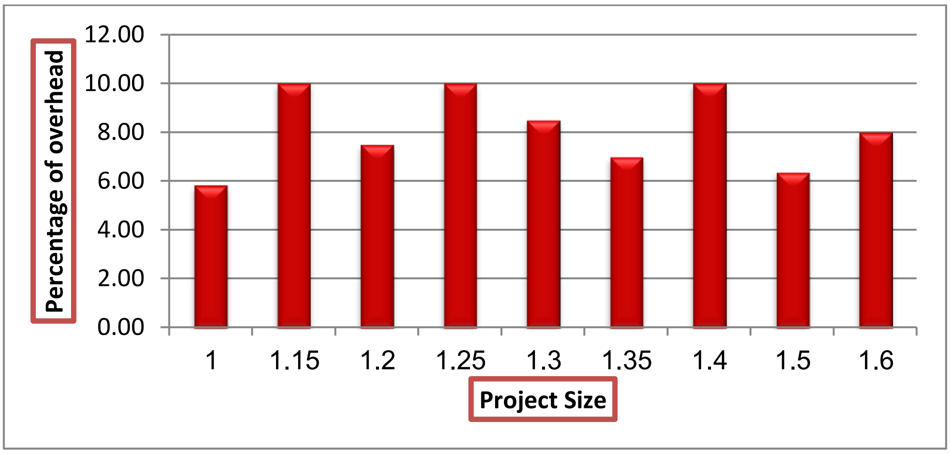

Figure (4. 9): Overhead Percentage vs. Total Contract Amount.

A careful inspection to Figure (4-9) clearly shows that there is a random relationship between the total contract value and the percentage of overhead percentage for the school construction projects in Gaza, because of different requirements needed from each project.

IX. The Influence of Firms Need for Work on the Percentage of Overhead Cost

Number of projects that the contractors have in a single year effects the percentage of overhead. The contractors benefit from using equipment and staff in many projects done at the same time. It was clear that the overhead percentage decreased when the number of projects, that the contractor had, increased.

Table (4. 10): Firms Need for Work and the Percentage of Overhead Cost

SN	Firms need for work.	OH %	
		Range(Min-Max)	Avarage
1	0	10	10.0
2	1	4-5	4.8
3	2	10	10.0
4	3	10	10.0
5	4	4-6	5.2
6	5	5-10	6.8
7	10	6	6.0
8	12	4	4.0
9	23	10	10.0

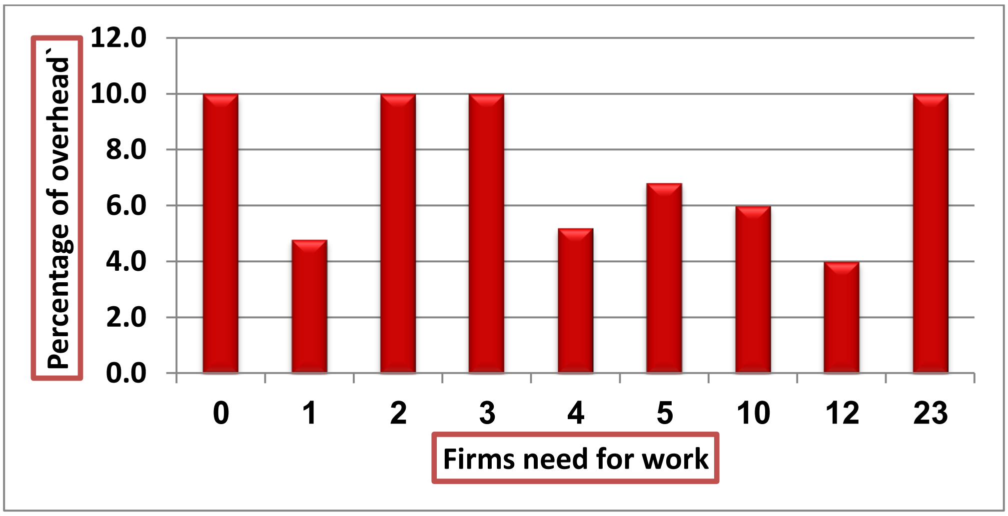

Figure (4. 10): Overhead Percentage vs. Firms Need for Work.

The analysis in Figure (4-10) shows that 3% of contractors who had zero project in the year take 10% OH percentage, 4.8% OH percentage for 14% of one project, 10% OH percentage for 20% of one project, 10% OH percentage for 3% of one project, 5.2% OH percentage for 14% of one project, 6.8% OH percentage for 31% of one project, 6% OH percentage for 9% of one project, 4% OH percentage for 3% of one project, and 10% OH percentage for 3% of one project.

X. The Influence of Economic Inflation on the Percentage of Overhead Cost

In economics, inflation is a sustained increase in the general price level of goods and services in an economy over a period of time. (Wyplosz & Burda, 1997; Blanchard, 2000; Barro, 1997; Abel & Bernanke, 1995)

Table (4. 11): Economic Inflation and the Percentage of Overhead Cost

SN	Economic inflation	OH %	
		Range (Min-Max)	Avarage
1	1	5-10	8.8
2	2	5-10	6.7
3	3	10	10.0
4	4	4-10	7
5	5	5-10	6.5

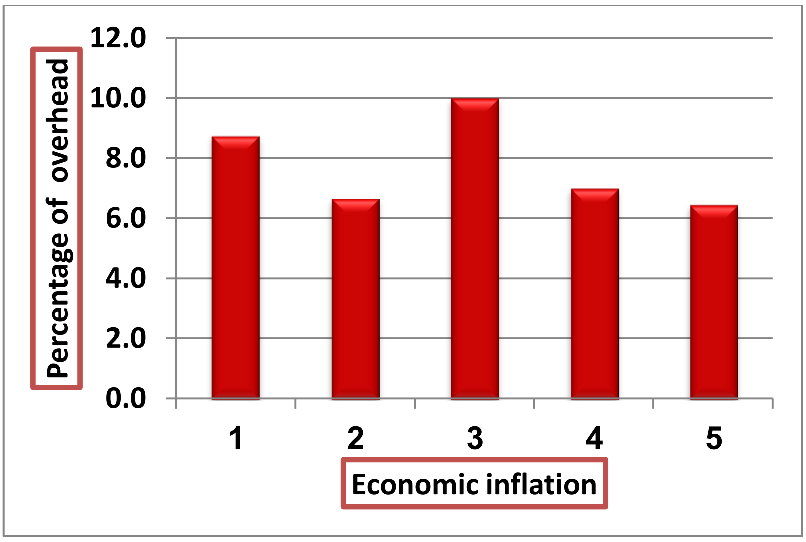

Figure (4. 11): Overhead Percentage vs. Economic Inflation.

See table (4-11) and figure (4-11), 11% of projects for 8.8% OH percentage had very low effect of economic inflation, 9%, 3%, 40%, 37% of projects for 6.7%, 10%, 7% and 6.5% OH percentage respectively had low, medium, high, very high effect of economic inflation respectively.

4.3. Data Encoding Scheme

This part shows the technique that was used to encode the input data in order to make accurate modeling of the system, see table (4-12). Artificial networks only deal with numeric input data. Therefore, the raw data must often be converted from the external environment to numeric form (Kshirsagar and Rathod, 2012).

Table (4. 12): Real-Life Data Field Encoding Scheme

Factor No.	Factor	Subcategories	Category Coding
5	Existence of Documentation for Implemented Projects		
		No, Yes - 1 year	1
		yes - 3 year	3
		Yes - 5 year	5
		yes - 7 year	7
6	Management system for overhead cost		
		Yes	1
		No	2
7	Contract Amount $ (less than)		
		1,000,000	1
		1,150,000	1.15
		1,200,000	1.2
		1,250,000	1.25
		1,300,000	1.3
		1,350,000	1.35
		1,400,000	1.4
		1,500,000	1.5
		1,600,000	1.6
9	(firm Firm need for work (No. of project in the		
		0-1	1
		2	2
		3	3
		4	4
		5	5
		10	10
		12	12
		23	23

4.4. Analysis of ANN Model

This part describes the design of an ANN model for predicting the percentage of overhead costs in school construction projects, in Gaza. The MATLAB program was selected to build the model. MATLAB provides Neural Network Toolbox that provides algorithms, pretrained models, and apps to create, train, visualize, and simulate both shallow and deep neural networks. MATLAB version R2013a was used to develop, train, test, and validate the designed neural network model structure.

4.4.1. Determining the Best Model

The way for determining the best model is by looking for the model that has minimum MSE and R larger than 0.93. Neural Network Fitting Tool used to generate the model. Eight-factor was used as input, seventy projects used as sample, the network Architecture was input, and hidden and output layer. Number of hidden neurons is from 1 to 20 hidden neurons. See table (4-13)

Table (4. 13): Result of analysis ANN models

Model	No. of Hidden	Training		Validation		test	
No.	Neurons	MSE	R	MSE	R	MSE	R
1	1	4.23	0.52	3.23	0.60	6.35	0.048
2	2	1.98	0.80	3.31	0.54	4.06	0.53
3	3	0.19	0.98	0.36	0.97	0.37	0.97
4	4	1.92	0.82	0.73	0.92	1.44	0.88
5	5	0.06	0.995	2.10	0.83	5.97	0.79
6	6	0.19	0.99	0.90	0.95	0.17	0.98
7	7	0.39	0.97	2.03	0.84	0.82	0.82
8	8	0.07	0.995	1.67	0.84	1.35	0.87
9	9	0.62	0.94	1.61	0.82	2.54	0.81
10	10	0.40	0.97	0.09	0.994	1.124	0.95
11	11	0.02	0.998	0.14	0.98	0.10	0.993
12	12	0.67	0.94	1.16	0.90	1.46	0.88
13	13	0.1	0.992	0.13	0.994	0.12	0.99
14	14	0.0004	1	0.26	0.97	0.29	0.97
15	15	0.26	0.98	1.33	0.88	0.47	0.97
16	16	0.17	0.99	1.26	0.88	1.15	0.95
17	17	0.14	0.99	0.96	0.91	1.02	0.86
18	18	0	1	0.49	0.96	0.49	0.95
19	19	0	1	0.01	0.999	0.98	0.93
20	20	0	1	0.13	0.989	0.13	0.987

The selected model has 20 hidden neurons, MSE equal 0 and R = 1 for training phase, MSE equal 0.13 and R = 0.989 for Validation phase and MSE equal 0.13 and R = 0.987 for test phase. The following figure show the relationship between actual and prediction value in different phases of the model.

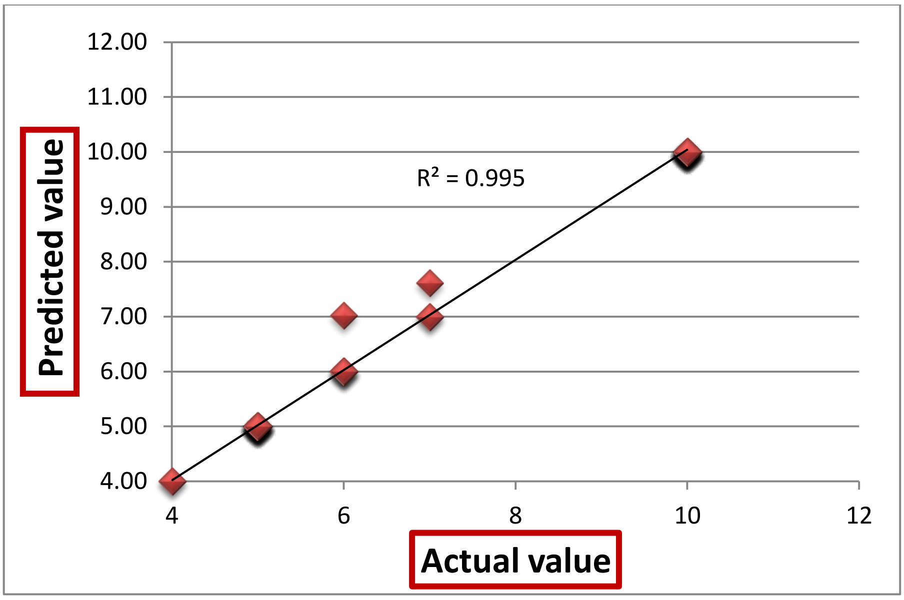

Figure (4. 12): A comparison between the actual cost of the trained set and the corresponding ANN predicted values.

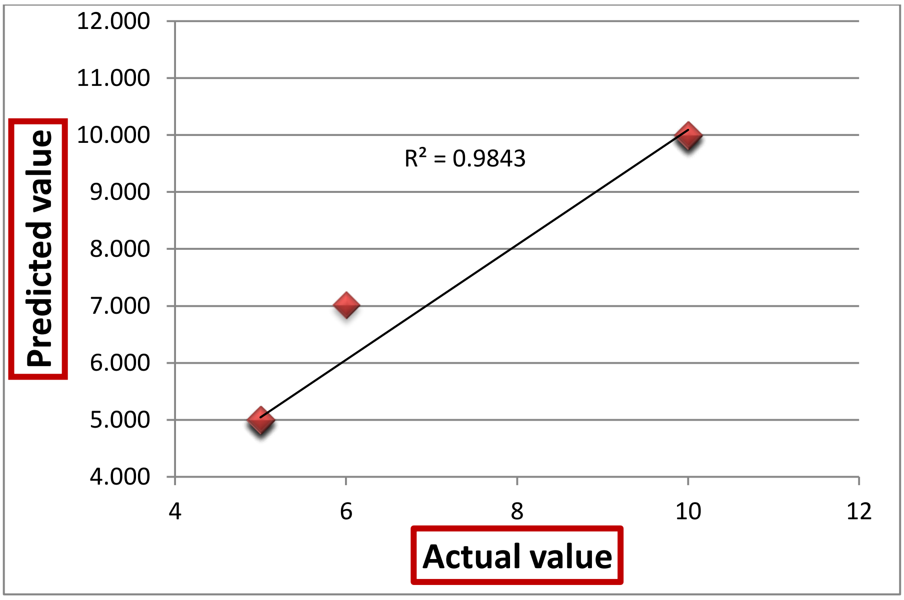

Figure (4. 13): A comparison between the actual cost of the Validated set and the corresponding ANN predicted values.

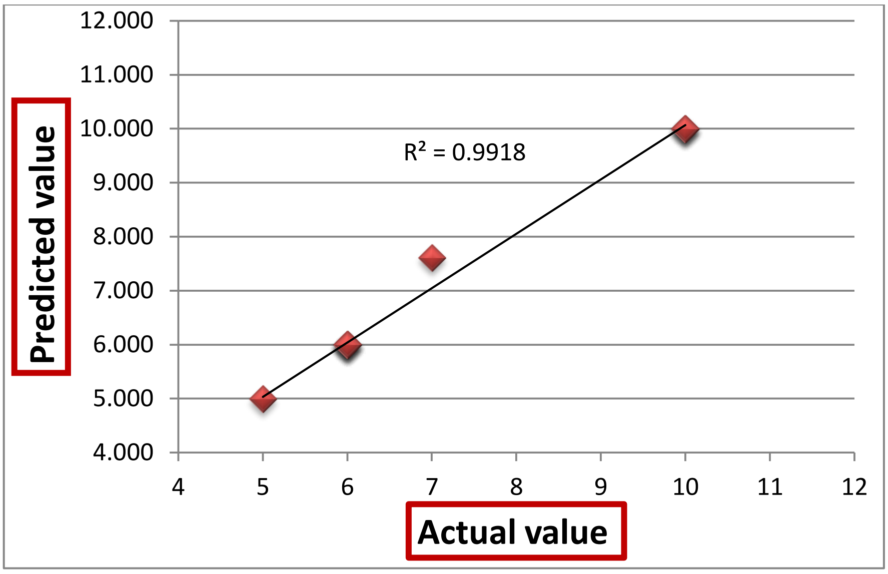

Figure (4. 14): A comparison between the actual cost of the Tested set and the corresponding ANN predicted values.

I. Mean Squared Normalized Error Performance Function (MSE)

MSE measures the average of the squares of the errors or deviations—that is, the difference between the estimator and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

$$MSE = \frac{1}{N}\sum_{j}^{N}(T_j - P_j)^2$$

Where, N is total number of training set, T_j and P_j are target and actual output of a data set, respectively. The maen square error is a good overall measure of the successfulness performance of a training run (Arafa & Alqedra, 2011)

II. Correlation Coefficient (R)

Regression analysis was used to ascertain the relationship between the estimated cost and the actual cost. The results of linear regressing are illustrated graphically in Figure (4.13). The correlation coefficient (R) is 0.987, indicating that; there is a good linear correlation between the actual value and the estimated neural network cost at tested phase.

4.4.2. Sensitivity Analysis

The influence of the input parameters on the performance of the trained ANN model was evaluated using sensitivity analysis. This study would comment on the significance of each parameter to the network and whether any change in the size of the network is necessary. The sensitivity analysis was carried out by varying one parameter at a time and the corresponding change in the cost as a percentage was reported.

Table (4. 14): Result of sensitivity analysis of ANN models

Factor No.	Factor	% of effected input parameters on output	Degree of effected input parameters *
P1	The company's experience	4.62	2
P3	No. of participant contractors in one school	7.74	4
P4	No. of similar projects in the same year	17.32	6
P5	Existence of documentation for implemented projects	19.04	7
P6	Management system for overhead cost	3.51	1
P7	Contract amount $	13.49	5
P9	Firm need for work (No. of project in the firm).	27.96	8
P10	Economic inflation	6.32	3

* Degree of effected input parameters (1=low - 8=high).

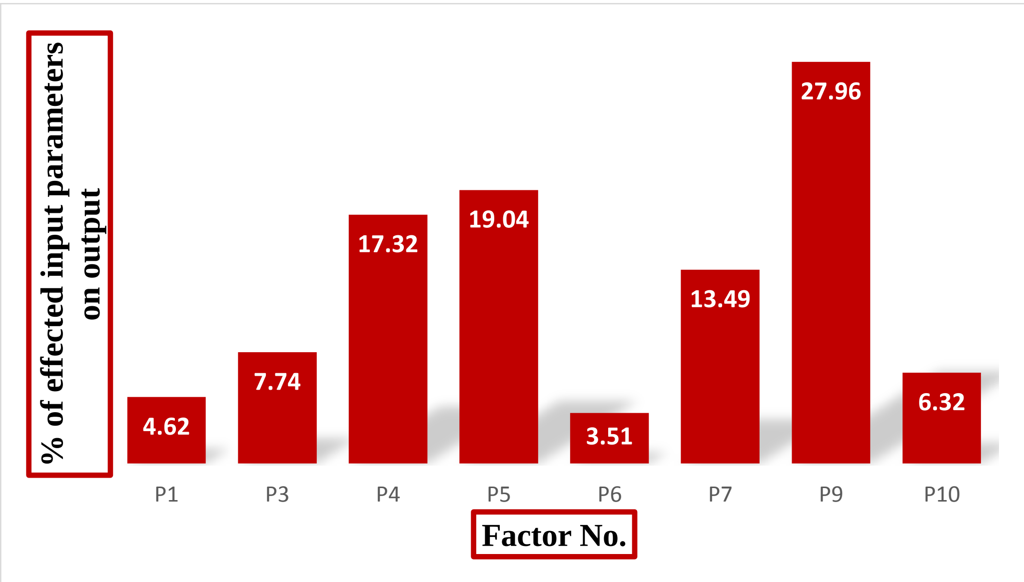

Figure (4. 15): Sensitivity analysis of the input parameters on the output of the ANN model

The sensitivity analysis results of each input parameter are presented in Figure (4.24) and table (4.14) Figure (4.24) shows that the firm need for work, existence of documentation for implemented projects, No. of similar projects in the same year and contract amount have significant to very significant influence on the output of the network which is the percentage of OH cost of the school construction. Management system for overhead cost, the company's experience, Economic inflation and No. of participant contractors in one school showed small to very small influence on the output.

The way of making sensitivity analysis will explain in this example:

Example (4.2): The Example will take from table (4.14) first row **(Factor No. P1):** The selected model used to make sensitivity analysis for input.

Step 1: The data will be as follow:

Table (4. 15): First trailer will take minimum value for all factor exclude P1**.**

New Results	OH %	6.62	6.62	6.56	6.62	6.56	……..	6.53
The same of collected data	***P1***	4	4	2	4	2	……..	1
Min value	***P3***	3	3	3	3	3	……..	3
Min value	***P4***	2	2	2	2	2	……..	2
Min value	***P5***	1	1	1	1	1	……..	1
Min value	***P6***	1	1	1	1	1	……..	1
Min value	***P7***	1	1	1	1	1	……..	1
Min value	***P9***	1	1	1	1	1	……..	1
Min value	***P10***	1	1	1	1	1	……..	1

Table (4. 16): Second trailer will take average value for all factor exclude P1**.**

New Results	OH %	12.28	12.28	12.24	12.28	12.24	……..	12.21
The same of collected data	***P1***	4	4	2	4	2	……..	1
Average value	***P3***	11	11	11	11	11	……..	11
Average value	***P4***	8	8	8	8	8	……..	8
Average value	***P5***	5	5	5	5	5	……..	5
Average value	***P6***	1	1	1	1	1	……..	1
Average value	***P7***	1.3	1.3	1.3	1.3	1.3	……..	1.3
Average value	***P9***	5	5	5	5	5	……..	5
Average value	***P10***	3	3	3	3	3	……..	3

Table (4. 17): Third trailer will take maximum value for all factor exclude P1**.**

New Results	OH %	11.50	11.50	10.92	11.50	10.92	……..	10.60
The same of collected data	***P1***	20	20	20	20	20	……..	1
Max value	***P3***	17	17	17	17	17	……..	20
Max value	***P4***	7	7	7	7	7	……..	17
Max value	***P5***	2	2	2	2	2	……..	7
Max value	***P6***	1.6	1.6	1.6	1.6	1.6	……..	2
Max value	***P7***	23	23	23	23	23	……..	1.6
Max value	***P9***	5	5	5	5	5	……..	23
Max value	***P10***	20	20	20	20	20	……..	5

Step 2: Analysis is as follow:

Table (4. 18): Analysis of output for sensitivity analysis for input 1

	New Results (OH %)			
P1	Min value	Average value	Max value	Average of 3 value (Min, Average and max)
1	6.53	12.21	10.60	9.78
2	6.56	12.24	10.92	9.91
3	6.59	12.26	11.22	10.02
4	6.62	12.28	11.50	10.13
5	6.65	12.29	11.75	10.23
7	6.72	12.33	12.20	10.42
20	6.65	13.85	13.64	11.38
30	5.01	14.79	13.78	11.20
Different between max value and min value				**11.38 - 9.78 = 1.6**

Table (4. 19): The way for identify the Degree of effected input parameters:

Input	**Different between max value and min value**	**% of effected input parameters on output**	**Degree of effected input parameters ***
P1	1.6	4.62	2
P3	2.68	7.74	4
P4	6	17.32	6
P5	6.59	19.04	7
P6	1.22	3.51	1
P7	4.67	13.49	5
P9	9.68	27.96	8
P10	2.19	6.32	3
SUM	**34.63**	**100**	

- **% of effected input parameters on output** for P1 $= \frac{1.6}{34.63} = 4.62$
- Degree of effected input parameters will take number 2.

Chapter 5

Chapter Five: Summary, Conclusion and Recommendations

This Chapter concludes the whole work that was carried out through this research included introduction, summary, conclusions and recommendations for future work.

5.1. Introduction

This research developed and tested a prediction model to assess the percentage of overhead costs for school construction projects in Gaza, using the artificial neural network technique. A feed forward network consisting of an input buffer with 8 input neurons, one hidden layer, with 20 hidden neurons, with a sigmoid transfer function, and one output neurons was developed. This model is based on two successive steps. First step is to identify key factors that affect the percentage of overhead cost from a formal questionnaire. Second step is to collect 70 school construction projects based on these factor. This chapter presents the major conclusions from the results obtained, and recommendations for future works.

5.2. Summary

Construction firms should carefully examine contract conditions and perform all the necessary precautions to make sure that project 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 overhead cost for school construction projects in the first (A&B) category of construction companies, in Gaza. The impacts of different factors on the percentage of projects overhead costs were deeply investigated. The survey results illustrated that overhead costs are greatly affected by many factors. Among these factors come company's experience, closure and the inability to obtain materials, intensity of competition from other contractors, number of projects, the existence of documentation and records for information on projects that have been implemented already, setting up system for monitoring, follow-up, and evaluation of company overheads costs, project size, mechanism of company financial dues (payments), firms need for work and Economic inflation. All of these factors make the detailed estimation of such overhead costs a more difficult task. An ANN-Based model was developed to predict the percentage of overhead cost for school construction projects, in Gaza, during the tendering process. A sample of school projects was selected as a test sample for this study. This sample contain the first (A&B) and second categories of construction companies. 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 overhead cost. It was found that an ANN-Based Model is a suitable tool for the percentage of overhead cost assessment, in Gaza.

5.3. Conclusions

The following conclusions may be drawn from this study:

1. Twenty-four factors conducted from literature review that was the base of questionnaire structure.
2. Many factors are not accounted in Gaza due to reasons of siege and closure while it is a great contributor in other countries' construction markets
3. The questionnaire analysis shows the top ten factors that influence the percentage of overhead costs for school construction projects.
4. The analysis of the collected data gathered from seventy real-life school construction projects all from UNRWA included the companies' experience, intensity of competition from other contractors, number of projects, the existence of documentation and records for information on projects that have been implemented already, setting up system for monitoring, follow-up, and evaluation of company overheads costs, project size, firms need for work and Economic inflation are identified as the top eight factors that affect the value of the percentage of overhead costs for school construction projects, in Gaza;
5. Closure and the inability to obtain materials, mechanism of company financial dues (payments) are the least affecting factors in the percentage of overhead costs for school construction projects, in Gaza;
6. The results of testing for this designed model indicated a testing mean squared normalized error performance function (MSE) value 0.13; and
7. Testing was carried out on eleven new facts that were still unseen by the network. The results of the selected model have 20 hidden neurons, MSE equal 0 and R = 1 for training phase, MSE equal 0.13and R = 0.989 for Validation phase and MSE equal 0.13 and R = 0.987 for test phase.
8. A sensitivity analysis was carried out to study the influence of each input parameter on the performance of the ANN model to predict the OH cost percentage in school construction projects. The performed sensitivity analysis showed

that the firm need for work, existence of documentation for implemented projects, No. of similar projects in the same year and contract amount are the most effective parameters influencing the output of the network. The remaining parameters had small effect on the estimated value but it is believed that their existence could be important to enhance the ability of the model to learn and generalize the results.

5.4. Recommendations for Future Work

The current study showed very promising results in predicting the cost of school projects, and this approach will continue to make impressive gains especially in civil engineering field. However, some recommendations should be presented for decision-makers in the construction sector and future studies to support the findings of this study;

1. All construction parties are encourged to be more aware about cost estimation development and pay more attention for using this developed technique in estimation process.
2. 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
3. The development of artificial neural network models requires the presence of structured database for the finished projects in the construction companies. Unfortunately most 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 Gaza.

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 period 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.

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APPENDIX A

Questionnaire

The Islamic University –Gaza
Higher Education Deanship
Faculty of Engineering
Construction Management

الجامعة الاسلامية – غزة
عمادة الدراسات العليا
كلية الهندسة – ادارة التشييد

استبانة حول

العوامل المؤثرة علي التكاليف الغير مباشرة في انشاء المدارس في قطاع غزة

Influential Factors on Overhead Cost in School Buildings in Gaza Strip

الاخ \ الأخت المهندس \ ـة مدير المشروع......

تحية طيبة وبعد،

نظرا لأهمية قطاع الانشاءات في قطاع غزة، ومن منطلق المخاطر التي يواجها المقاول في مجال الانشاءات توجهنا لدراسة طريقة لتقدير التكاليف الادارية (الغير مباشرة او العامة) في انشاء المدارس في قطاع غزة، فإننا نتقدم لسيادتكم بجزيل الشكر والعرفان لمساهمتكم في الاجابة على هذه الاستبانة التي تهدف الي دراسة العوامل المؤثرة على تقدير التكاليف الادارية في مشاريع انشاء المدارس في قطاع غزة، وذلك من خلال التركيز علي اهم العوامل الحرجة التي تؤثر على التسعير.

مكونات الاستبانة:

الجزء الاول: التعريف بالجهة المعنية.

الجزء الثاني: العوامل المؤثرة على تقدير التكاليف الغير مباشرة في انشاء مباني المدارس في قطاع غزة.

الجزء الثالث: كتابة عوامل حالية تؤثر على عملية التقدير ودرجة تأثرها.

الجزء الرابع: التعليق.

والتكاليف الادارية تعرف بأنها التكاليف التي لا يمكن تحديدها أو المحملة على مشروع بناء أو إلى وحدة إنتاج البناء. ولذلك، التكاليف الادارية تنقسم عموما إلى فئتين: تكاليف خاصة بالمكتب وتكاليف خاصة بالموقع.

علما بان هذه الدراسة هي جزء من البحث التكميلي لنيل درجة الماجستير في ادارة المشاريع الهندسية، للباحثة المهندسة\ **ربا محمد عوض،** تحت اشراف الدكتور \ **خالد عبد الرؤوف الحلاق**

وانني أثمن جهدكم واجاباتكم على الاسئلة المطروحة في الاستبانة

وتقبلوا فائق الاحترام والتقدير

الباحثة \ م. ربا محمد عوض

2017

1- التعريف بالجهة المعنية

1. اسم الشركة:

....

2. سنة انشاء الشركة:

....

3. التصنيف:

□ اولى أ □ اولى ب

4. عدد الموظفين في الشركة:

□ أقل من 3 □ 3 - 6 □ 7- 10 □اكثر من 10

5. عدد سنوات الخبرة في مجال الانشاءات لمن يقوم بتعبئة الاستبانة:

□ اقل من 3 سنوات □ 3– اقل من 6 سنوات □ 6– اقل من 10 سنوات □اكثر من 10 سنوات فأكثر

6. عدد المشاريع المتعلقة بإنشاء مباني المدارس المنجزة خلال السنوات الخمسة الاخيرة لمن يقوم بتعبئة الاستبانة:

□1-5 مشاريع □6-10 مشاريع □11-15 مشروع □أكثر من 15 مشروع

2- العوامل المؤثر على عملية التقدير في مشاريع إنشاء مباني المدارس في قطاع غزة

- الأرقام من (1) الي (5) تحدد مدي قوة تأثير العامل على عملية التقدير في مشاريع إنشاء مباني المدارس من وجهة نظرك، حيث أن الرقم (1) يشير الي عدم تأثير هذا العامل نهائيا على عملية التقدير بينما يشير الرقم (5) الي عامل الأكثر تأثيرا.
- الرجاء وضع إشارة (x) في المربع حسب قوة التأثير.

❖ **الجزء الاول**

درجة تأثير العامل علي عملية التقدير					العامل المؤثر (Factor)	الرقم
5	4	3	2	1		
					Setting up system for monitoring, follow-up, and evaluation of company overheads costs. وضع الشركة نظام للرصد والمتابعة والتقييم لتكاليف النفقات الادارية.	-1
					Using computerized systems استخدام النظم المحوسبة	-2
					Separation between the home office and field overhead costs الفصل بين التكاليف الادارية الخاصة بالمكتب والخاصة بالميدان (الموقع)	-3
					The existence of documentation and records for information on projects that have been implemented already وجود وثائق وسجلات عن المشاريع التي تم تنفيذها بالفعل	-4
					Company response in finding solutions for claims and disputes استجابة الشركة في إيجاد حلول للمطالبات والمنازعات	-5
					The company's experience in implementing similar projects تجربة الشركة في تنفيذ مشاريع مماثلة	-6
					Mechanism of company financial dues (payments) آلية الشركة في المستحقات المالية (المدفوعات)	-7
					Legal environment and public policy in the home country. البيئة القانونية والسياسات العامة في الوطن.	-8
					Firms need for work. حاجة الشركات للعمل	-9
					Project Size. حجم المشروع	-10
					Project Duration. مدة المشروع	-11
					Projects tight time schedule. الجدول الزمني للمشاريع ضيق	-12
					Project Type. نوع المشروع	-13
					Project Location. موقع المشروع.	-14
					Type-Nature of Client. طبيعة صاحب العمل	-15
					Type of Contract. نوع العقد.	-16
					Contractual terms of the project الشروط التعاقدية للمشروع	-17
					The need for specialty contractors الحاجة لمقاولين متخصصين	-18
					Percentage of sub-contracted works. نسبة الاعمال التي يقوم بها مقاولو الباطن	-19
					Special Site Preparation Requirements. متطلبات إعداد الموقع الخاص.	-20
					Closure and the inability to obtain materials الإغلاق وعدم القدرة على الحصول على المواد	-21

					Economic inflation **التضخم الاقتصادي**	**-22**
					Intensity of competition from other contractors **شدة المنافسة مع مقاولين آخرين**	**-23**
					Number of projects **عدد المشاريع المتاحة في السوق**	**-24**

❖ **الجزء الثاني**

(اذكر **عوامل أخري** تؤثر على التكاليف غير المباشرة –الإدارية- التي تؤخذ بعين الاعتبار حاليا في شركات الانشاء في قطاع غزة **ومع ذكر** درجة تأثيرها)

3- التعليقات

الرجاء اضافة أي تعليق قد يساهم في تطوير هذا البحث.

APPENDIX B

Project data collection sheet

PROJECTDATA COLLECTION SHEET

- **The adapted construction technology is :**

No.	Project Name	
	Contractor Name	
1	No. of school projects that company carried out for last 5 year.	
2	Year of construction the project	
3	No. of Participant Contractors	
4	No. of similar projects in the same year	
5	Does the company have an obligation to follow up overhead costs?	
6	Are there documents and records of projects that have already been implemented?	
7	Contract Amount $	
8	Is there a company mechanism in the financial dues (payments)?	
9	No. of project in the firm in the same year (Firm need for work)	
10	Is there a rise in the price of goods in the same year?	
*	Project Site Overhead Cost Percentage (%)	

ENGINEER,

Ruba Mohammed Awad

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 Gaza by UNRWA and many construction firms, during the five year period 2013-2017. The data collected contained the percentage of projects 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

OH %	5	4	4	10	4	5	5	5	5	10	10	10	7	10	10	10	10	10
P1	4	4	2	4	2	3	3	3	4	5	5	5	3	3	3	3	2	2
P3	12	3	10	14	9	11	12	13	12	10	5	12	7	12	11	19	11	17
P4	13	17	17	13	17	17	13	8	3	3	17	8	17	17	17	8	17	13
P5	1	1	7	1	5	5	5	5	1	1	1	1	5	1	1	1	5	5
P6	1	1	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2
P7	1.00	1.50	1.32	1.40	1.30	1.00	1.00	1.50	1.00	1.60	1.40	1.30	1.35	1.27	1.27	1.25	1.00	1.50
P9	4	4	1	2	12	1	1	1	4	5	5	5	5	2	2	3	23	1
P10	5	4	4	5	4	4	5	1	2	2	4	1	4	4	4	1	4	5

Table (C-1)
The Data Used During the Analysis and the Modeling Phases

OH %	5	5	5	5	5	6	6	5	10	10	10	6	6	6	10	7	6	5
P1	30	30	30	30	30	2	2	1	4	4	4	4	4	4	7	20	1	4
P3	10	6	11	9	10	18	13	5	9	13	5	11	8	20	9	3	19	12
P4	13	3	13	13	13	13	13	17	13	8	2	17	17	13	17	17	13	13
P5	1	1	1	1	1	3	3	1	5	5	5	1	1	1	1	1	3	1
P6	1	1	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2	1
P7	1.00	1.00	1.50	1.50	1.00	1.00	1.00	1.20	1.17	1.13	1.34	1.50	1.50	1.00	1.50	1.00	1.58	1.00
P9	5	5	5	5	5	4	4	1	2	2	2	10	10	10	2	5	5	4
P10	5	2	5	5	5	5	5	4	5	1	3	4	4	5	4	4	5	5

Table (C-1)
The Data Used During the Analysis and the Modeling Phases

OH %	4	4	10	4	5	5	5	5	10	10	10	7	10	10	10	10	10	5
P1	4	2	4	2	3	3	3	4	5	5	5	3	3	3	3	2	2	30
P3	3	10	14	9	11	12	13	12	10	5	12	7	12	11	19	11	17	10
P4	17	17	13	17	17	13	8	3	3	17	8	17	17	17	8	17	13	13
P5	1	7	1	5	5	5	5	1	1	1	1	5	1	1	1	5	5	1
P6	1	2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	1
P7	1.50	1.32	1.40	1.30	1.00	1.00	1.50	1.00	1.60	1.40	1.30	1.35	1.27	1.27	1.25	1.00	1.50	1.00
P9	4	1	2	12	1	1	1	4	5	5	5	5	2	2	3	23	1	5
P10	4	4	5	4	4	5	1	2	2	4	1	4	4	4	1	4	5	5

Table (C-1)
The Data Used During the Analysis and the Modeling Phases

OH %	5	5	5	5	6	6	5	10	10	10	6	6	6	10	7	6
P1	30	30	30	30	2	2	1	4	4	4	4	4	4	7	20	1
P3	6	11	9	10	18	13	5	9	13	5	11	8	20	9	3	19
P4	3	13	13	13	13	13	17	13	8	2	17	17	13	17	17	13
P5	1	1	1	1	3	3	1	5	5	5	1	1	1	1	1	3
P6	1	1	1	1	2	2	1	2	2	2	2	2	2	2	2	2
P7	1.00	1.50	1.50	1.00	1.00	1.00	1.20	1.17	1.13	1.34	1.50	1.50	1.00	1.50	1.00	1.58
P9	5	5	5	5	4	4	1	2	2	2	10	10	10	2	5	5
P10	2	5	5	5	5	5	4	5	1	3	4	4	5	4	4	5

APPENDIX D

The Neural Network Fitting Tool

The following section presents how Toolbox used.

The steps of using Neural Network Fitting Tool will be as follows:

1. Insert input and target in the MATLAB workspace. (See Appendix C)

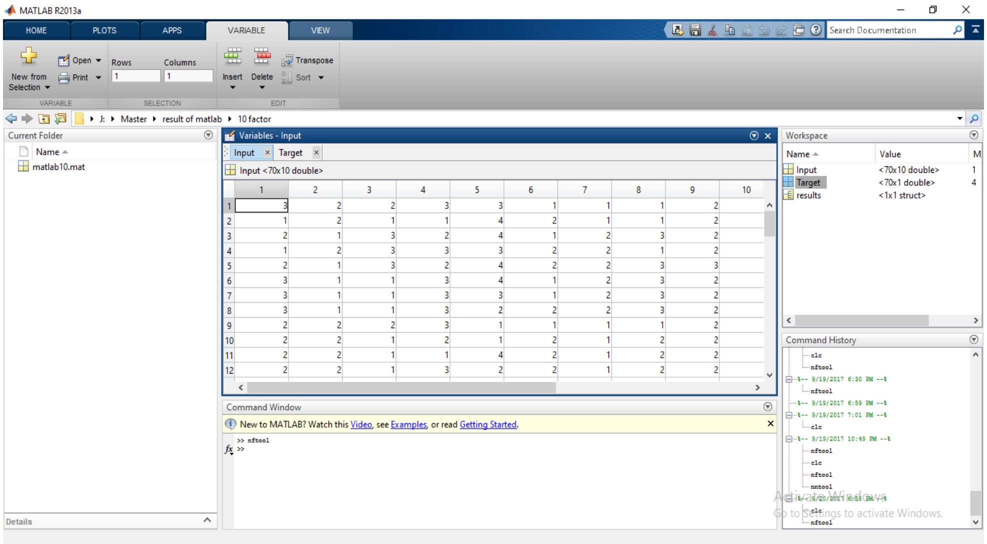

Figure (D. 1): Matlab window to import input and target data.

2. Open the Neural Network Start GUI with this command: nnstart

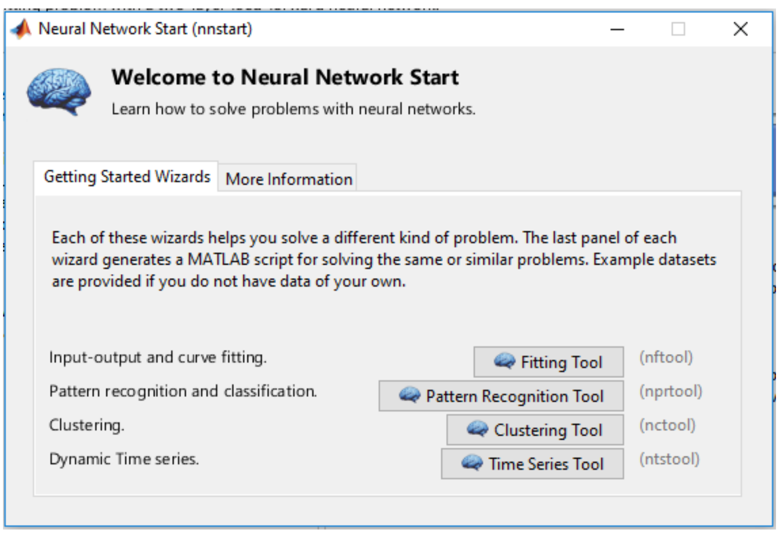

Figure (D. 2): Neural Network Start window

3. Click Fitting Tool to open the Neural Network Fitting Tool.

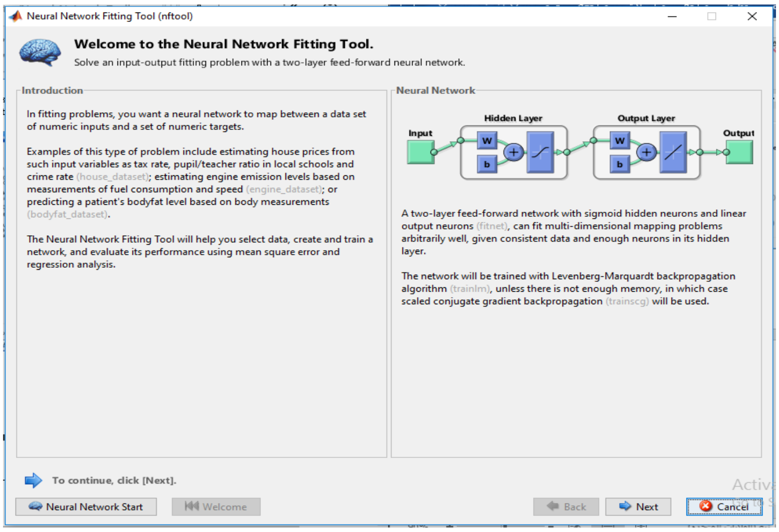

Figure (D. 3): Neural Network Fitting Tool window

4. Click Next to proceed
5. Click Inputs and Targets in the Select Data window to load data from the MATLAB workspace.

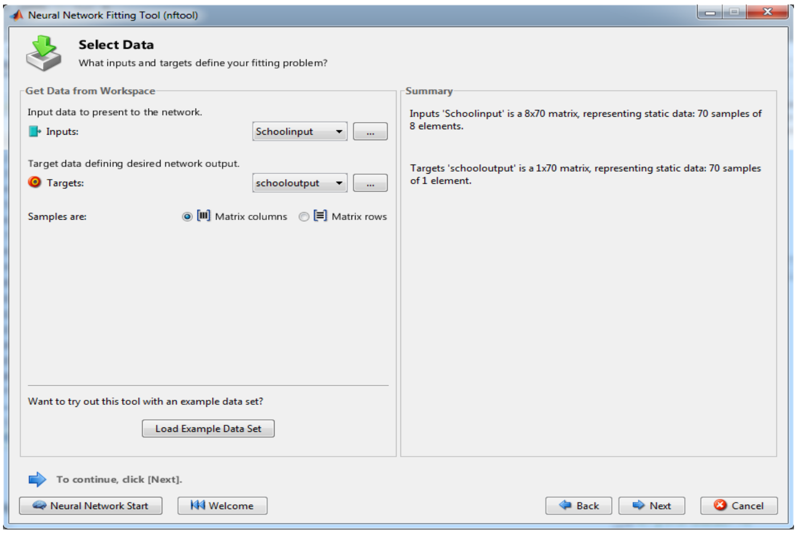

Figure (D. 4): Selecting Data window

6. Click Next to display the Validation and Test Data window, shown in the following figure. The validation and test data sets are each set to 15% of the original data.

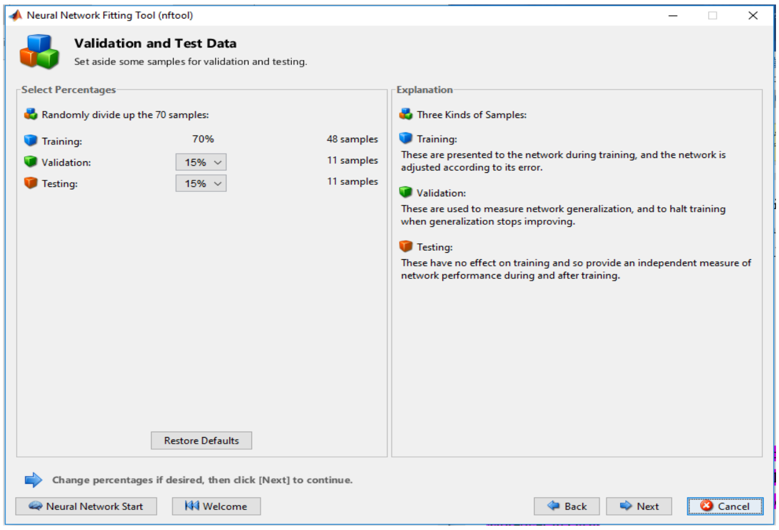

Figure (D. 5): Validation and Test Data window

With these settings, the input vectors and target vectors will be randomly divided into three sets as follows:

- 70% will be used for training.
- 15% will be used to validate that the network is generalizing and to stop training before overfitting.
- The last 15% will be used as a completely independent test of network generalization.

7. Click Next.

The standard network that is used for function fitting is a two-layer feed forward network, with a sigmoid transfer function in the hidden layer and a linear transfer function in the output layer. The default number of hidden neurons is set to 10. The model will done from 0 to 20 hidden neurons.

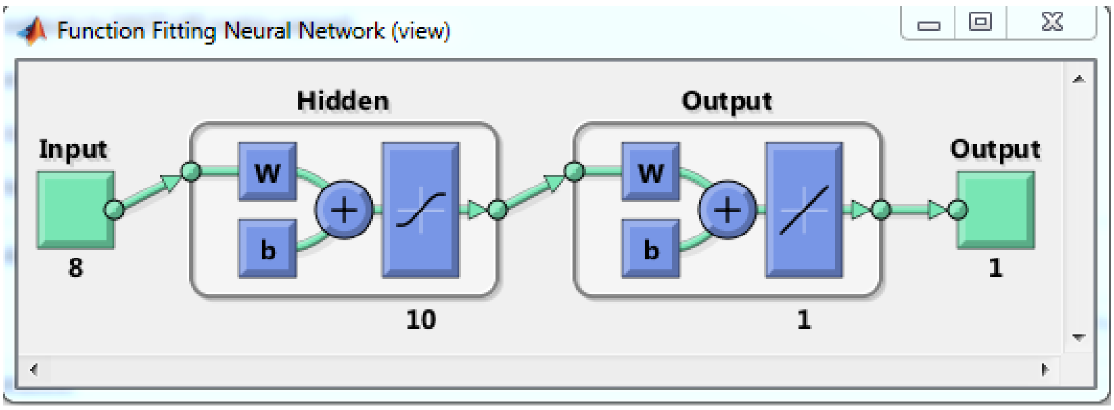

Figure (D. 6): Network Architecture window

8. Click Next.
9. Click Train.

   The training continued until the validation error failed to decrease for six iterations (validation stop)

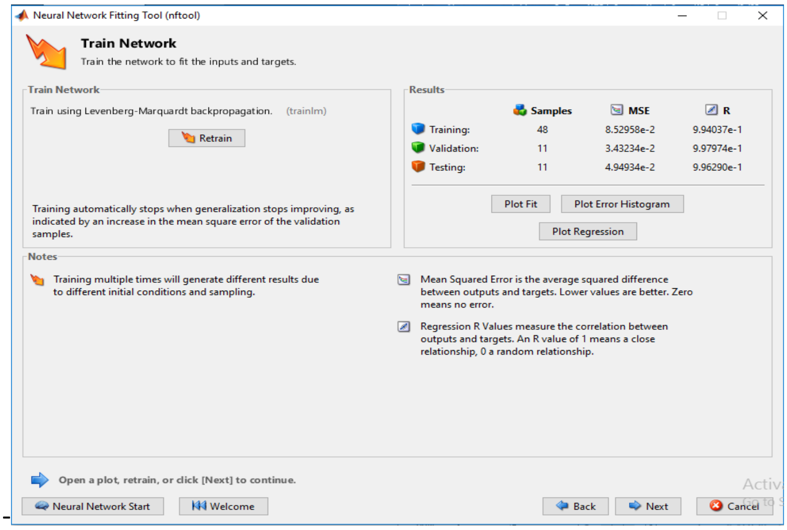

Figure (D. 7): Training Network window

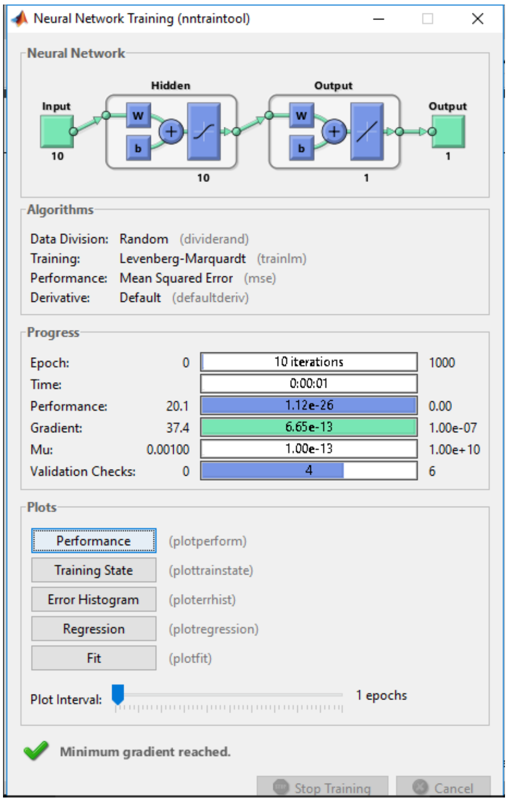

Figure (D. 8): Neural Network Training window

10. Under Plots, click Regression. This is used to validate the network performance.

    The following regression plots display the network outputs with respect to targets for training, validation, and test sets. For a perfect fit, the data should fall along a 45degree line, where the network outputs are equal to the targets. For this problem, the fit is reasonably good for all data sets, with R values in each case of 0.93 or above. If even more accurate results were required, you could retrain the network by clicking Retrain in nftool. This will change the initial weights and biases of the network, and may produce an improved network after retraining. Other options are provided on the following pane.

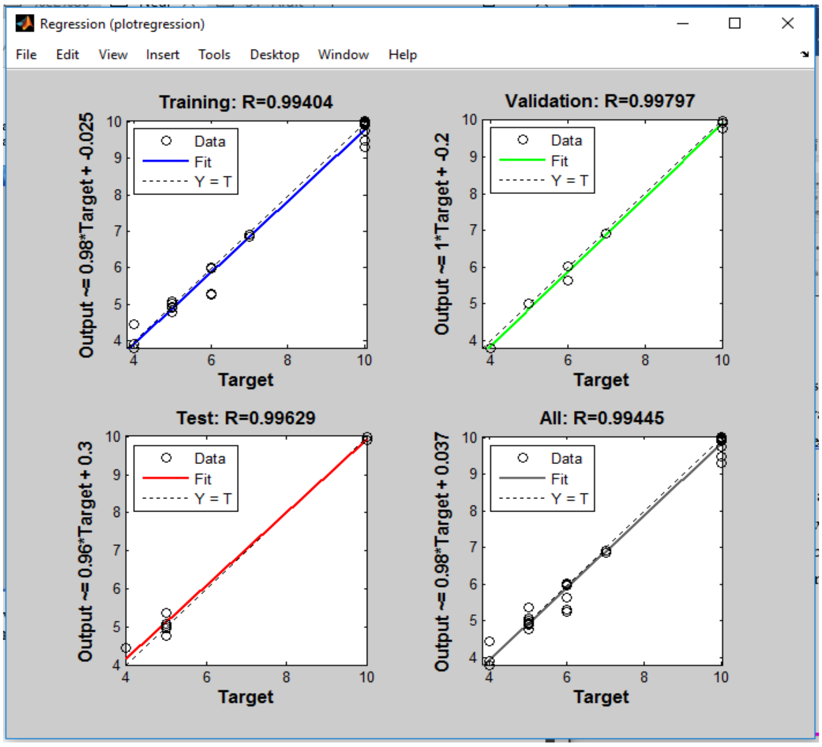

Figure (D. 9): Regression window

11. View the error histogram to obtain additional verification of network performance. Under the Plots pane, click Error Histogram.

The blue bars represent training data, the green bars represent validation data, and the red bars represent testing data. The histogram can give you an indication of outliers, which are data points where the fit is significantly worse than most of data. In this case, you can see that while most errors fall between -0.06 and 0.25, there is a training point with an error of 0.27, 0.48 & -0.42 and validation points with errors of 0.36.

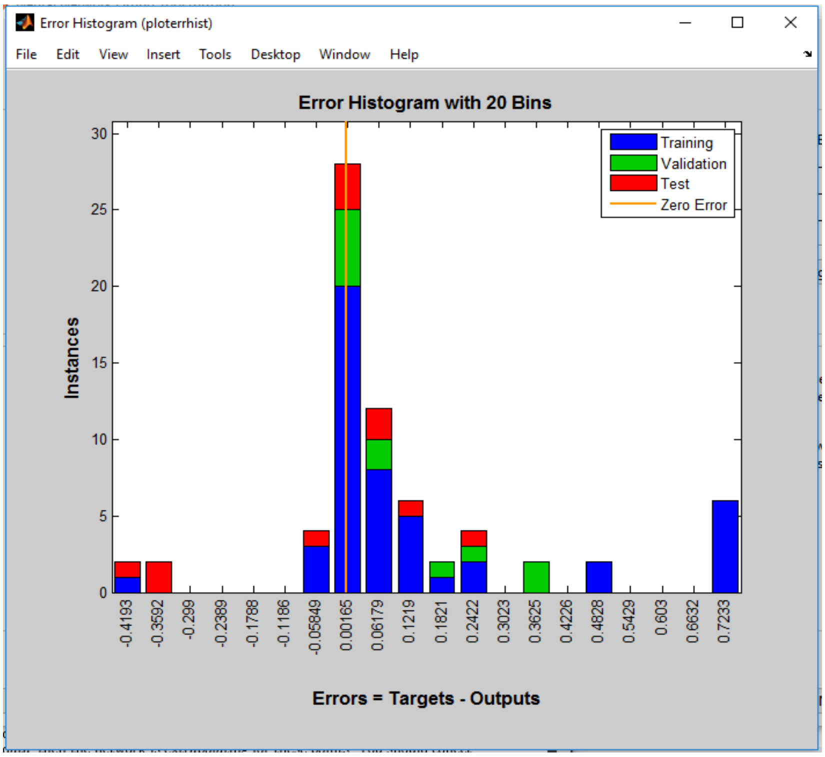

Figure (D. 10): Error Histogram window

12. Click Next

13. Click Next

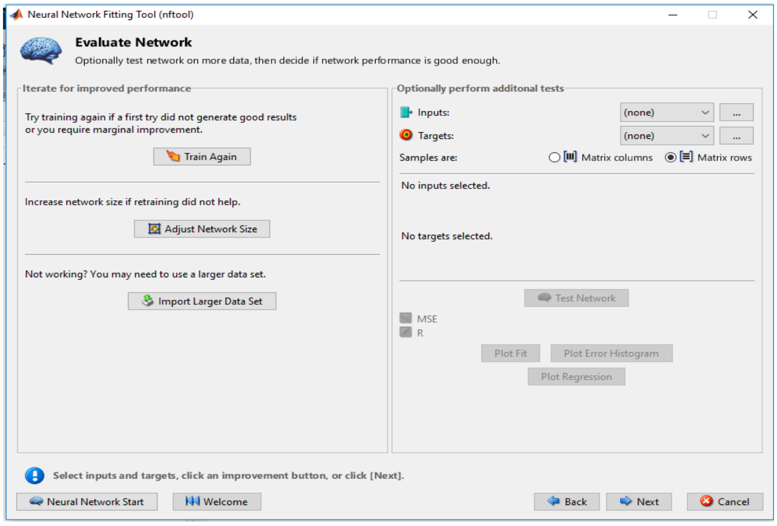

Figure (D. 11): Evaluate Network window

14. Click save results

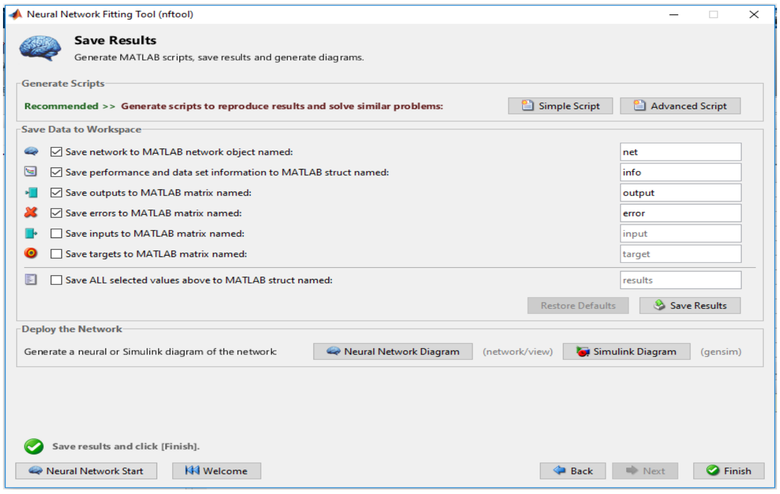

Figure (D. 12): Saving Result window