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Civil Engineering

COST ESTIMATION FOR BUILDING CONSTRUCTION PROJECTS USING AN ARTIFICIAL NEURAL NETWORK (ANN)

Zainulabdeen Ali ALTAHER

Master’s Thesis

Supervisor

Assoc. Prof. Dr. Sepanta NAİMİ

Istanbul, 2023

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The thesis titled COST ESTIMATION FOR BUILDING CONSTRUCTION PROJECTS USING AN ARTIFICIAL NEURAL NETWORK (ANN) prepared by ZAINULABDEEN ALI ALTAHER and submitted on 14/04/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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Zainulabdeen Ali ALTAHER

Signature

DEDICATION

To my beloved mother and father, my brother and sisters, and all my friends, you have always respected what I wanted to do and have given me full support and encouragement throughout my life. I would like to express my great appreciation for your great love.

ABSTRACT

COST ESTIMATION FOR BUILDING CONSTRUCTION PROJECTS USING AN ARTIFICIAL NEURAL NETWORK (ANN)

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The success of a project depends upon the performance of the input resources when controlling costs. Many problems can face the project managers, but the main problem is the costing process due to varying circumstances. To support early predictions of total construction costs of buildings, it is necessary to establish a model that can present an accurate cost estimation. in this research, the ANN model has been used to estimate the cost of the project using developed rules. the presented rules were developed based on the zone of the building site. the reason for that this the project site position may have a different condition in Iraq, and that causes the different price of building cost. the present system involves influence factors that affect the building cost. identifying the effective cost factors to use in the ANN model. the ANN decision line results from the present system have been specified and used to estimate the costs. the method to achieve the thesis goal was validated by using the real case study building cost as a validation step. then, the numerical results of different building sizes were compared with a real case study and applied to the BIM model. the results observed an error percentage of about 7.69% from the actual cost.

Keywords: ANN, BIM, Estimation Method Rules, Cost Estimation, Revit Building Cost.

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ABBREVIATIONS

ANN	:	Artificial Neural Network
GLM	:	Generalized Linear Model
EPC	:	Engineering Process Control
MLP	:	Multilayer Perceptron
PCA	:	Principal Component Analysis
EDA	:	Exploratory Data Analysis
ICA	:	Independent Component Analysis
SVM	:	Support Vector Machine
AI	:	Artificial Intelligence
ROC	:	Receiver Operating Characteristic
PCA	:	Principal Component Analysis
EDA	:	Exploratory Data Analysis
ICA	:	Independent Component Analysis
RBF	:	Radial Basis Function
N	:	The Number of Categories
W	:	Weight
LM	:	Levenberg-Marquardt
SVM	:	Support Vector Machine
FFR	:	Fusion Feature Reduction
KPCA	:	Kernel Principal Component Analysis

FWA	:	Fireworks Algorithm
SARG	:	Self-Adjusting Association Rules Generator
BP	:	Back-Propagation
CNN	:	Convolution Neural Network
ANFIS	:	Adaptive Neuro-Fuzzy Inference System
CWOA	:	Trained by chaotic Whale Optimization Algorithm
FFE	:	Feature Fusion Extraction
KELM	:	Kernel Extreme Learning Machine
MGWO	:	Modified Grey Wolf Optimizer
CCPR	:	Control Chart Pattern Recognition
AI	:	Artificial Intelligence

1. INTRODUCTION

1.1 OVERVIEW

The owner's ability to forecast project costs relies heavily on the accuracy of the estimated costs. The topic of how much it costs to build a house frequently arises in the minds of estimators. To answer that, we need a model that the estimator or even the owner may use to anticipate the expenses associated with funding the building of residential homes in practice. [1]. As defined by the Association for the Advancement of Cost Engineering (AACE), cost estimating serves as the foundation for all of these activities and more. The researchers described a cost estimate as "the prediction process used to quantify costs and price the resources required by the scope of an investment choice, activity, or project.". Estimated costs are also important in building contract tendering since they help determine the expected costs of resources used in the tender price. According to Smith & Mason (1997), "Cost estimating is the examination of numerous aspects, the most significant of which are labor, and material.". Changes in project management may also occur as a result of the integration of economic, environmental and social issues into the management of projects. [2]. Controlling the building process requires that the project not only fulfill quality output requirements, but also time and financial targets. Waste is a major source of project failures. Construction of a single-family home creates between two and four tons of garbage. Up to a third of the total manufacturing expenses can be blamed on this. Building type, construction materials, design circumstances, and even structure location may all affect how much energy a building consumes. An important construction project is the construction of a new government headquarters. The range of official buildings includes conference areas incorporated into the official environment, reception, official support spaces such as workrooms, storage rooms, and telephone and communications equipment rooms. Every government facility has the potential to be more energy efficient. Even relatively new buildings can save money when more efficient technology and methods are developed. However, the successful continual improvement of building performance requires more than just chances; industry experts often talk about energy efficiency being a part of the business culture [4]. For cost control, a variety of approaches, including ANN and Fuzzy NN, as well as SVM and PSO, have been employed. The qualitative approach relies on expert judgment or heuristic and quantitative methods to estimate building costs accurately. Statistical, intuitive, and analytical models are all examples of qualitative models. Analogous, parametric, and analogy-based models are three of the most common quantitative models. Only 2% of the approaches used in the proposal techniques are qualitative, such as the AHP, which are intuitive methods like these [5].

1.2 COST PROCESSES IN CONSTRUCTION

Many aspects contribute to accurate cost estimating, such as selecting the best person for the project, using the best equipment and tools for the job, and ensuring that supplies are of the highest quality, amount, source, price, and delivery date. In order to successfully complete the project, managers are required to have the necessary skills and resources, while adhering to the budget and time constraints. Men, materials, machinery, and money are all examples of resource inputs that are relevant to a project's cost. [6] These input resources are critical to the success of a project when predicting costs [8]. One of the biggest challenges facing a construction project manager is the high number of materials wasted as a result of a variety of factors [7]. This problem necessitates continual monitoring of the losses by a supervisor. Materials can be wasted at any level of the supply chain, from purchase to storage to use. One or more of the following factors can contribute to procurement waste: incorrect specifications, overbuying to cover for unanticipated and unforeseeable events, late purchasing of short-life commodities, inefficient and needless handling of goods, and transportation waste [8]. A variety of factors can lead to product waste while it is in storage: damage and breakage during handling, degradation due to inappropriate storage and storage conditions that are not properly maintained and short shelf lives. The supervisor's carelessness and negligence are also to blame, as are a lack of pre-work preparation and coordination, improper accounting, and poor storage practices. Other contributing factors include long-term storage at the worksite and excessive issuances from central stores with no follow-up from the stores to return unused surplus materials. Another source of expenditure is labor inefficiency and ineffectiveness. Time may be squandered in a variety of ways, including inactive waiting, needless travel, tardiness, early departure, unannounced breaks, toll delays, and delays in receiving materials and job instructions, to name just a few. [9][10].

1.3 BUILDING INFORMATION MODELING

Construction managers need to understand the procedures and tools that are utilized throughout a project's lifespan, beyond the design phase. There is a requirement to manage the asset from inception through to operation and end of life. To get the most out of BIM, construction managers need to comprehend, investigate, contribute, and validate the data. They need to use model information and new methods of working to better support new building techniques, scheduling, cost, quality, coordination, fabrication, sequencing, and facilities management to mention but a few. BIM system may be used for planning, design, building, operation and maintenance of any facility. Architects make up the vast majority of those who make use of BIM technology. Although its merits have been recognized and underlined specifically in contrast with previous innovations such us Computer Aided Design (CAD) tools, its application is deemed still in an early stage due to limited uptake by architects [1]. The term "BIM" is most commonly used to describe the work of the design team. Even though construction managers (CM) aren't normally engaged in model writing, they play a critical role in ensuring that all of the necessary components for a successful project are present and right. This enlarged position of construction manager necessitates the use of new tools, methods, and skill sets, all of which must be considered by him [2]. In this regard, BIM has been described as digital data in the form of a 3-D model, which is able to help the construction team better comprehend the project. The approach of BIM is the polar opposite. It organizes all data into a single database and links each item to that data (building and building components). Since all data are intelligently linked together in one place, the BIM system functions as a centralized database. The core model also aids in collaboration amongst all concerned disciplines because of its simplicity (BIM interoperability). CAD, on the other hand, necessitates a more traditional approach to communication between the various parties, as seen in figure 1.1 [3].

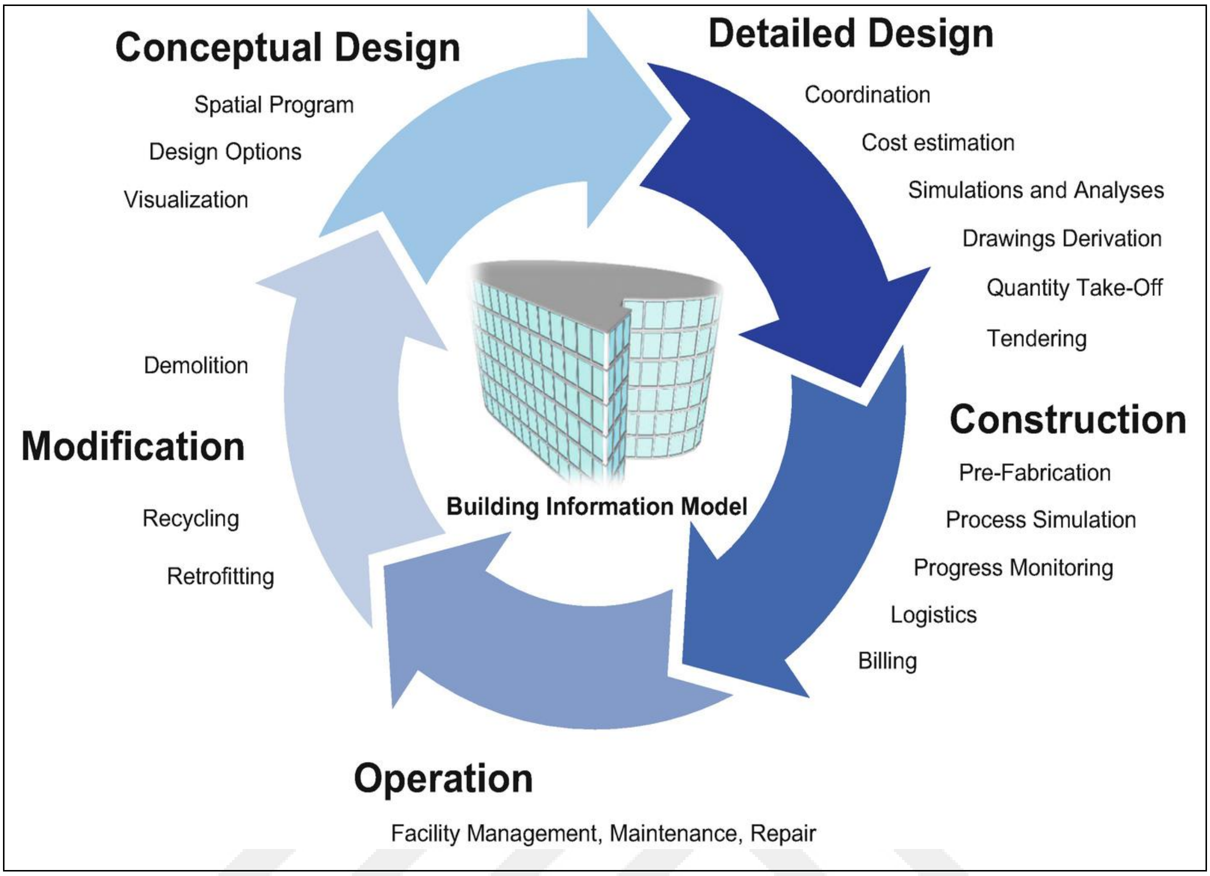


Figure 1.1: Data Exchange in Comparison with BIM Interoperability.

Every stage of a building's lifespan can benefit from the use of building information modeling (BIM). Apps in this category deal to a variety of BIM-related aspects, including how the technology is deployed. Only a few of the many ways BIM may be used in the design, planning, and construction stages of a project are included below.

1.4 THE APPLICATIONS OF BIM

Every stage of a building's lifespan can benefit from the use of building information modeling (BIM). Apps in this category deal to a variety of BIM-related aspects, including how the technology is deployed. The following are just a few examples of how BIM may be used in the many stages of the development process, from conceptualization through construction.

Project Management: This includes the scheduling of development. The specific time schedules may be created in such a way that the contractual employees and other players receive exactly what they need [4].

Preparing the construction site for various temporary facilities such as a materials warehouse, construction equipment, etc. in order to minimize onsite disputes throughout the building process. When fresh building supplies are ordered and delivered to the construction site, they take up space until they are actually put to use. The materials must be placed in such a way that they don't interfere with the construction process or the arrival of additional building materials and elements. All phases of the construction process will be represented by the model, which will include both permanent and temporary structures on site. Construction schedule models (4D) will be used to examine space planning, logistics on site, timing requirements for temporary construction work and safety [5].

Increasing India's energy efficiency is a top priority for the government. 70% of the structures that will be needed in 2030 will be constructed in the following two decades, from 2012 to 2032. Energy demand is expected to double by 2032, according to forecasts. Because of limited resources, such a significant increase in energy supply will be challenging to manage. It was in 2001 that India's government enacted the Energy Conservation Act (ECAct) and formed the Bureau of Energy Efficiency (BEE) in accordance with the legislation. Among BEE's initial projects was the creation of an Energy Conservation Action Plan in August 2002 [6].

When it comes to estimating costs, a good example might be a model that calculates the weights of several criteria. At an early stage of a building project, models are also being developed that can estimate both the duration and expense of a project. The use of BIM makes it possible to depict construction operations and associated costs. With BIM technology, cost estimation is more accurate than with traditional techniques [7].

1.5 PROBLEM STATEMENT

Each building project has a unique set of obstacles, which vary based on the project's features and nature. Successful projects are sometimes shown as a three-pointed iron triangle: time, money, or scope (or performance/quality). When it comes to project success, the iron triangle has been criticised as having too restrictive a definition of what constitutes a successful project. Many years have passed since projects ran into issues, yet there is always room for improvement in how projects recognize problems before they occur. Studying the elements that influence project performance is one way to improve it. Members of a construction project team are able to perform at a high level if they study the issues involved. The capacity to forecast future project performance based on the effective project components is what is meant by predicting the performance of projects based on their current performance. To measure the project's performance, an artificial model based on the most recent, most successful official building projects is proposed in this proposal.

1.6 THE OBJECTIVE OF STUDY

The main objective or the present study is to provide a strategy to improve construction project teams' capacity for accurately estimating the costs of construction projects in Iraq. To achieve an accurate estimate of the project's cost, researchers devised a computer model that could simulate various site and work circumstances. After multiple attempts to construct project management systems, the elements are utilized to enhance the selected possibilities of project execution in these projects depending on the project's changing nature and the specifics of each project.

1.7 THESIS ORGANIZATION

Five chapters are included in this thesis. Chapter one provides an overview of the project's intended audience based on the attributes of the building.

Chapter two provides a basic overview of the criteria used in various studies to pick a building.

Chapter three details the experiment's protocol, including the variables being examined and the methods used to collect the data.

Chapter four focuses on the final outcome and the calculation of the work. The fifth chapter is the final one.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Building projects usually need estimating the cost, analyzing, and summarizing easily available data. There may be a number of factors to consider, such as the number of people involved, the materials and equipment used, and even the per-unit costs associated with certain job items. In the building process, estimation is a critical phase since the success or failure of a project is directly related to its accuracy from the conceptual method to the final categories. As a result, cost estimating is often not a purely technological activity that is both efficient and precise, but rather a subjective technique in which estimation methods assess the effectiveness of a building project's components [8]. Estimating the cost of a construction project is critical, but it is also variable since it is used to estimate the possible magnitude of resource component costs in a project tender. A high amount of risk is inherent to the construction business due to the requirement that virtually all projects be put out to contract before construction can begin. For another way of putting it, the construction business stands out from others in its field due to its set selling pricing or production costs [9]. Cost forecasting's major goal is to produce accurate and meaningful cost estimates for a building project. A customer's needs and relevant facts are all that matter when it comes to determining a pricing. It is possible to see the data that was utilized to arrive at the estimate. Clients and contractors could wish to know the lowest bid price at this time or the entire project cost size only after the job is done. Customers must keep this in mind when commencing a building project; it impacts the applicability of a project and offers budgetary control during the tendering and construction process [10].

2.2 STRATEGY OF COST ESTIMATION

The project can be rescheduled to allow for any time overruns if the initial planning and budget were wrong. Due to the competitive nature of the bidding process, estimates may be affected by erroneous predication of the purpose of work included in the building. There's a good probability that future projects in many states will be priced based on a single, generic estimate. Being thorough in preconstruction and realistic in terms of project deadlines and prices from architectural engineers and contractors are essential for a successful outcome.

Designers, contractors, and owners can use project forecasting as a chance to express their concerns regarding the project's budget and timeframes [4]. The condition of preconstruction and design services has a significant impact on the potential of a project before construction even begins. Preconstruction is just as important as the construction phase since it lays the groundwork for a complex project and can save money. To guarantee that the contractor has a more advantageous process in papers, less misunderstanding among administrators, and a solid project list in the future that may save future costs, a good planning pattern prior to the beginning of construction is essential [11].

2.3 METHODS FOR ASSESSING THE MAGNITUDE OF COSTS

There are several variables that affect the cost estimation. There are several benefits to using any one approach, including ease of use and the confidence that the total cost of completing a job, from start to finish, will be relatively low. Even though there are many various ways to classify project expenses, one of the most basic is to split them into two categories: direct cost and indirect cost. Assumptions underlying each item are included in the cost estimate, which is more than just a list of costs. The basis of estimate report comprises these computations and cost accuracy forecasts, as well as cost exclusions and inclusions. Estimate reports are used by those involved in construction projects to look at projected costs and see where they differ from actual expenditures. Speed, validity, and consistency are all important considerations when implementing new technologies. A few examples are functional units, cube technique, surface area, surface variable, floor enclosures, approximate amounts, element analysis, extrapolation, resource analysis, and cost engineering.. Due to their inaccuracies and uncertainties, the procedures referred to herein are inferior. Another flaw is their failure to account for client property, consultant and derive qualities, contractor property, contractual processes such as procurement methods, external goods, and marketing aspects [12].

Linear regression and expert systems are further methods for estimating costs. Other methods include dynamic linear coding, risk analysis, and simulation. These approaches, however, are unable to cope with challenges such as incomplete or conflicting data, as well as the many variables that influence the final cost of a project. Coordination and interconnectedness of elements that impact cost are not known in advance The input-output relationship is too complicated and ambiguous to correctly and successfully describe quantitatively. Calculating project costs prior to developing a visual representation is known as "parametric or raw estimates." A preliminary evaluation that includes a projection of future building costs. An evaluation like this one is done on a regular basis as part of the project's preliminary feasibility report. A rough estimate can only be made at this point because there is so little information available regarding the scope of the project and the specifics of the project itself. In other words, before making any further project decisions, a conceptual assessment informs the concerned customer of the quantity of work to be expected [13].

2.4 PROCESSES OF COST ESTIMATION'S CONCEPTS

Assumptions that support each expense are also included in the cost estimating process. A report named the foundation of estimate includes these calculations, as well as cost accuracy estimates, as well as cost exclusions and inclusions. Building project participants rely on this estimate report to understand how and where real prices differ from those projected in the project's budget [14].

In addition to the main categories of indirect costs, the expenses of the building firm are further split. The following are some of the most typical types of outlays [15]:

Labor is the worth of human work utilized to accomplish project objectives.

Materials taken into account How much it costs to bring about anything. The cost of obtaining and maintaining project-related equipment is known as "equipment." Services are the costs incurred by a firm when it acquires a new business. Non-physical computer programs. Hardware is a term used to describe the computer's physical components. The cost of housing or employing specialized tools, services, or locations, in terms of their total dollar value.

It is possible to estimate the amount of the projected expenses in either a detailed or an estimated state, depending on the specifics of the project. Cost estimates based on such characteristics are the most common kind of data. Only a small portion of the entire project cost is spent on building. In any event, the construction project manager has control over this expense. At various phases of the planned construction project, the precision required for building cost projections varies, ranging from rough values at the beginning to relatively exact figures for budgetary control before construction. The magnitude of cost estimates supplied for the early classes is likely to be less accurate since the design decisions made at the beginning of a project's life cycle are more uncertain than those made at later phases. Cost estimates are only as accurate as the facts available at the time of calculation, in general [16]. Figure 2.1 explained the variation in cost estimation accuracy in different stages of the project implementation

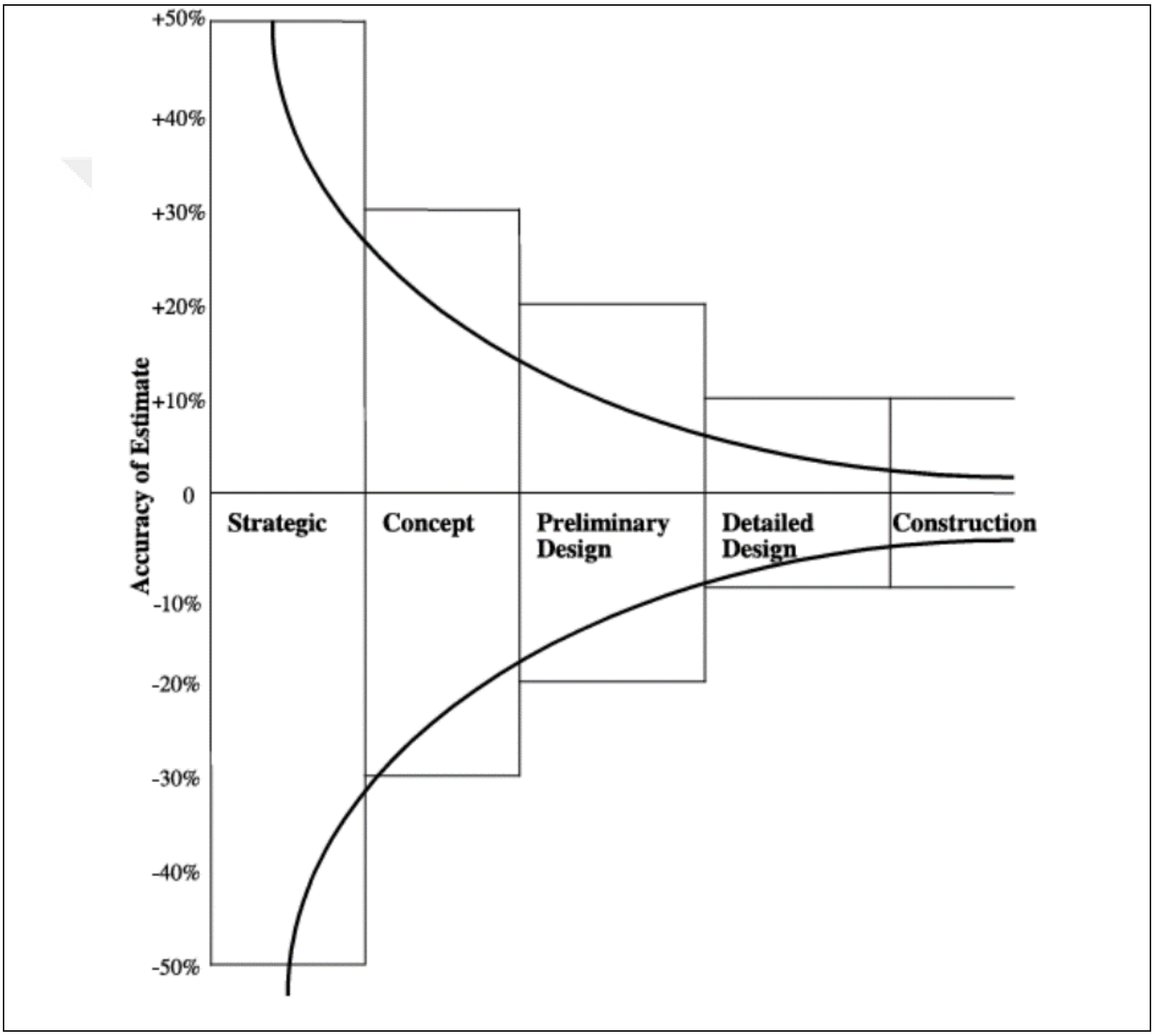


Figure 2.1: Cost Estimation Accuracy in Different Construction Project Stages [17].

Cost estimates for building can be seen from a number of aspects due to the range of institutional needs. Regardless of which of the different forms of cost predictors is deployed at various phases of a project, cost predictors may be best grouped into three basic groups depending on their features. A construction cost estimate serves one of three basic functions: making, bidding, and estimating. A design cost or a bid assessment is used to determine the funding of a project [18].

2.4.1 Estimates for Design

Different design estimations indicate the development of a design during the design and planning phases of a project. A screen evaluation or ranking of size estimate is typically produced before the business is developed, and so must be based on the magnitude of expected costs of close to appropriate facilities built in the past. An early estimate, also known as a conceptual estimate, is based on the conceptual design of the structure for the state at the time the fundamental procedures for the deriving were established. When the scope of the assignment is fully specified and thorough design is underway, the detailed estimate or final estimate is developed so that the main parts of the company are identified. When the finalized plans and specifications are available for the owner to receive bids from building contractors, the engineer's computation is based on them. The design expert will use predictable numbers for contractors' expenses and profits while computing these estimations. The expenses related with a facility might be separated into a hierarchy of levels appropriate for the aim of magnitude of cost assessment. The amount of complexity in decomposing the company into tasks is depending on the sort of cost estimate to be prepared. The quantity of information in defining tasks for conceptual estimates, for example, is rather basic; for detailed estimates, the level of detail may be quite good [19].

2.4.2 Estimated Bids

The contractor's desire to get the work and the estimation tools at his disposal are often reflected in the company's bid forecasts. There are some firms that have established cost-estimating procedures in place, while there are others that do. Since the lowest bidder often wins out in most bidding wars, any time spent on cost estimating is time that the contractor who isn't the top bidder loses. This means the contractor may put in as little effort as possible to come up with a cost estimate if it thinks it has a poor possibility of success. Price quotations for various projects to be subcontracted by speciality subcontractors may be obtained by government contractors planning to engage contractors in the construction of a facility. As a result, the primary contractor will now delegate responsibility for preparing cost estimates to subcontractors [20].

A bid estimate might be prepared based on the outgoings from the objectives supplied by the owner or on the construction procedures designed by the contractor to complete the project if the general contractor is doing all or part of the building. These data publishes may include, for example, the cost of a constant-volume footing, which could be used to facilitate cost calculations using information that can be obtained. It's possible that the contractor will want to look at the actual magnitude of construction costs, taking into consideration potential construction techniques and the corresponding size of expenditures, if the project is determined to be unique. It is possible to use criteria for cost estimates to analyze elements like labor, materials, and equipment needed to complete certain tasks. Public tender bid estimates include direct construction costs with field supervision as well as an additional premium to compensate for public costs or profits. The precise cost of a construction project, which is then utilized to generate bid estimates, is frequently derived using a variety of means [21].

2.4.3 Estimation for Project Controlling

During construction, both the owner and the contractor have a strong incentive to adhere to particular cost-cutting principles. In order to prepare long-term financing for the facilities, the owner should adopt a budget estimate early on. Due of this, budgeted amounts are commonly based on the detailed estimate, which is more exact and ready far earlier than the engineer's estimate. In the course of the project's development, the anticipated cost of completion will be updated on a regular basis [22].

In the event of a change in owner-requested restrictions or an unanticipated magnitude of overruns or savings, the predicted cost must be revised. The bid estimate is typically included in the budget estimate used by the contractor for project management and construction finance design. Every now and then, it's possible to increase the estimated cost of the well's construction in order to ensure sufficient cash flow for the project's completion [23].

2.4.4 Revised Estimated Cost

The sanctioned estimate amount is increased by at least 5%, which necessitates the creation of a new cost estimate. An increase in the price of raw materials, the cost of transportation, or some other factor might be to blame. If there is a change in the estimate, an explanation should be included on the amended estimate's final page [24].

2.4.5 Estimated Additional Costs

When more work is necessary during the course of the initial project, an accurate estimate of the additional cost must be made on the spot. Further costs for additional work were included in this estimate sheet, including any additional costs for which permission is required [25].

2.4.6 Estimated Annual Repair Costs

In order to calculate the quantity of construction maintenance expenditures necessary to maintain a structure safe, an annual repair cost estimate, also known as an annual mending estimate, is prepared. When determining a building's yearly maintenance budget, tasks like whitewashing, painting, and minor repairs are becoming increasingly significant [26].

2.5 COST ESTIMATION METHODS

Total wall length is measured and multiplied by running meter rate to arrive at construction cost using the estimated amount technique of anticipated cost. Each running meter, foundation, and superstructure are taken into account while determining the rate. Excavation costs, brickwork costs, and the price of the plinth are all taken into account when determining a price per square meter for a new foundation. Quantities such as wall masonry, woodwork, floor finish, and so on are analyzed in order to calculate the rate for each running meter while the superstructure is in good condition [27].

2.6 FACTORS AFFECTING COST MODEL EVALUATION

As a building enterprise evolves, more and more information becomes available to the public. Various sorts of data and processes are employed at various stages of the project. When the nature of building projects changes, new ways might be devised. Many techniques and phases of the project should be included in an effective cost estimating model. Successful outcomes need a model with a wide range of capabilities that can respond to both internal and external trends [28].

Many resources, including time, information, personnel, and the cost model, must be used to estimate project costs.. The scale of cost model also necessitates these resources for its creation, operation, and upkeep. There are many steps in the estimating process, thus a cost forecasting algorithm must be able to accommodate the demands of the people who create and use it. For example, an estimator may demand that the modeling be user-friendly in addition to providing a good estimate. A model that is both acceptable to users and versatile enough to be readily controlled is also needed for model creators. As a result, when developing a cost model, several practical aspects should be taken into account in order to increase its applicability [29].

Because most cost models are based on historical data, it is necessary to collect enough data for estimation. The simplest method to begin a realistic estimate of facility size of cost is to identify the costs of comparable projects then compare these magnitudes of costs to the magnitude the costs of the present facility. Future building projects are often non-repetitive and include unique and distinctive components that are likely innovative. As a result of such vulnerability, estimators may be unable to give enough data for the range of pricing of new, particular projects. As the number of building project data develops, this issue gets more prevalent and regular [30].

(B. Amade & E. Akpan, 2014) Identifying and evaluating the various approaches of executing project cost projections in construction projects in Owerri, Imo State, are the primary goals of this research. Ultimately, due to cost overruns and project abandonment, even the most sophisticated construction projects were unable to achieve a reliable temporary project size for the estimated implementation costs, according to the report. 53 project managers from connected construction firms in Owerri, Imo State, were polled for their thoughts. Based on eighteen (18) factors established in the literature as possible predictors of project cost forecast accuracy, the topical investigation tool was modified. The study used descriptive and inferential statistics, the mean value of the score, and the parameter-analytical technique of the primary method to assess the process score for the parameters with SPSS. To begin with, the study found that detailed estimating methods are the most commonly utilized approach for project size estimation. It was discovered via the parameters analysis that project type and nature are the most unstable aspects impacting the accuracy of Owerri building cost estimation. The order of bids, the location of construction, the closure and blockade of borders, the size and scope of construction, the availability of material costs, the contractor's workload, the site limits, and the specifics were followed. Capacity building is outlined in the drawings, specifications, and market circumstances [27]

(S. Ji, et al., 2019) According to this research, a cost estimating model was developed using a modification technique that takes into account both influencing factors and monetary value variables. A government-funded study was conducted using data from Korea's residential development, which was used in the study. As a result, the cost prediction results were more accurate and stable. The case study indicated that the suggested cost model beats the standard CBR cost model in terms of performance. Researchers in this study devised a new method for creating parameter estimates that reduces the number of important variables to a manageable amount while also improving the accuracy of the cost model's estimated magnitude. By multiplying the new parameters by their costs, the costing system is able to dynamically respond to repeated requests for cost recalculations in a timely manner. The suggested cost modeling is able to overcome the limitations of traditional cost modeling by simplifying a large number of significant factors into a few basic representations. The study's findings might aid and encourage those in charge of making decisions to generate expense projections. However, the generality of the suggested cost model must be validated by include it in a wider range of construction projects than only reinforced concrete work on residential structures. In addition, it is necessary to assess the suitability of various modification approaches and cost models. Improved cost estimation models and comparative studies using additional approaches, such as ANNs and regular parametric methods, will be required in the future [31]

(O. Torp & O. Klakegg, 2016) For the purpose of estimating costs, this research aims to begin a comprehensive examination of all project expenses. Cost overruns in construction are widespread, despite the use of tools and procedures for assessing uncertainty. According to this study, some of the issues that arise when using cost estimating approaches are discussed as well as possible fixes. The goal of this research was to show how to fix some of the early shortcomings in the present cost estimating method. The decommissioning of the Barsebäck Nuclear Power Plant may be used as an example of how to solve these challenges. It's a fascinating issue, considering the difficulty of the project and the lack of personal knowledge with nuclear power plant decommissioning, given the intricacy of the problem. However, it has not yet been extensively utilized to estimate project costs in this way by the study's researchers. A more accurate cost estimation uncertainty analysis may be achievable, according to the findings of this study. Some of the issues related with cost estimating under ambiguity can be alleviated by a very good process that involves such a qualified group of specialists working through a well-structured method, focusing on risks and possibilities, and making use of a top-down trend[32]

(O. Shehatto, 2013) With Artificial Neural Networks, a great degree of accuracy was proven in the generation of modeling to predict the cost of construction projects (ANN). To cope with non-linear conditions, artificial neural networks (ANNs) are a relatively new trend in cost assessment. Partial data sets, erroneous or missing data, and extremely complicated challenges can all be handled by it. To create this model, quantitative and qualitative approaches were employed to identify essential features of building project expenses that comprise skeleton and finishing stages. The Gaza Strip's building industry provided information on 169 different projects. Project cost was a dependent variable in the ANN model, which took into consideration eleven important parameters of independent input variables. The models were trained using Neurosolution software. This neural network's models have been quite successful in forecasting building project costs without the need for more detailed drawings, according to their results. Refined models have an acceptable average error in the test data. Land area and the number of floors are the most significant factors in building costs, according to a sensitivity analysis research According to this study, the created model and cost index should be combined to offer an accurate estimate every time. Furthermore, it encourages all parties involved in the construction industry to pay more attention to the development of ANN in the price range by archiving all project data and conducting further studies and workshops in order to take full advantage of this evolving approach and integrate more outputs into a model.[33]

(A. Erbe, 2014) The study compared the MIPP computation using a literature review search strategy and criteria. To guide the official scale of service charges by architects and engineers

(German: HOAI), the Association for the Advancement of Cost Engineering (AACE) provides general direction with a guideline known as the "cost cone." It is stated that the MIPP section in the industry's initial cost guidelines is more forgiving of quantity in terms of precision than building in Germany, especially in the early phases. It is possible to identify and categorize feasible cause solutions, such as I the intensity of competition, which includes the influence of technology, (ii) demands on account. (iii) experts, (iii) materials and supplies, (iv) project implementation time, and (v) an estimate of predicted cash flows are the most common factors. As a final note, the paper suggests further directions for investigation. An initial comparison was made between MIPP rules and non-German building construction standards in terms of their size [34]

(A. Challal & M. Tkiouat, 2012) Consolidate and sustain national and worldwide improvements in the number of cost information and actual sales accounts, as well as represent the existing links between expenditures and construction project management employees, and computer donation in construction management tools. Modeling the size and expense of a building project is one of the primary objectives. A strategy for figuring out how long a piece of real estate will take to build was selected after weighing the benefits and drawbacks of several cost estimating approaches. Cost analyses of the project's price components have taken into account all of the interrelationships between the cost approach's components. Construction project delays, management goals, and construction program functions may all be evaluated once identifying potential flaws in cost prediction methods have been identified [35].

(H. Yaman, E. TAŞ, 2007) Based on Turkish construction industry functional characteristics, this study's goal is to create a general computer-aided construction cost estimating model that can be employed in the relevant and planning phases. In the research design, the functional features of building were taken into account and a construction pricing model based on these factors was presented.. Using prior functional elements as a foundation, computer-based quantification has been utilized to define the fundamental ideas and functional processes of the cost analysis volume. Automating the labor-intensive process of calculating building costs was one of the primary goals of the program's development. It is presently at the testing stage, where it is being utilized to educate students as well as students themselves. Using all current public sector and market prices in the volume of the costing process, increasing the number of structures stored in the database to obtain more accurate results, estimating the costs of various types of construction, and more accurately estimating the percentage of the structural functional component is proposed. For the purpose of further investigation. As the number of similar structures in the database grows, so does the accuracy of the cost estimate volume.[36]

(A. Awosina, et al., 2018) For the purpose of developing mitigation solutions, the study analyzed the repercussions of incorrectly scaled predicted costs for stakeholders in building projects. A systematic questionnaire was used to gather empirical data and to review past studies on the size of the cost estimate. It also includes suitable sampling of advanced buildings functioning in quantity surveying professions and construction firms in the Cape Town area. In order to perform the study, a quantitative approach was used, and the results were presented using descriptive statistics of central tendency. The study's findings demonstrated that faulty cost estimates on construction projects resulted in reputation and confidence damage among project participants, financial vulnerability or revenue loss. The study was unable to get statistics above the real duration of projects that were overestimated or inflated for comparative analyses of private sector projects because of the confidentiality of a portion of project expenditures in the private construction industry. Focusing on the negative impacts and implications of erroneous cost projections, the paper provides a mitigation approach for the building project stakeholders [37]

(H. Doloi, 2010) Conceptual models were sought to be developed by looking at the board members' viewpoints during the building process, and this study aimed to do so. Structured interviews conducted with representatives from a small number of carefully chosen businesses provided the basis for the generation of data and a few rich visuals displayed above each stage of project development. Using the soft system approach, the concept models were then turned into rich visuals enabling the building of a new body of knowledge in the field. Political and legislative factors have a significant impact in the formation of a work case during the genesis stage of a building project [38].

(T. Williams, 2021) Project cost estimates, project timing, and project success were all found to have a strong association in the study. A total of 110 Liberian construction firms were surveyed for historical data. More than linear regression, the results of the standard regression analysis demonstrated that the entire model was statistically significant. The cost of the building project was statistically relevant. There was no project management at all. In order to control project costs and schedules and assure project success, it is vital to create firm managers to take advantage of relevant project control training and internal capacity development facilities. Cost and scheduling surplus savings must be used to support important development that lifts the disadvantaged by restoring their dignity and increasing standard of life. This is a consequence of successful social transformation.[39]

(M. Hussein, et al., 2021) Basra oilfields' drilling contracts are described in this paper, and the concepts of well construction cost estimation are discussed in relation to them. For drilling operations, a breakdown of cost was also provided by the research in its findings. The study also addressed the issue of how to estimate the cost of a well using a probabilistic approach instead of a deterministic one. An in-depth analysis was conducted to identify the factors that affect the scale of the well's cost and to provide a technique for an onshore well in the south of Iraqi. Well construction expenses are divided into three categories: fixed, time-dependent, and depth-dependent. These three categories were used in this study to determine the potential size of the costs. It is hoped that the outcomes of this study would assist managers in making better investment decisions [40]. Cost estimation in project management is the process of estimating the money and other resources that will be required to complete the project within the specified parameters [41]. A project's budget cannot be determined without first estimating its total cost, which includes everything from materials to labor [42]. The success of project management is significantly dependent on the accuracy of cost estimates. Dealing with the numerous costs that can arise during the project management life cycle could be the difference between a successful plan and an unsuccessful one [43] if an accurate cost estimation strategy is not implemented. However, cost estimation is much more difficult than it appears. Unpredictable expenditures and cost management challenges are two outcomes of project risk. Calculating a budget that can support the financial commitment required for a successful project requires cost assessment, which takes into account direct and indirect costs [44]. Techniques for estimating the cost of a project are pertinent to both the construction of a bridge and the development of ground-breaking new software. The more precise you can be about the amount of money required to achieve your objective, the better. Project management applications such as Project Manager [45].

Simplify cost estimation. Include project expenses, employment costs, and the hourly rate of your team. As you progress through the planning phase, our Gantt chart will automatically calculate your project costs [46]. Typical components of a project estimate include tasks, resources, time, rate, equipment, and software [47]. When creating estimates, managers may consider the project's duration, size, scope, and complexity [48].

3. METHODOLOGY

3.1 OVERVIEW

This chapter provides an explanation of the research techniques that were utilized in this particular study. In this study, an examination of historical data was utilized to uncover relationships between the key factors that determine construction project expenses. The goal of this was to create estimates for future endeavors based on the findings of this study. In this section, we are going to discuss how to do research, what elements influence building expenses, as well as how to gather and evaluate data. The objectives of a study plan may be classified in two ways: quantitatively and qualitatively, respectively, through the use of qualitative and quantitative approaches. The qualitative research approach seeks to learn more about the perspectives and ideas that individuals have on a specific topic as its ultimate objective. It is also employed in situations where there is only a smattering of understanding regarding the subject at hand. The process of gathering facts and searching for patterns is called quantitative data analysis. This type of analysis also entails analyzing whether or not the patterns found fit up with already established theories and the results of past research. During the data collection phase of this study, both qualitative and quantitative approaches were utilized with the goal of gaining an understanding of the elements that have a role in determining the total cost of construction projects in Iraq during the conceptual stage. In addition to getting data from other sources, it is important for each project to finish filling out a form that includes the input components as well as the real cost of the project. The major purpose of this study is to design an ANN model that has the potential to supplant the method that is currently used to estimate costs associated with building projects. As part of this research, we will also discuss mean shift detection and identification as well as ANN-based pattern recognition as an added perk (PR). A schematic representation of an ANN pattern recognition framework is presented in Figure 3.1 to illustrate the overarching concept of pattern recognition application. Because it is constructed up of a large number of interconnected processing components, the operation of a neural network is simple to understand. Neural computing and processing needs have to be anticipated as part of efforts to develop already available ANN-based PR approaches. The relative importance of the linkages can be changed on the fly depending on which input and output pairs are being considered.

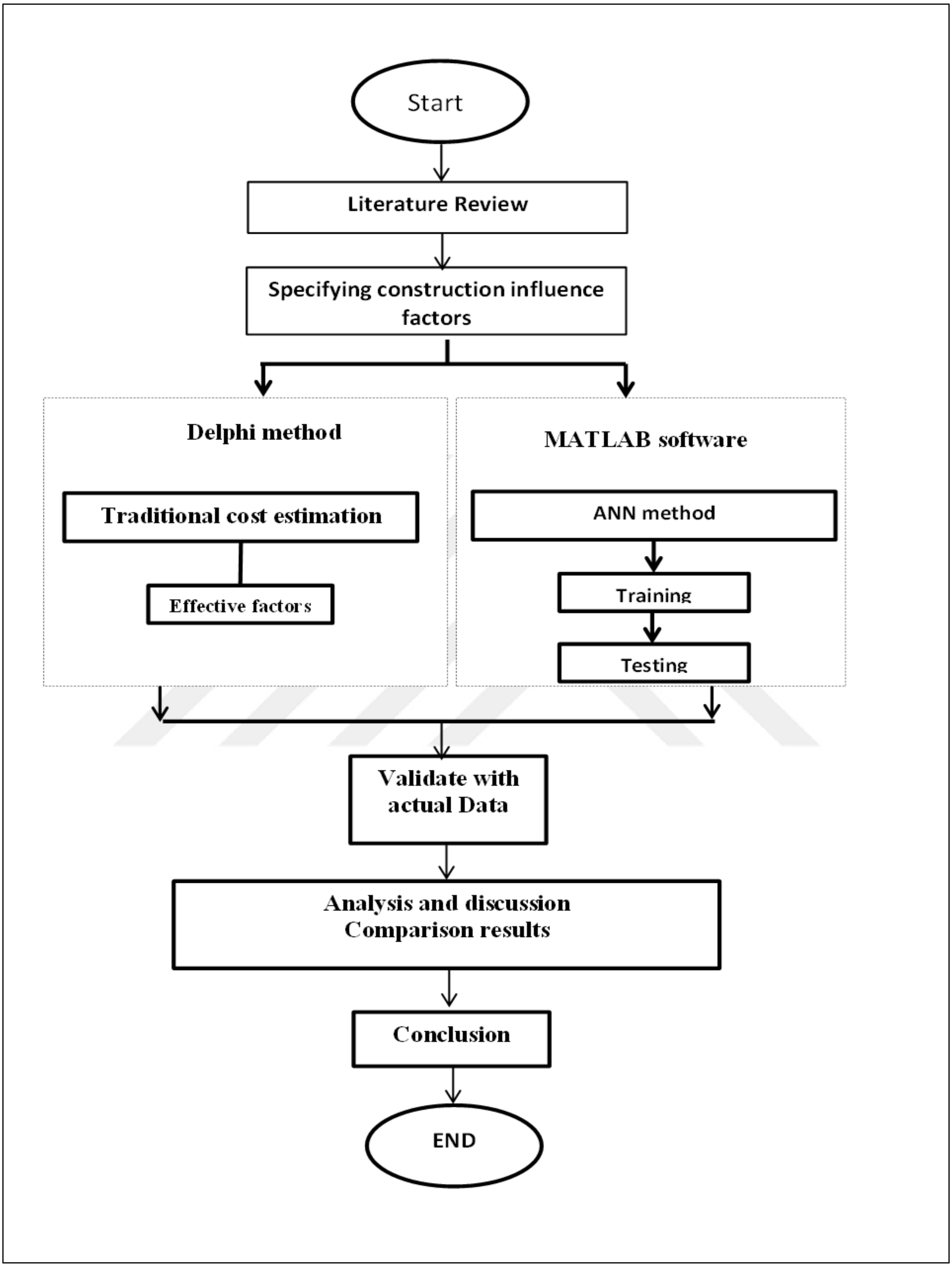


Figure 3.1: Shows The Overall Structure of a Pattern Recognition Application.

The most advanced control mechanisms now accessible must be described in detail in order to begin creating a thesis based on pattern recognition. Completing this crucial stage may be accomplished by reviewing similar publications and listing all of the methods and procedures previously employed. Comparing all of the findings will reveal any discrepancies or inaccuracies in the data. The gap will represent the distance between the current state of events and the researcher's desired end result.

3.2 EFFECTIVE COST FACTORS

Data from industrial processes will be used to identify faults in the manufacturing process by utilizing integrated techniques that can build, develop, and enable a system that tests data from those processes. In the next section, you will find the most important settings. When it comes to building a neural network model, knowing which factors have a real impact on the cost of construction projects is one of the most important jobs. Multiple methodologies were used to assess these criteria in Iraqi building projects because of the importance of determining these factors.

a. Type of foundation: There are a wide variety of foundations to choose from depending on soil type and building loads, including isolated foundations, raft or mat foundations, and other options.

i. Shallow Foundations: The soil's safe bearing capability is not exceeded by this form of foundation. Open footing is another name for it. Excavate to the bottom of the footing before building the foundation for a shallow structure. This sort of foundation makes the whole footing visible. It is best suited to light-weight structures that are situated in ideal soil conditions. Freezing may harm foundations with a shallow depth. Because of this, they need to be kept warm throughout the winter. It's important that they're built below the frost line and shielded from the heat of the house. When a single column will be carrying the bulk of the structure's weight, concrete footings, whether round, square, or rectangular, should be used. Engineers divide the entire weight on the column by the soil's safe bearing capability while creating a pad foundation. The sort of form that may be built will be determined by the amount of pressure exerted. They're a good idea if the structure has a distinct column.

ii. Deep Foundations: To ensure that the structure sits firmly on the ground, substantial foundations are used. In deep seas, they're frequently dependable in targeting hard strata. If you're dealing with soil that's easily compacted, piles are your best bet. Bridges across large bodies of water, such as rivers and canals, are best served by using girders. If irrigation is feasible, that would be an added bonus. Vertically drilled piles can be divided into two types of working modes. Bearing heaps are one type of pile, whereas friction piles are another. When the hard stratum is not too deep, bearing piles can be used. They transmit the weight directly to the hard surface. ' When the soil is too soft, frictional piles are the best option. In order to create friction, the skin is intentionally kept rough. Eventually, the abrasions wear off and the framework fails completely.

iii. Raft Foundation: Third, the structure's raft foundation is made from thick reinforced concrete that covers the structure's whole bottom region. In soils with limited bearing capability, this form of foundation is used to support large structural loads.

b. type of slab

i. One-Way Flat Slab: A one-way flat slab employs 4 to 6 inches of concrete to sustain large loads and is one of the most prevalent slab types in building projects. There are other slab kinds as well. The support structure is referenced in the slab's name. If only one of the two directions is supported, it's not a good fit for this type of application. Using this sort of slab is a cost-effective and straightforward option for both commercial and residential applications alike. It's less expensive than other slabs, especially if you're building a ground-level project. Unlike other slab kinds, one-way flat slabs have a lower span capacity than other types of slabs. Many bridge and ceiling installations would be unsuitable for this type of material.

ii. Two-Way Flat Slab :Using support beams at all four corners of a two-way flat slab, the weight is evenly distributed throughout the whole surface. Levels that need to sustain the weight of subsequent floors are often constructed using this sort of joist. It's advisable to look at the scope and size of a certain project to determine which type you'll require. A one-way slab should be considered if one path is longer than the other by a ratio of two to one.

iii. Pre-Tension Slab: Pre-tension slabs are a good way to avoid compression while also boosting overall strength and durability. High-tensile steel wires are used to accomplish this. Before the concrete is poured into the structure, hydraulic jacks produce stress in the system. The cables' strain prevents the concrete chunks from dangerously splitting in the case of a break in the structure. To make a thinner product, use a pre-tensioned slab. Pre- and post-tensioned slabs use less concrete than conventional reinforced slabs. Because the slab is in tension, there is less of a requirement for joints. The slab may not have any joints at all in certain constructions.

iv. Waffle Slab: This polished slab, which resembles a waffle in appearance, is often utilized in restaurants, shopping malls, and other commercial establishments. To create a grand foyer with minimum column support, a square-pod system may be used to store recessed lighting and adjust acoustics. A waffle slab takes a long time and a lot of money to build and install. In spite of the gorgeous structure and unforgettable interior, many commercial or residential projects are unable to afford the technique.

v. Post-Tension Slab: The pre-tension and post-tension slabs are identical in terms of their properties. After the concrete is poured, the wires are tightened and the tension is created. A similar result may be achieved by using this material. Inexperienced concrete crews may leave air gaps in the slab while using this method. It is more likely that a sudden slab fracture will occur if these spaces allow corrosion of the steel cables that run through them.

vi. Hollow Core Slab: It is easy to use these pre-poured slabs because they are delivered to your construction site. Your project will take less time and effort if you use this method. Installing hollow core slabs on supporting columns is as simple as lifting them with a crane. When compared to other slab alternatives, hollow core slabs have a very long span distance. Wiring and piping can be installed much more quickly and cheaply because to the holes in the walls that were cut out during the manufacturing process. If you want hollow core slabs, make sure you get them from a reliable construction company. These slabs can be damaged by casting mistakes and incorrect shipment, which rapidly becomes a costly and time-consuming scenario.

vii. Hardy Slab:The term "hard slab" refers to the method of constructing a slab out of concrete blocks. As soon as these blocks are in place, a formwork surrounding the structure is erected and reinforcement is inserted between each of them. Afterwards, concrete is poured around the blocks. In warmer areas, this method is most commonly employed. As a result, it not only saves money on concrete prices, but it also provides better sound and heat insulation than conventional slabs. This type of slab has a lower load capacity and is more expensive to repair, but it is a handy and cost-effective solution for mid- to long spans and moderate loads.

viii. Ribbed Slab: Slabs with ribs, like waffle slabs, are commonly mistaken for one another. There are large grids or bands of the beams in the underside of a ribbed slab, whereas a waffle slab has deeper areas of the underside of the beam. Ribbed slabs, such as waffle slabs, are flexible, light in section, affordable, and capable of being built for greater spans than other types of slab construction. A waffle or grid slab has all the same advantages and downsides.

ix. Composite Slab: When two or more materials are used to make an object, it is referred to as being a composite. Concrete and steel decking are used to construct the composite slab. Reinforcement cages can be put on top of the steel decking in trapezoidal, rectangular, or re-entrant shapes. The addition of the steel decking improves buckling stability by increasing torsional stability.

c. type of walls

i. Load Bearing Walls: A structural element is a wall that bears the weight of the structure. It is responsible for supporting the whole weight of a home, from the roof to the basement. Structural components such as beams, slabs, and walls on the upper levels are supported by it. Load-bearing wall refers to the wall directly above the beam. It's made to support weight up in the air. To put it another way, it's more likely to be a load-bearing wall if there are no walls or posts directly above it. Also, load-bearing walls are able to support the weight of their own contents. One of these walls is usually stacked on top of the other on every story. An interior or exterior load-bearing wall can be constructed using these materials. Floor joists or ridges can often be seen running perpendicular to this type of wall. These loads can be supported by concrete. The beams are anchored directly into the ground using concrete footings. It's not uncommon for interior wall loads to follow the ridge. Non-load-bearing walls are those that do not contribute to the structure's stability and instead support themselves. It is not capable of supporting the weight of the roof above. It's a framed building. In most cases, they are used to partition the building into individual rooms. They're designed to be more lightweight. Non-load-bearing walls can be removed without putting the safety of the structure in jeopardy. The joists and rafters of non-load-bearing walls can be used to identify them. Neither they nor the property are accountable for the property's gravitational support. It saves money. "Curtain wall" is the name given to this piece of wall.

ii. Non Load Bearing Wall: The internal leaf and the exterior leaf are the names given to the two walls. A hollow wall is another name for this type of wall. The foundation is lighter as a result of their reduced weight.. They serve the same purpose as a sound barrier. In terms of thermal insulation, cavity walls are superior to solid walls due to the presence of air, which inhibits heat transfer. In comparison to a solid wall, their heat transfer rate is half that. Compared to other solid walls, it is more cost-effective. It's built to withstand fire. Noise may be kept out using a cavity wall.

i. shear Walls: The wall is framed. Resistance to lateral pressures is the primary purpose of this product. This lateral force is transmitted to the ground's foundation via the building's outer walls, floors, and roofs. Shear walls play a significant role in huge structures, such as skyscrapers. For the most part, it's made of concrete or masonry. It's built to withstand earthquakes because to its sturdy structure. Stiffness is provided in that direction. Shear barriers are simple to build and implement. It's symmetrical placement is intended to minimize the negative impacts of a twist. Stability is not an issue with the shear wall.

ii. Partition Walls: It employed to demarcate areas within structures. It can be made of stone or brick if you want it to be sturdy. It's a framed structure. Walls, ceilings, and floors all have fasteners for attaching the divider wall. In terms of its own weight, it is more than capable of handling it. It can withstand a lot of punishment. It's sturdy enough to hold up wall-mounted fixtures. The fire-retardant partition wall serves as a sound barrier.

iii. Panel Walls: It is a non-bearing wall between columns or pillars that are supported. Glue and nails are both used to secure the panel in place once it has been painted. Rustic, boards, and frame are some of the paneling options. Hardwoods or low-cost pine can be used to make paneling for a room. Before installing panel walls, a room should be painted in a neutral color.

iv. Veneered Walls: We are supporting the material with a veneered wall. Brick or stone can be used to construct it. Brick is the most popular material for a veneered wall. There is barely any thickness to the wall. When construction rules started requiring insulation in the inside walls, it became the new standard. It's a breeze to carry about. In veneered walls, building is completed in a shorter period of time.

v. Faced Walls: Under load, stone face and backing work together as a single unit to create this type of wall. Streamlining the appearance of the room. It is simple to erect a fronted wall.

d. type of Soil for Building Foundation: varied geotechnical qualities of soils have distinct behavior on the structures. Higher the specific gravity, higher will be the load bearing ability of soils. Density index is utilized for the compaction of coarse grained soils. Consistency limitations show the qualities of fine grained soils; therefore fine grained soils can be employed for the construction of low permeability layer for disposal of solid wastes and core in earth dams. Particle size reveals the gradation of soils, which assists in building of roads, dams, embankments, design of filters, etc. Compaction enhances the bearing capacity of soils. Consolidation qualities of soils indicate the settling of constructions. Permeability conveys the concept about the stability of foundations, seepage via embankments, etc. Shear strength is the most essential geotechnical feature of soils, aid in stability of civil engineering constructions on or below the earth. The interactions among distinct geotechnical features of soils might aid the researchers while constructing the foundations for different sorts of civil engineering constructions. Different types of soil will effect building’s foundation in different ways. Determining the type of soil a structure will be built on influences the project’s construction and future repairs. Here are five of the most popular forms of dirt foundation used in building. We study which type is typically the greatest sort of soil to build on.

i. Clay: Clay is a poor choice for building foundations because of its tendency to move about when it dries or wets. Uneven flooring might be the consequence of fractures or fissures in the structure. Stability is increased by deeper foundations in clay soil. A drilled pier foundation or a slab-on-grade foundation would be the ideal choice for a house built on clay soil. Structural stability can be increased by drilling deeper into the clay using pier foundations and counteracting the clay soil's shrinking and expanding propensity by using slab foundations.

ii. sand and gravel.: The big particles of sand and gravel help this soil to swiftly drain water (which is good for buildings). Reducing the amount of water retained in the building reduces the danger of structural and non-structural fractures forming. Additional stability can be gained via using compacted sand and gravel as a foundation. It's possible for sand to be rinsed away after some time. If you're dealing with sandy soil, you'll want to use the helical pier (also known as helical anchors, screw piles, or screw anchors).

iii. Rock/Bedrock: Sandstone, limestone, and other rock types all have great carrying capacities, making them suitable choices (making this type of foundation ideal for larger buildings). In geology, bedrock is the rock layer underneath the soil. Bedrock, in contrast to clay, is more solid and impervious to water damage. When a result, your building is less prone to cracking as it moves or settles. When constructing a rock foundation, it is critical to check that the ground is level before beginning work.

iv. Loam :Because of its optimum proportions of silt, sand, and clay, loam is the greatest soil type for building. It's the finest of both worlds, achieving the perfect harmony for a foundation's support. As a rule, loam does not expand or contract significantly when exposed to water, and it does so rather nicely. Undecomposed material may and should be screened prior to construction as the only possible negative of constructing on loam.

v. Peat: Peat is made up of rotting plants and/or organic debris and is commonly found in bogs and other wetland environments. In spite of its high water retention capacity, it is regarded as one of the worst soil types for use as a foundation because of how easily it may shift and how little it can support weight. Peat soil can be used for construction, however the resulting structure is extremely vulnerable to fractures and other sorts of damage.

vi. Silt: As with peat, silt's propensity to hold water for an extended period makes it an unsuitable foundation material. Because silt shifts and expands due to this feature, the building does not have any support and is subjected to recurrent, long-term stress. It's possible that this will lead to structural problems. A better sort of soil should be used for building if at all possible.

3.3 ANN DESIGN

Machine learning is the process of teaching a computer to infer a certain function from the training data. A set of examples for supervised learning is utilized to train this data. The classifier is a function produced by the supervised learning algorithm after it examines the training data in a methodical manner. As long as the output value is right, an inferred function should be able to correctly anticipate any valid input object. As a result, working with the learning algorithm necessitates a variety of training scenarios. The data created for training purposes; the computer data specification that will be used in this research are:

a. Core i7 @ 2.8 GHz processor from Intel

b. The amount of RAM (RAM) loaded on the device is 8GB

c. A 64-bit operating system is required.

d. MATLAB R2018a was used.

Mathematica (MATLAB) is a multi-model computing environment and fourth generation programming language. Programming languages such as FORTRAN and C++ may be used to develop MATLAB user interfaces, which can then be used to interact with other MATLAB programs and do computations. MATLAB can also translate functions and data from other programs, such as C, C++, and Python. The MATLAB program is utilized in a wide range of industries, including mechanical engineering, electrical engineering, and image processing. Data types in MATLAB are organized in a hierarchical manner. In MATLAB, all variables are arrays, with the identical field names for each element. In addition, MATLAB supports dynamic domains and offers a number of options for authenticating and sharing users.

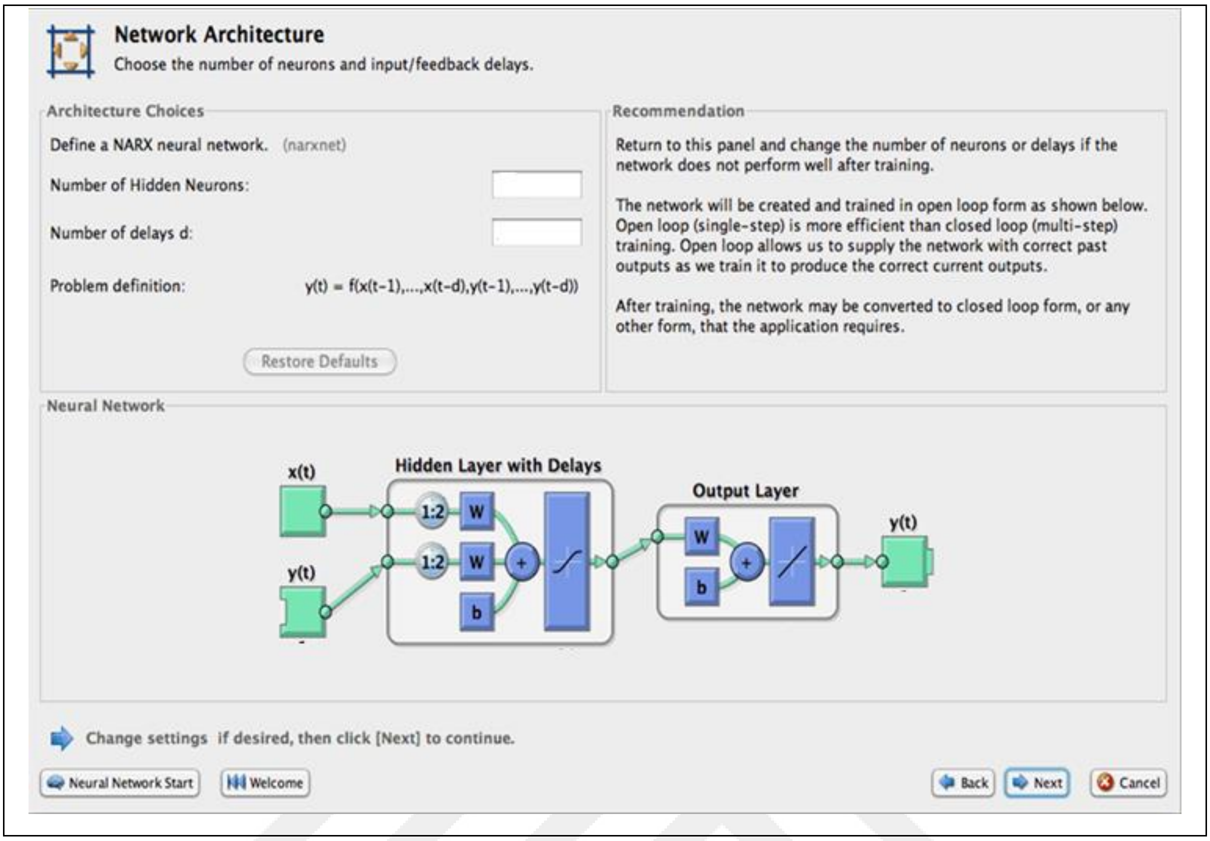


Figure 3.2: Network Architecture.

It is possible to distribute your own MATLAB methods and applications by combining MATLAB code with others. Any relationship between outputs and inputs may be learned using two-layered neural networks with a single hidden layer that produce enough neurons to learn. It is generally necessary to add additional levels to nods of the problem if the problem grows more complicated. Sizes for input and output variables are determined by the data they represent. During the training process, this will occur. A computerized system divides each sample into groups for training and verification before the actual test can begin. Data continues to improve as a result of network-based training. Network resolution can be improved by using the test set. The algorithm's design is depicted in Figure 3.3.

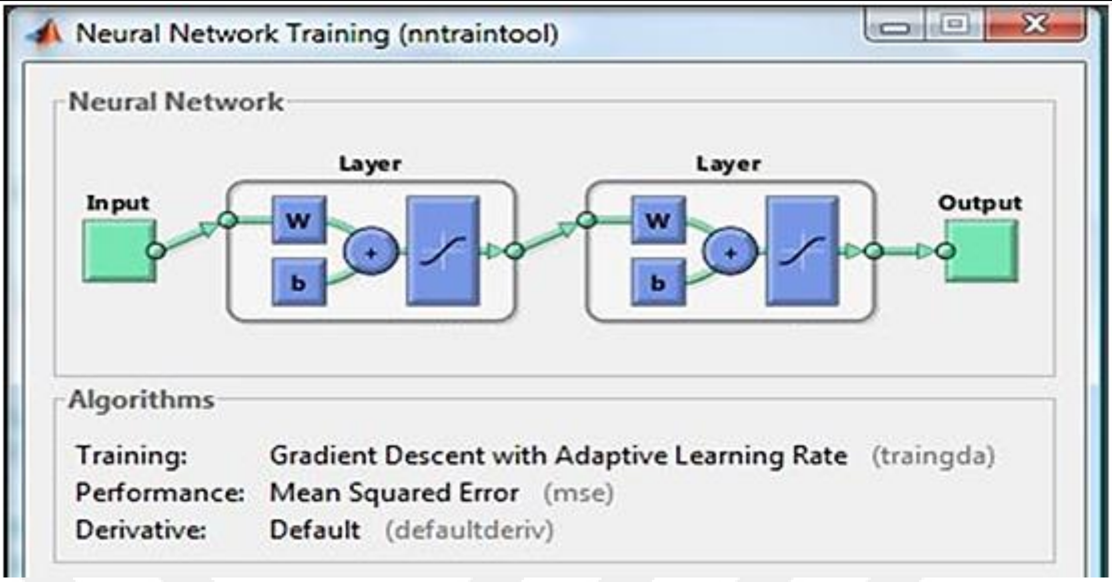


Figure 3.3: Network Training.

The test samples can be affected by the assessment of the mean square error of a trained neural network. Using this method, we can see how effectively the network works with the data. Thus, the output of the network is expected to fall between the range 0 to 1.

3.4 PROBLEM SITUATION AND SOLUTION

Process monitoring in industry helps people and groups become better problem solvers and decision makers. The link between sample size, lot size, and the precision with which the feature of the raw data should be explored is a common topic in sampling statistics. Become more adept at solving difficulties and making key judgments during the monitoring process. Sample size and batch size are typically linked to the accuracy of predicting the properties of the data valum in statistical processes derived from samples. After implementing the product requirements and depending on the development approach employed, a model for issue solving has been created in which the product is tested at various points during the project through sampling. The primary focus of this investigation is the monitoring and diagnosis of sample data. An starting set of parameters determines how the manufacturing process will turn out, and that process output is a statistically controlled scenario. It is then compared to the findings derived using the indexes listed in the applicable specifications. Data from real-world industrial processes is the primary focus of this study. For the most part, manufacturing processes relied heavily on the first setup of machine settings and the initial output of the process as a whole. Following this, standard values, such as those cited in the applicable specification, were used to compare a particular sample's findings.

3.5 PERFORMANCE VALIDATION USING ACTUAL DATA

An important part of industrial process validation is verifying the data that is utilized and obtained. To monitor and accurately diagnose variables, this procedure uses information circumstances associated with algebraic computational approaches to measure and repair the intended faults. The techniques for applying industrial data are referred to as the data accuracy verification process. According to the Mean Square Error (MSE), each operation is rated based on how well it performs in training and testing. Using the hard-limit transfer function hardlim, a perceptron neuron is shown in the image below. Hard-limit transfer function gets an additional 1 input through bias in addition to the weighted sum of the weighted inputs from all external inputs (w1j). Using a hard limit, the following transfer function will only return one of two values: 0 or 1. As long as the net transfer function input equals or exceeds zero, a perceptron neuron outputs a 1. A perceptron can categorize input vectors using the hard-limit transfer function, which splits the input space into two zones. If the net input n is less than 0 or greater than 0, the outputs will be 0; otherwise, they will be 1. Here is a figure showing the input space of a two-input hard limit neuron with weights w1,1 = 1, w1,2 = 1, and b = 1. The classification space is divided into two halves by the decision boundary line L atWp + b = 0. The bias b shifts this line in a direction parallel to the weight matrix W. The hard-limit neuron outputs a 1 when input vectors are above and to the left of the line L. Neuron output 0 when input vectors are below and to the right of line L. Weight and bias variables can be used to orient and alter the dividing line to categorize the input space as desired. The origin of hard-limit neurons will always be the starting point of a classification line, regardless of bias. When two sets of input vectors are not on opposing sides of an origin, a bias can be added to the neuron's output. Bias allows the decision boundary to be moved away from the origin, as shown in the graph above. The nnd4db sample program is one possibility. A decision boundary may be moved, fresh inputs can be chosen to classify, and the learning rule used repeatedly to construct a network that properly classifies the input vectors can be seen.

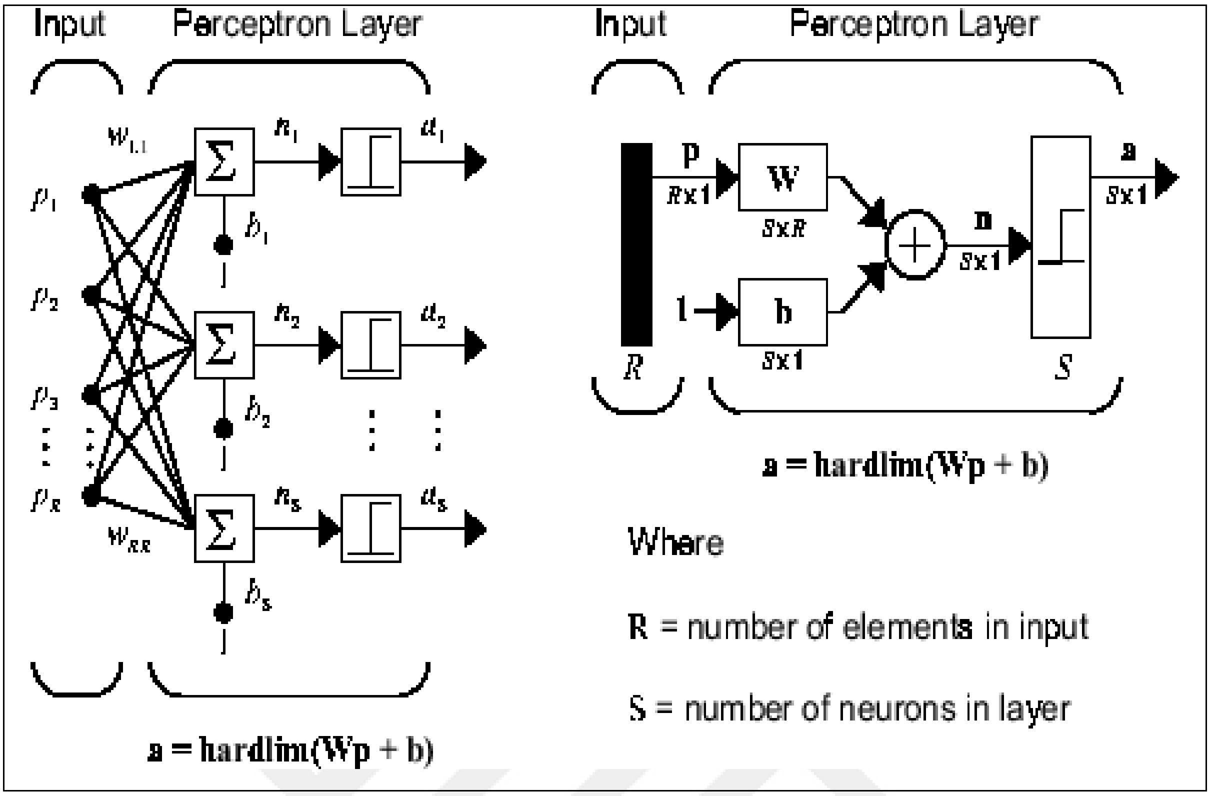


Figure 3.4: The ANN Internal Processes.

Cautions describe the kinds of issues that can be solved using perceptrons. Samples are automatically used to generate training, validation, and test sets. The training set is used to instruct the network. As long as the network's performance on the validation set increases, training will continue. The test set provides an impartial evaluation of network accuracy. You may see exactly what algorithms are being used to train your network by using our NN Training Tool. There is also a display showing the current stage of training, with the criterion that led to training being paused indicated with green. A variety of useful charts may be viewed by clicking on the bottom buttons both during and after training. For further information on each algorithm, click on the buttons or links next to its name in the plot. It is now possible to assess how much the trained neural network's mean squared error differs from the testing samples. Let's see how well the network performs when applied to real-world data. Using a computer algorithm, the samples are automatically separated into three categories: training, validation, and final testing. The network is taught how to use the training set. While the validation set is being improved, training will continue indefinitely. Accuracy of the network may be evaluated using the test set. There are two things you can see in the NN Training Tool: the network being trained and the algorithms that are being employed. During training, the current training state is shown, and the factors that led to training being halted are underlined. During and after training, the buttons at the bottom open important graphs. Documentation on the algorithms and plot buttons may be accessed via links adjacent to their names. Testing samples may now be used to quantify the mean squared error of the trained neural network. When applied to real-world data, this will give us a sense of how well the network performs We may use the vec2ind function to retrieve the class indices as the location of the highest element in each output vector, which is in the range 0 to 1.

3.6 BIM MODEL

Other project-related data was obtained and compiled by meeting with the designers who delivered the BIM models. In essence, the test was based on a case study concept. First, a literature search was conducted focusing on project duration and cost control, as well as the use of CAD and BIM technologies. Conceptual foundations and current techniques to project duration and cost management were examined and recommendations were provided A list of current issues in the AEC manufacturing industry has been compiled. An actual project's BIM model was used in tandem with the services of an out-of-town designer and construction manager. An examination of the method and model was conducted. The 3D models were used to show how this new project delivery method may assist improve a project's time and cost control by analyzing the data. BIM problems have been outlined, and solutions to these challenges have also been provided. Finally, the benefits of utilizing BIM for the project were emphasized. The future of BIM was discussed, and recommendations were made. Additionally, the fundamental issues that limit the adoption of BIM were explored.

3.6.1 As-Built 3D BIM Model

It is a method of constructing BIM objects that represent structure components, with both geometric and non-geometric features as well as relationships taken into consideration. Information value and the level of detail offered by BIM can be influenced by the prior information collection, processing, and recognition processes. A model's accuracy or level of detail, for example, might be used to compare different approaches and their modeling capabilities (Tang. et al., 2010). However, there has yet to be developed any standard BIM assessment method for comparing model attributes. This type of interactive BIM modeling takes time and might be prone to mistakes (Eastman et al., 2011; Arayici., 2011; Remond et al., 2012). Rivet was used to mimic the case study, as illustrated in Figure 3.4

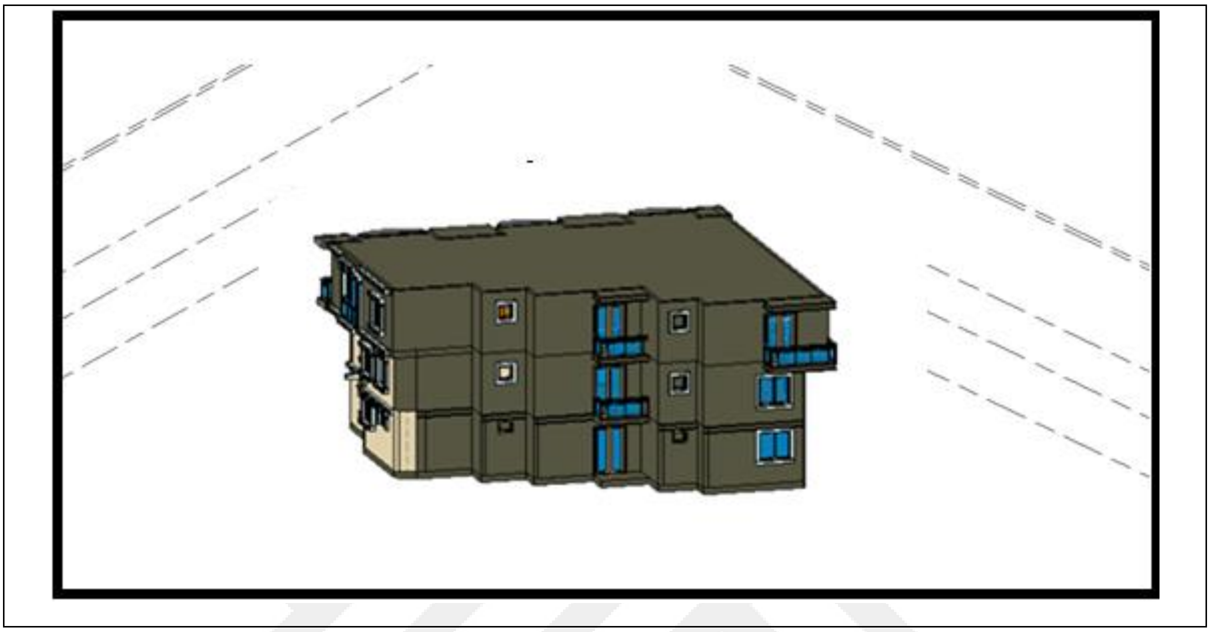


Figure 3.5: BIM- Rivet Drawing Geometry Result.

4. RESULTS AND DISCUSSION

Construction project cost estimation is critical because it serves as a basis to estimate the probable cost of resource components in a construction project tender. The construction sector is unusual in that it entails a high amount of risk due to the requirement that almost all projects be bid before work can begin. More than just a list of costs, a cost estimate contains the assumptions on which each line item is based. The estimate report's basis contains these computations and cost accuracy forecasts, as well as cost exclusions and inclusions. Participants in construction projects use the estimate report to assess project expenses and determine where actual costs diverge from planned costs. The estimate report. All of Iraq's regions have their own unique performance characteristics that may be identified in this thesis. When all of these things happen at the same time, as they often do in construction, the results can be costly. In order to create a house, you must spend money on the foundation, the structure, the floors, and the outside decoration. The overall number of factors discovered in the previous study was reduced after defining variables that were basically duplicates and combining components with similar meanings. The ANN algorithm was then attached to a set of rules designed to improve cost estimating accuracy. Using Revit software, a cost value is produced for the case study building quantity's building quantities based on practical factors following system validation.

4.1 THE USED FACTORS

Assumptions about the importance of project management by independent research factors are presented in this part, along with the rationale for each factor. Analysis of the physical, chemical and engineering features of soils is crucial in civil engineering and is influenced by the pressures put on them by loadings on their surface and subsurface. As part of a wider geotechnical investigation, researchers are now looking at how the site's groundwater interacts with soil in order to better understand how various constructions could affect the soil's behavior. Study of geometric qualities, stress on soil as consolidation, resistance and compressibility are all part of geotechnical evaluation. The physical and technical qualities of soil and water are influenced by their chemical composition. In addition to examining the samples to determine appropriate drilling methods, all geotechnical studies may be acquired via field work at the engineering structure. The soil was categorized into five kinds as previously stated in this study. Figure 4.1 depicts the unique qualities and costs associated with several types of soil.

Table 4.1: Type of Soil.

		Type of soil
1	F1	Clay
2	F2	Rock/Bedrock
3	F3	Loam
4	F4	Silt
5	F5	Peat

The building's kind of walls makes up the second set of factors to be taken into account. For protection and shelter, walls are a structural feature that divides the area (room) into two separate spaces (rooms). Outer walls and inner walls are the two most common types of walls. The outer walls of the home serve as a protective barrier, while the inside walls help to divide the space into the necessary number of rooms. Costs for various wall types are shown in table 4.2.

Table 4.2: Type of wall Materials.

		Type of wall materials
1	F6	Brick
2	F7	Stone
3	F8	Reinforced Concrete
4	F9	Hollow concrete block
5	F10	thrmiston

Structural element constructed of concrete, a slab is used to produce flat horizontal surfaces such as a roofing floor or roof. Beams, columns, walls, or the floor support a slab, which is normally 100 to 500 mm thick. Engineer Supply's measurement gadgets and construction tools are perfect for accurately determining the amount of concrete a slab would require. Table 4.3 shows the price per square foot for each slab type.

Table 4.3: Type of Slab.

		Type of slab
1	F11	Hardy Slab
2	F12	Hollow Core Slab
3	F13	Waffle Slab
4	F14	Two-Way Flat Slab
5	F15	One-Way Flat Slab

It is the substance that covers the exterior of a home or other structure. The structure of the building is protected from the elements by the building's exterior covering. A building's desired performance, level of upkeep, and cost are only a few of the considerations that go into the exterior plaster. There are a variety of exterior finishes to choose from. Sand-faced, for example, or roughcast or smooth cast, for example. Construction of the structures' exterior walls is completed using appropriate materials. Main exterior finish expenses are shown in table 4.4.

Table 4.4: Type of External Works.

		Type of external works
1	F16	Plaster
2	F17	Brick
3	F18	Brick veneer
4	F19	Stone
5	F20	Stone veneer

The lowest part of a building, the foundation is responsible for transferring the weight of the structure to the ground underneath it. The foundation's primary function is to disperse the weight of the structure over a vast area of earth. A list of foundations used in building is shown below. The following are the primary functions of foundations:

a. An area of land that is large enough to distribute the weight of the construction without exceeding its safe bearing capacity is ideal.

b. To ensure that the foundation does not settle unequally due to the uneven distribution of the weight on the subsoil.

c. Building on top of it, the superstructure needs a flat and sturdy surface.

d. In order to improve the structure's resistance against sliding, overturning, or other external pressures, such as wind and rain.

Verification of structural integrity by preventing lateral movement of the supporting material. Table 4.5 lists the prices for the two most common foundation types.

Table 4.5: Type of Foundation.

		Type of foundation
1	F21	Strip foundation
2	F22	Raft foundation

4.2 DELPHI RESULTS

In most circumstances, researchers adopt the Delphi approach because they lack or are unsure about the information they have and are unable to apply other processes that provide more proof. The goal is to obtain professional viewpoints from a variety of people and then use those perspectives to find common ground. Research questions can be answered using the Delphi technique, which is an established approach for gathering information from experts in the field. It gives individuals a chance to pause and think on their own perspectives in light of the anonymised ones of their fellow participants. The Delphi approach relies on experts who are aware of the expenses of construction to forecast future scenarios, anticipate the likelihood of occurrence, or reach agreement on a specific topic. As a result, the poll might include responses from subject matter experts. This thesis's percentage grading method was used to figure out how much money should be spent on building construction. A systematic methodology is needed to identify all of the aspects that are related to the construction project's activities. Table 4.6 shows the outcomes of the most notable performances.

Table 4.6: Type of Soil.

		Type of soil	un	Cost of ($)
1	F1	Clay	m3	17
2	F2	Rock/Bedrock	m3	19
3	F3	Loam	m3	9
4	F4	Silt	m3	16
5	F5	Peat	m3	16

Table 4.7: Type of Wall Materials.

		Type of wall materials		Cost ($)
1	F6	Brick	m2	50
2	F7	Stone	m2	60
3	F8	Reinforced Concrete	m2	300
4	F9	Hollow concrete block	m2	30
5	F10	thrmiston	m2	30

Table 4.8: Type of Slab.

		Type of slab		Cost ($)
1	F11	Hardy Slab	m2	250
2	F12	Hollow Core Slab	m2	250
3	F13	Waffle Slab	m2	300
4	F14	Two-Way Flat Slab	m2	400
5	F15	One-Way Flat Slab	m2	400

Table 4.9: Type of External Works.

		Type of external works		Cost ($)
1	F16	Plaster	m2	15
2	F17	Brick	m2	65
3	F18	Brick veneer	m2	30
4	F19	Stone	m2	60
5	F20	Stone veneer	m2	30

Table 4.10: Type of Foundation.

		Type of foundation	unit	Cost
1	F21	Strip foundation	ML	350
2	F22	Raft foundation	m2	400

4.3 RULES OF DECISION MODEL

The foundations for the civil engineering constructions can be situated either below or on the earth's surface. A foundation soil that is up to the task is necessary for their stability. It is necessary to conduct an analysis of the soil's qualities in order to determine whether or not it can serve as a foundation or contribute to the production of building materials. According to the findings of a variety of researchers, it is essential to conduct an evaluation of the geotechnical properties of the subsoil at the location of the project in order to generate pertinent input data that can be used in the design and construction of foundations for the proposed structures. The correct design and construction of civil engineering constructions prevents unfavorable effects on the surrounding environment, structural failure, and difficulties that arise after construction has been completed. When it comes to the design of structures and the planning of construction methods, having information about the surface and sub-surface properties of the land is absolutely necessary. It is preferable to invest some money in sub-surface investigation rather than overdesign the building and make it more expensive when there are structures that impose extremely large loads and the zone of effect is quite deep. This is because overdesigning the building might cause it to fail. It is very necessary to conduct in-depth study in the case of complicated projects that include the construction of massive structures, such as bridges, dams, and multi-story buildings. The objective of in-depth investigations is to establish the engineering qualities of the various strata's soils in order to plan for future construction. As it is, the process for determining the zone involves segmenting the map of Iraq into six different types, each of which is determined by the soil and earth parameters. Figures 4.1 and 4.2 display the MATLAB code that may be used to do that.

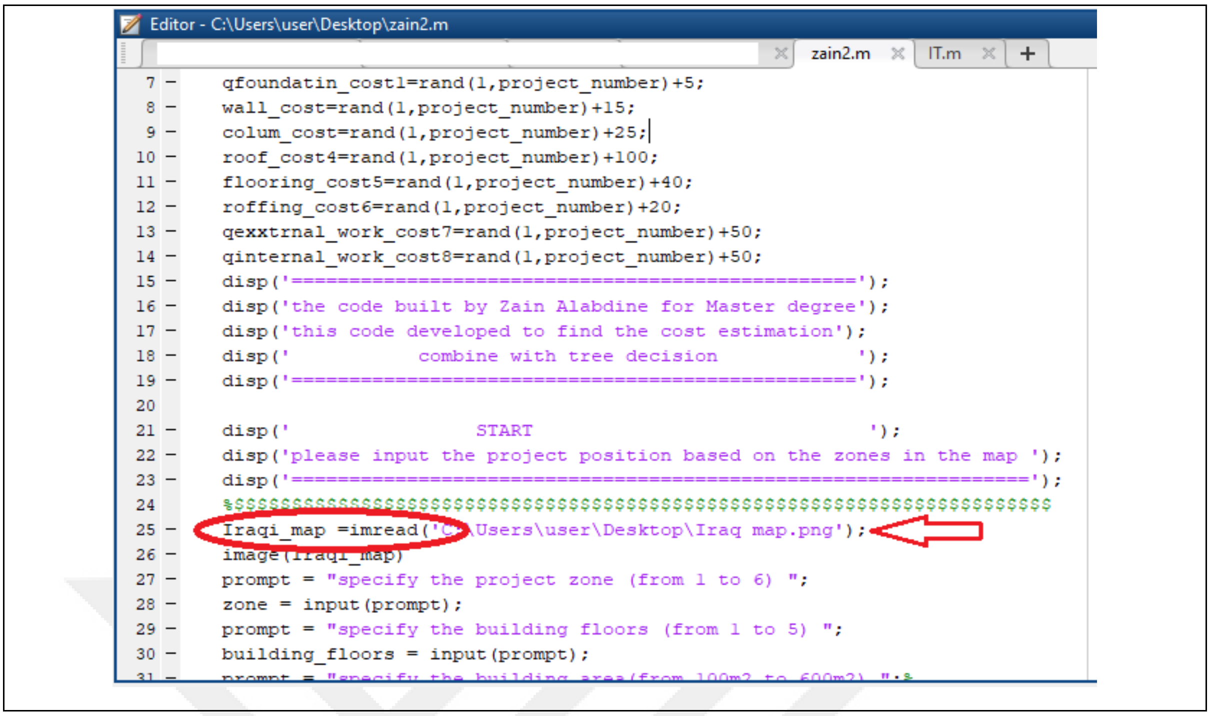


Figure 4.1: MATLAB Code for Zone Process.

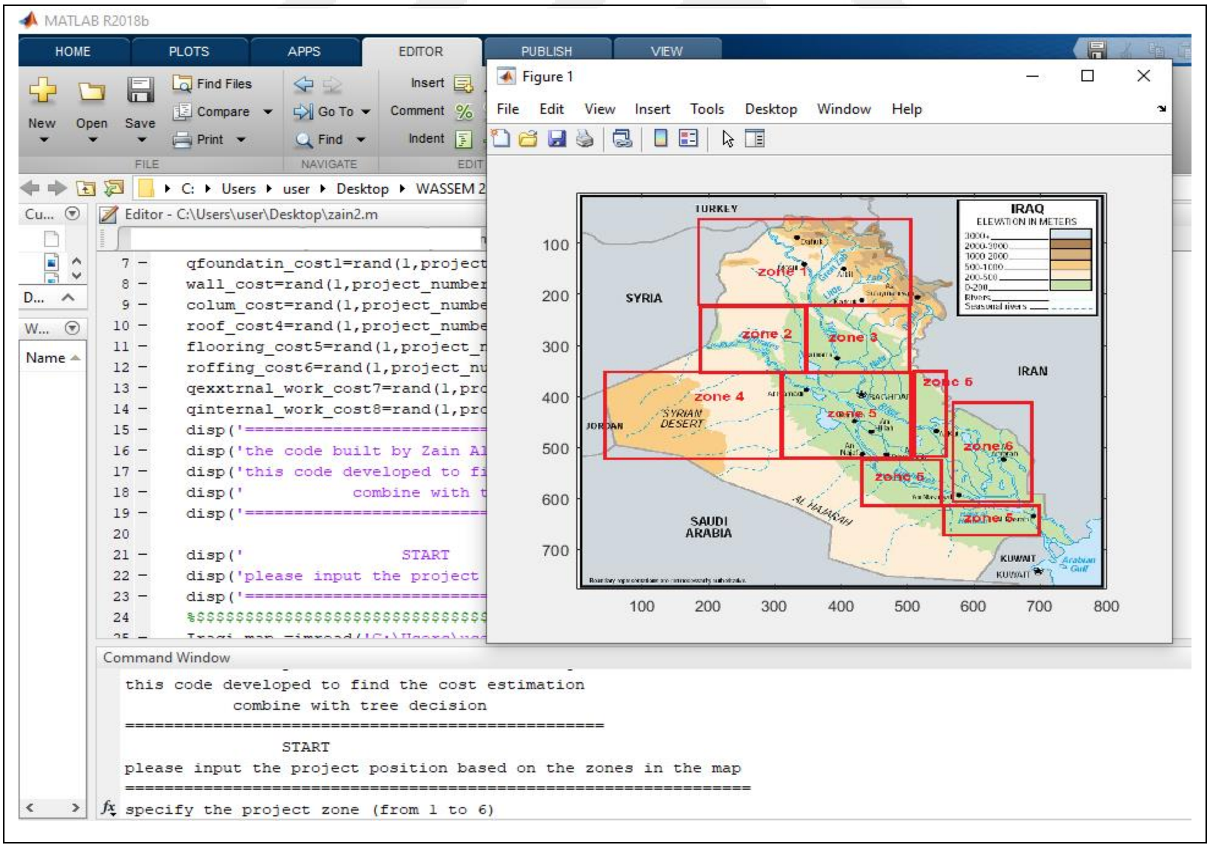
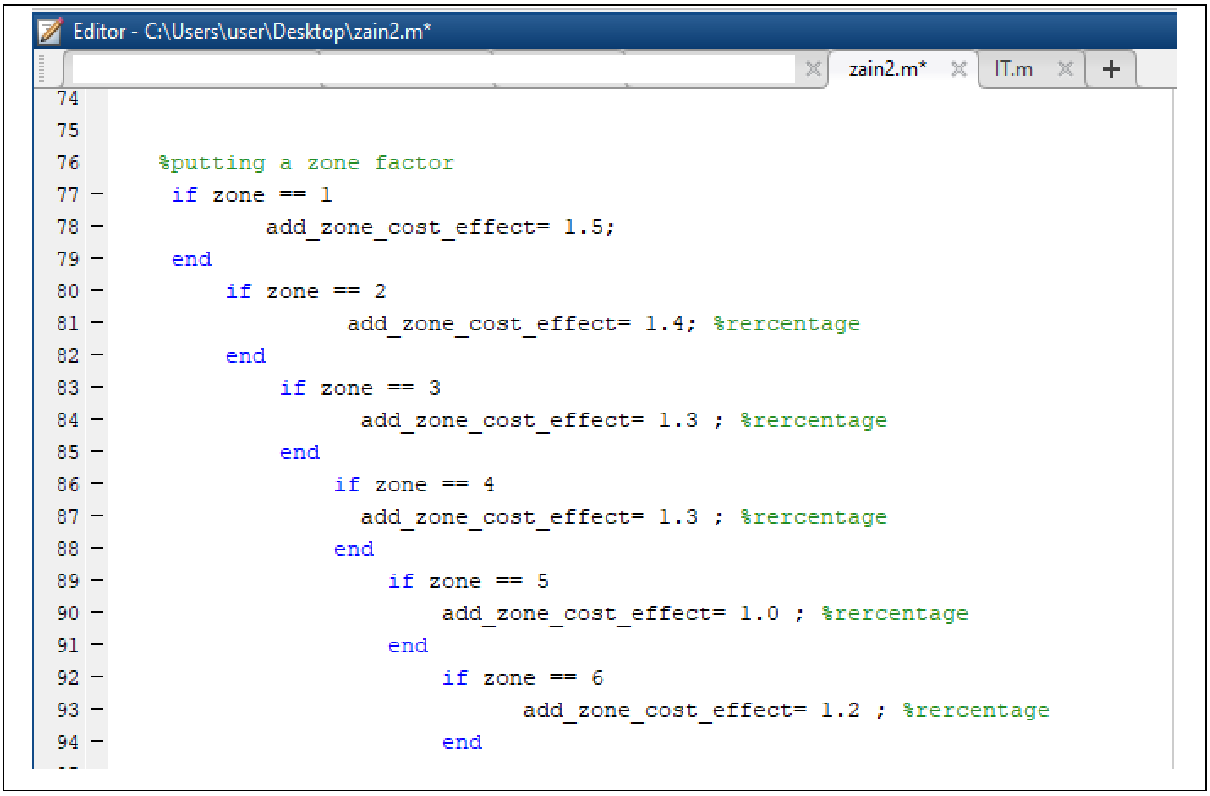


Figure 4.2: MATLAB Zone Results.

A decision model's rules are a diagram that depicts the various possible outcomes of a set of interconnected options. It enables the actions of various components to be weighed against one another based on the costs, probabilities, and rewards associated with those activities. They are useful for mapping out the ANN cost model method, which mathematically predicts the optimal option given a set of options. A decision rule will normally begin with a single node for each component of the construction, which then branches into the many outcomes that might occur. Each of these consequences brings about situations that incur extra costs. This gives it the appearance of a tree. There are three components that make up the tree of rules; the zone effect is the first of these components.




```
%putting a zone factor
 if zone == 1
        add_zone_cost_effect= 1.5;
 end
     if zone == 2
              add_zone_cost_effect= 1.4; %rercentage
     end
         if zone == 3
               add_zone_cost_effect= 1.3 ; %rercentage
         end
             if zone == 4
               add_zone_cost_effect= 1.3 ; %rercentage
             end
                 if zone == 5
                     add_zone_cost_effect= 1.0 ; %rercentage
                 end
                     if zone == 6
                           add_zone_cost_effect= 1.2 ; %rercentage
                     end
```

Figure 4.3: The Tree Rules of Zone Effect.

The same procedure applied on the building floors and the required building quality as shown in figure 4.4 and figure 4.5.

```
                        end

    %putting a building_floors  factor
     if building_floors == 1
        add_floor_cost_effect= 1.0;
     end
         if building_floors == 2
            add_floor_cost_effect= 1.015; %rercentage
         end
            if building_floors == 3
                add_floor_cost_effect= 1.035;  %rercentage
            end
                 if building_floors == 4
                    add_floor_cost_effect= 1.047 ; %rercentage
                 end
                     if building_floors == 5
                        add_floor_cost_effect= 1.072 ; %rercentage
                    end
```

Figure 4.4: The Floor Rules Condition.

```
    %putting a building_qualiy
    if building_qualiy == 1
           add_qualiy_cost_effect= 2.32;
           add_foundation_cost_effect= 1.3; %rercentage
           add_externa_finish_cost_effect= 2.8; %rercentage
    end
            if building_qualiy == 2
                add_qualiy_cost_effect= 1.5; %rercentage
                add_foundation_cost_effect= 1.1; %rercentage
                add_externa_finish_cost_effect= 1.5; %rercentage
            end
                     if building_qualiy == 3
                         add_qualiy_cost_effect= 1.0;  %rercentage
                         add_externa_finish_cost_effect= 1.3; %rercentage
                    end
```

Figure 4.5: The Quality Rules Condition.

4.4 ANN MODEL

It is possible to construct a neural network that is capable of performing effectively with unknown input by training many networks on a training set and comparing their defects on a validation set. This is the aim of a neural network. Numerous network parameters, such as the number of hidden layers and hidden nodes, transfer functions, and learning rules, were trained several times in order to arrive at the perfect weights for the model. This was done in order to get at the optimal weights.

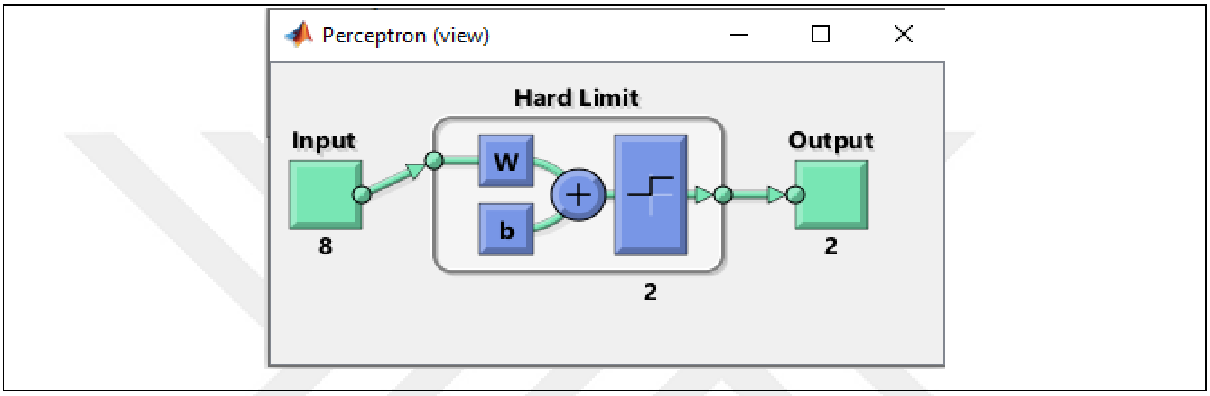


Figure 4.6: Perceptron View.

It is important to keep in mind that the earlier models in the field of cost estimate using neural networks utilized three distinct types of networks in order to achieve the most accurate findings.

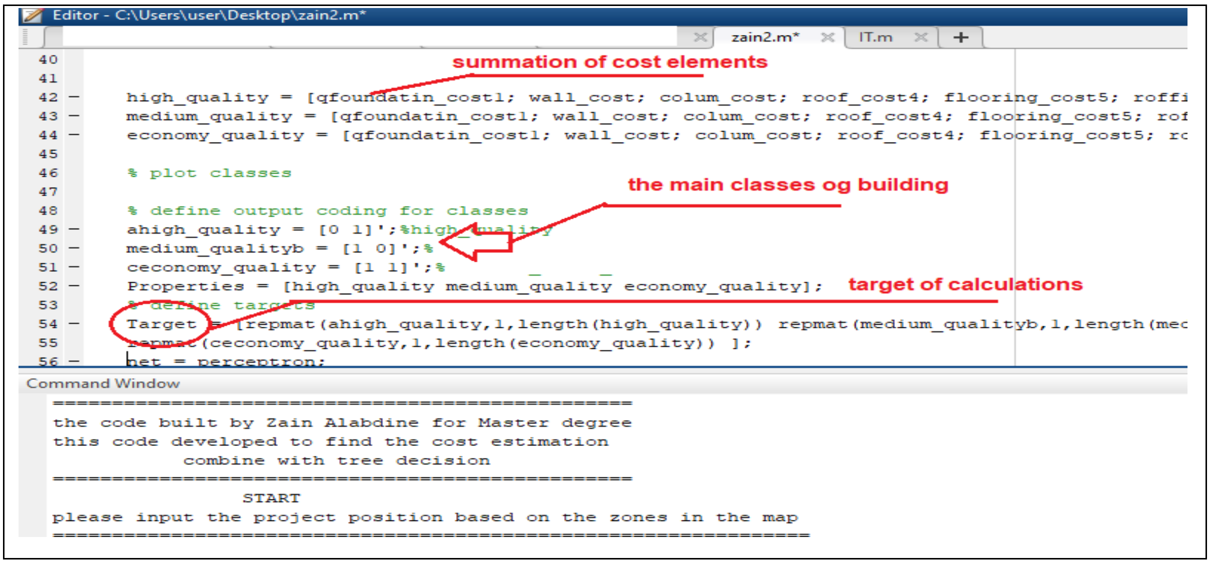


Figure 4.7: Classification of Building Type In MATLAB Code.

During the training phase, cross-validation was used to prevent the network from overtraining by computing the error in a cross validation set while the network was being trained using the training set. This was done to avoid the network from becoming over trained.

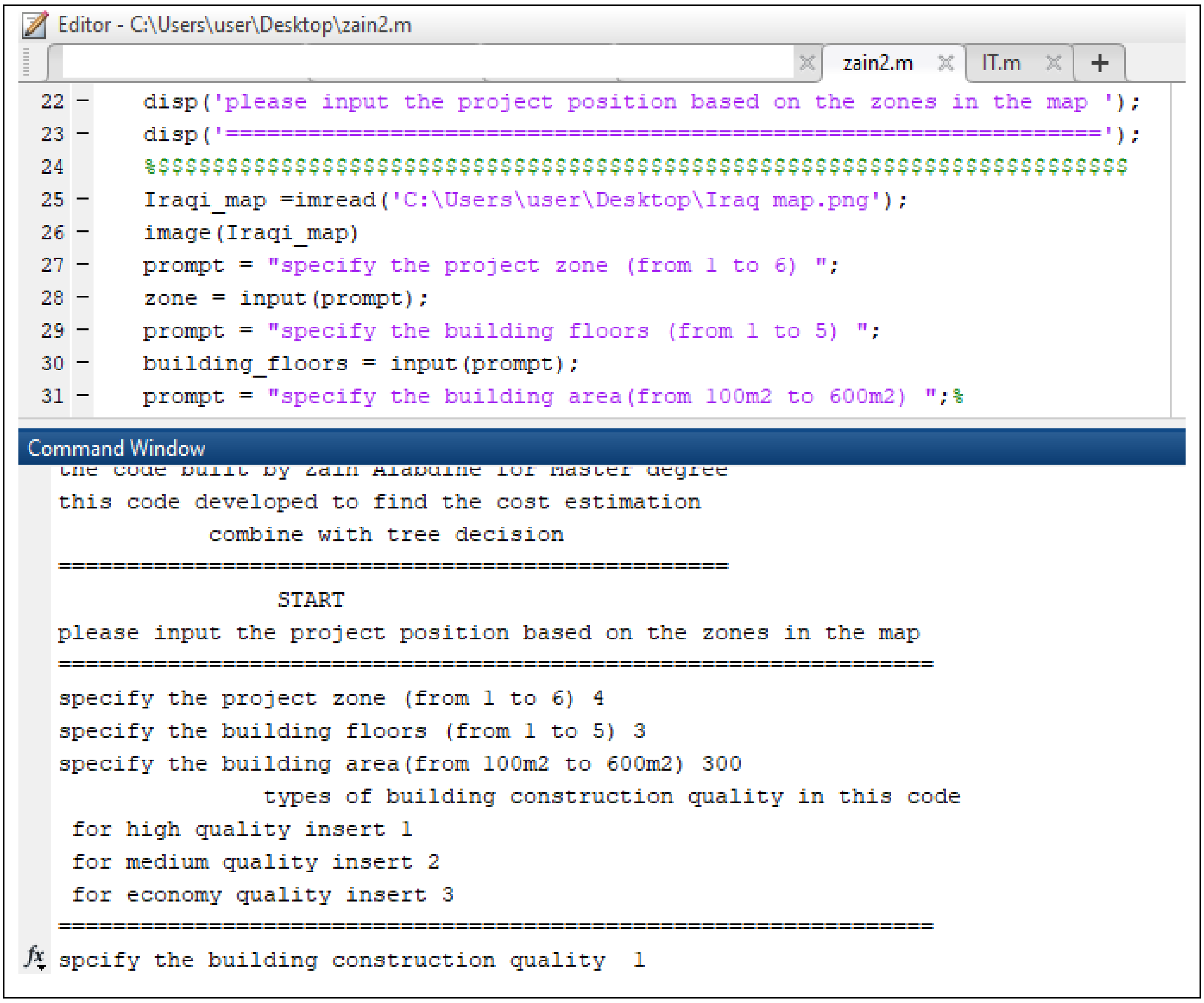


Figure 4.8: Influence Factors in MATLAB Code.

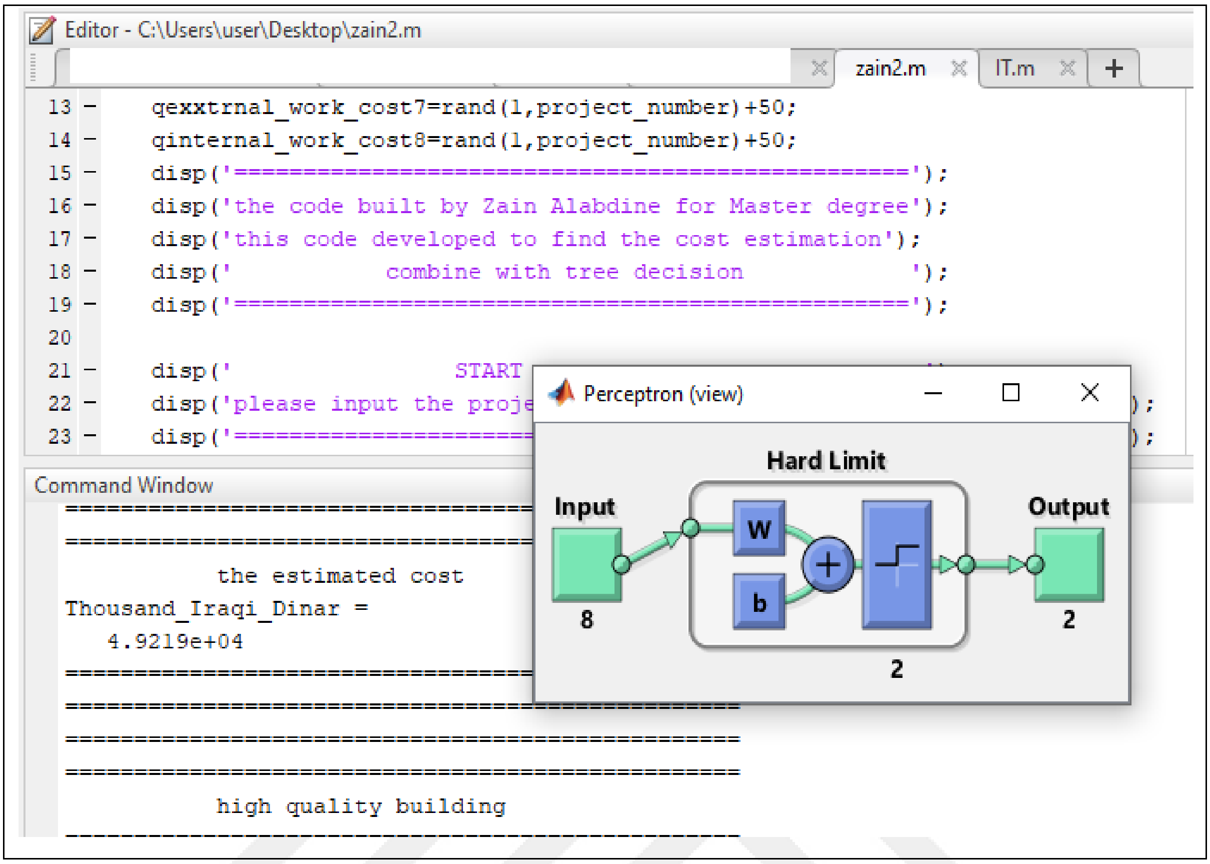


Figure 4.9: MATLAB Code Results.

4.5 VALIDATION THE COST MODEL

In order to collect all of the information that is required for each project, the system that is now being used was designed, built, and put into operation. We looked at the majority of Iraq's schools of higher education that provide programs leading to degrees in building engineering. The number of floors ends up being a significant component as well; in the real case study, it ranges from one to two levels, but in the BIM model, it stretches all the way up to five levels. In spite of the fact that the number of projects in the later categories is lower than the number of projects in the first category, it still provides a clear signal in the training of the model that increasing the number of floors in the building results in an increase in the total cost of the project. By using an appropriate structural system and making the appropriate selection of structural materials, it is feasible for a building to reduce the amount of excess material that it uses and the amount of waste that it generates. This will also improve the structure's adaptability, making it more suitable for a variety of uses. The Building Code specifies the minimum required levels of durability for a variety of architectural features, and this will be a key driver for the selection of the materials to be utilized in the construction of the structure. In addition to this, the requirements for durability and maintenance should be taken into consideration simultaneously across the expected duration of the building's service, which is the building's lifetime in service. There are certain materials that, at first appearance, do not appear to offer very high levels of durability; but, if the necessary amount of care is performed, these materials may truly run very well for many decades as long as the maintenance is performed. The performance of the building ought to be improved by the choice of construction materials, which should have such an effect. As can be seen in figures 4.10 and 4.11, the structure in question was a building with three stories that was situated in Baghdad, Iraq. This research focused on the building that was there.

Figure 4.10: The Used Case Study.

Figure 4.11: Side View of The Used Case Study.

As was said earlier, the purpose of the phase that is dedicated to testing the cost model is to assess whether or not the model that was produced was successful, as well as whether or not the appropriate degree of generality was attained. The ideal model, which gave more accurate cost forecasts without compromising precision, was built through a process of trial and error guided by the advice that came before it. This method enabled the model to deliver more accurate cost projections without compromising accuracy. This approach provided forecasts of costs that were more accurate. The numerical output of the system is displayed in tabular form in tables 4.11, which are respective tabular representations.

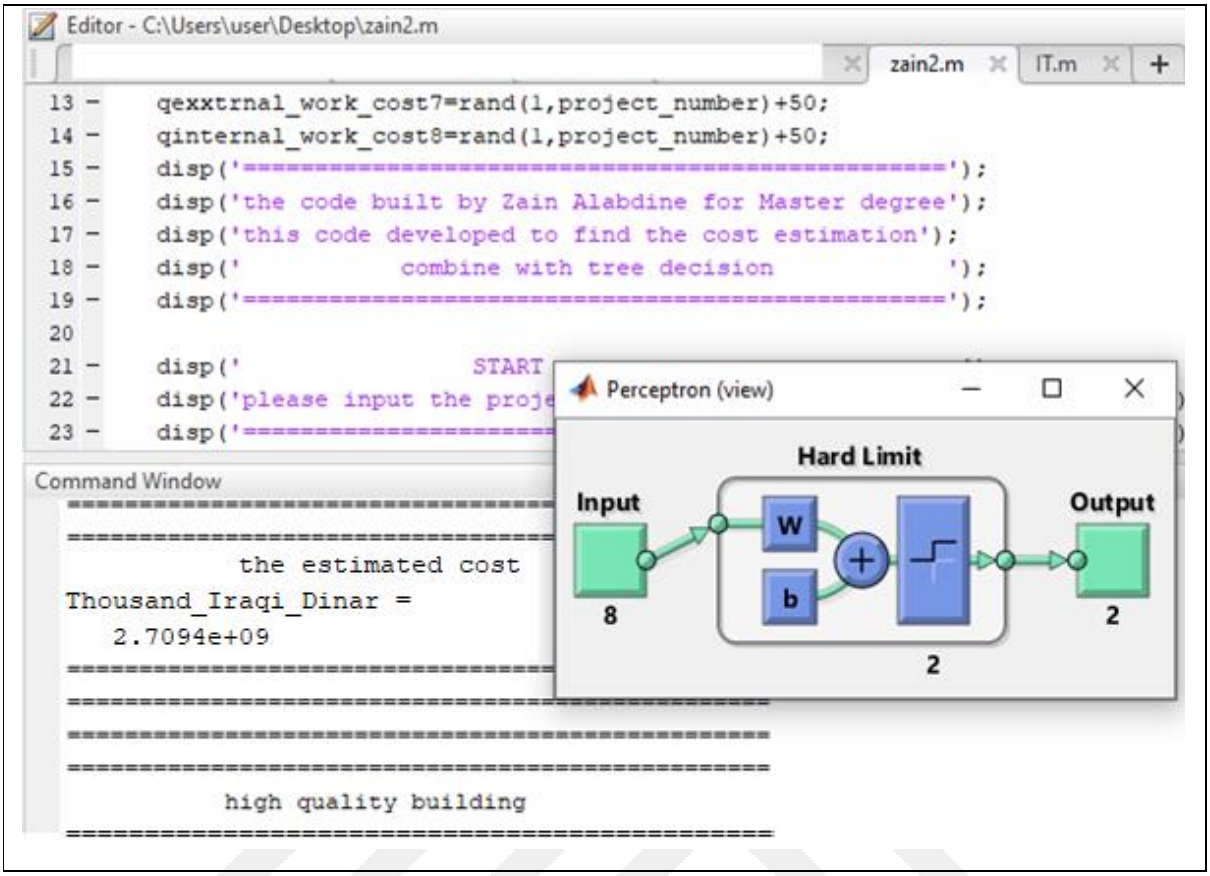


Figure 4.12: The ANN System Result.

Table 4.11: Comparison Between the Actual Cost and Estimated Cost in the Present ANN System

Actual cost (ID)	ANN cost result	Error %
2,935,000,000	2,709,400,000	7.69%

4.6 BIM CASE STUDY RESULTS

In addition to other documents, the Building Information Model (BIM) includes Revit drawings (Building Information Model). A piece of design software that goes by the name Revit is simply referred to as Revit. The majority of engineers and architects that have experience working with other software that is analogous to Revit should already be familiar with the foundations of the program. Revit is a building information modeling (BIM) application, which means that it helps bridge the gap between 2D and 3D design. All that is necessary for this is to have a single model, which can then be used as a reference to make several drawings. The fact that Revit is primarily aimed toward the architectural business, which is linked to the BOQ, is the distinction that stands out as the most important and crucial. Using the software application known as Revit, one is able to generate project drawings as well as virtual models. This is a very helpful tool. The Building Information Model (BIM) served as the inspiration for the design software Autodesk Revit. Simply put, Revit is compatible with BIM. There's no getting around that fact. While competing systems are designed to meet the needs of general model designers, Revit was created specifically with the requirements of engineers and architects in mind from the beginning. There is no question that BIM is incorporated into the curriculum in some form or another. This high degree of automation is seen in many different parts of the Revit program. It can retain knowledge and adjust its behavior to suit its environment. As a direct result of this, it is feasible to save time that would have otherwise been spent examining the designs to verify that everything is in correct running order. This results in a time savings that makes it possible to save money. Our investigation is centered on a residential building that has a height of two floors and a floor area that is around 350 square meters in size. This model is a representation of the structure that we are now examining. In line with the instructions provided in the third chapter, the model is constructed, and the results are shown in Figures 4.13 and 4.14 respectively.

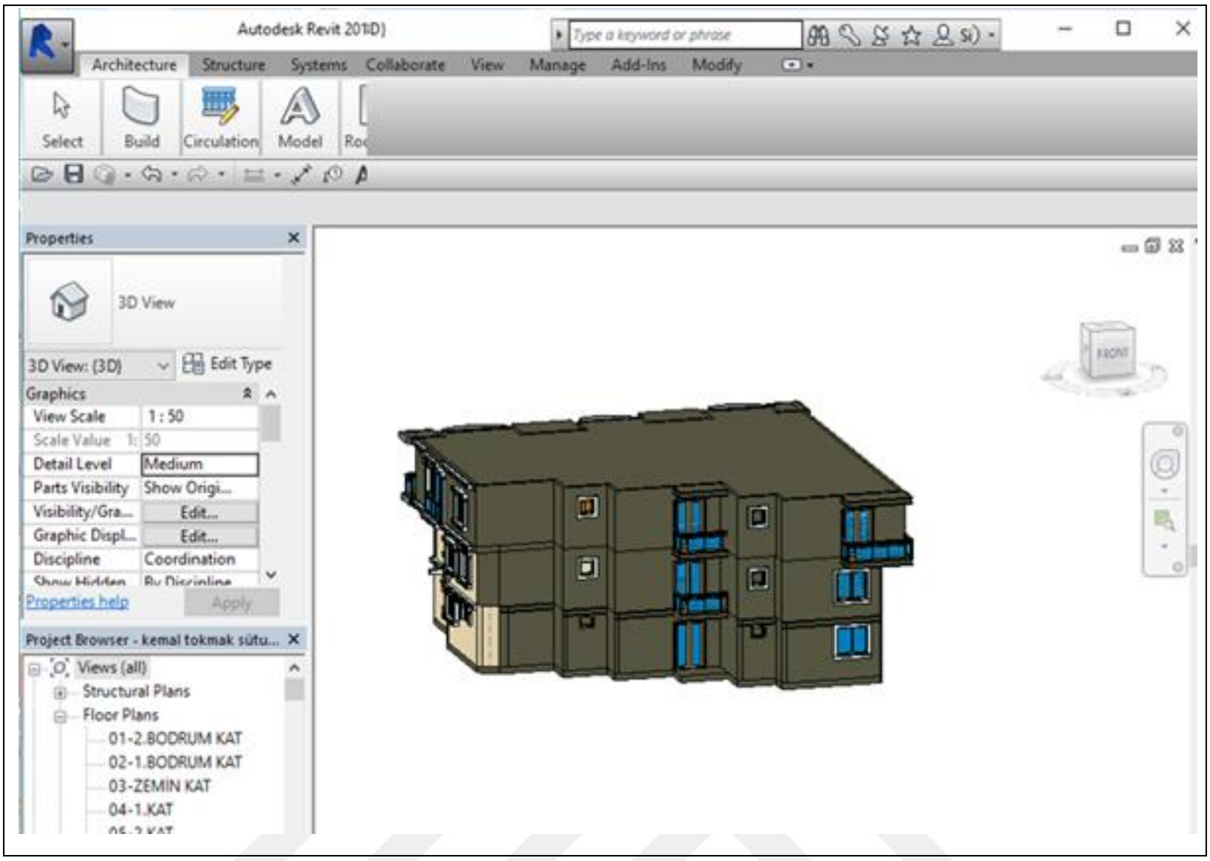


Figure 4.13: : Side View of The Case Study.

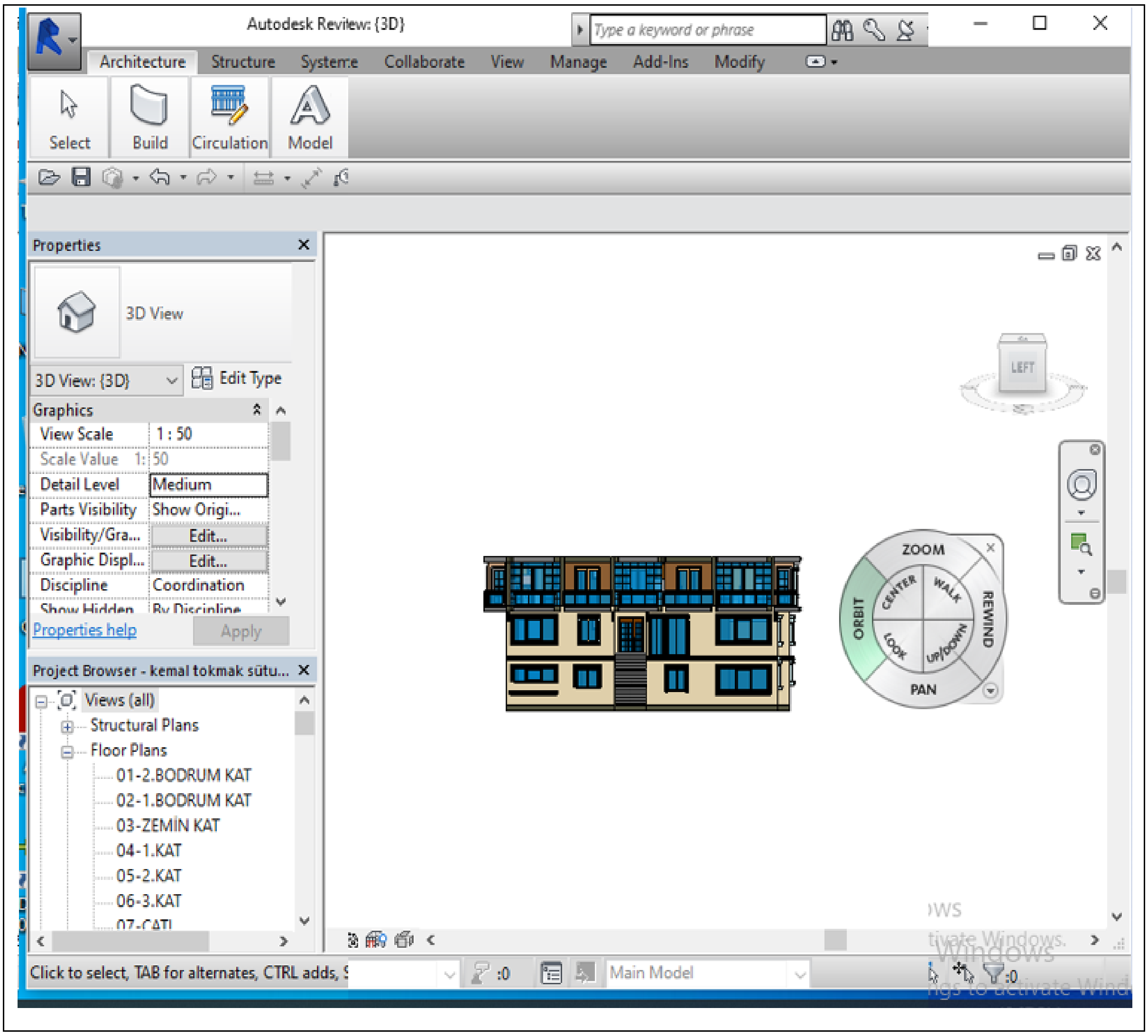


Figure 4.14: Front View of the Case Study.

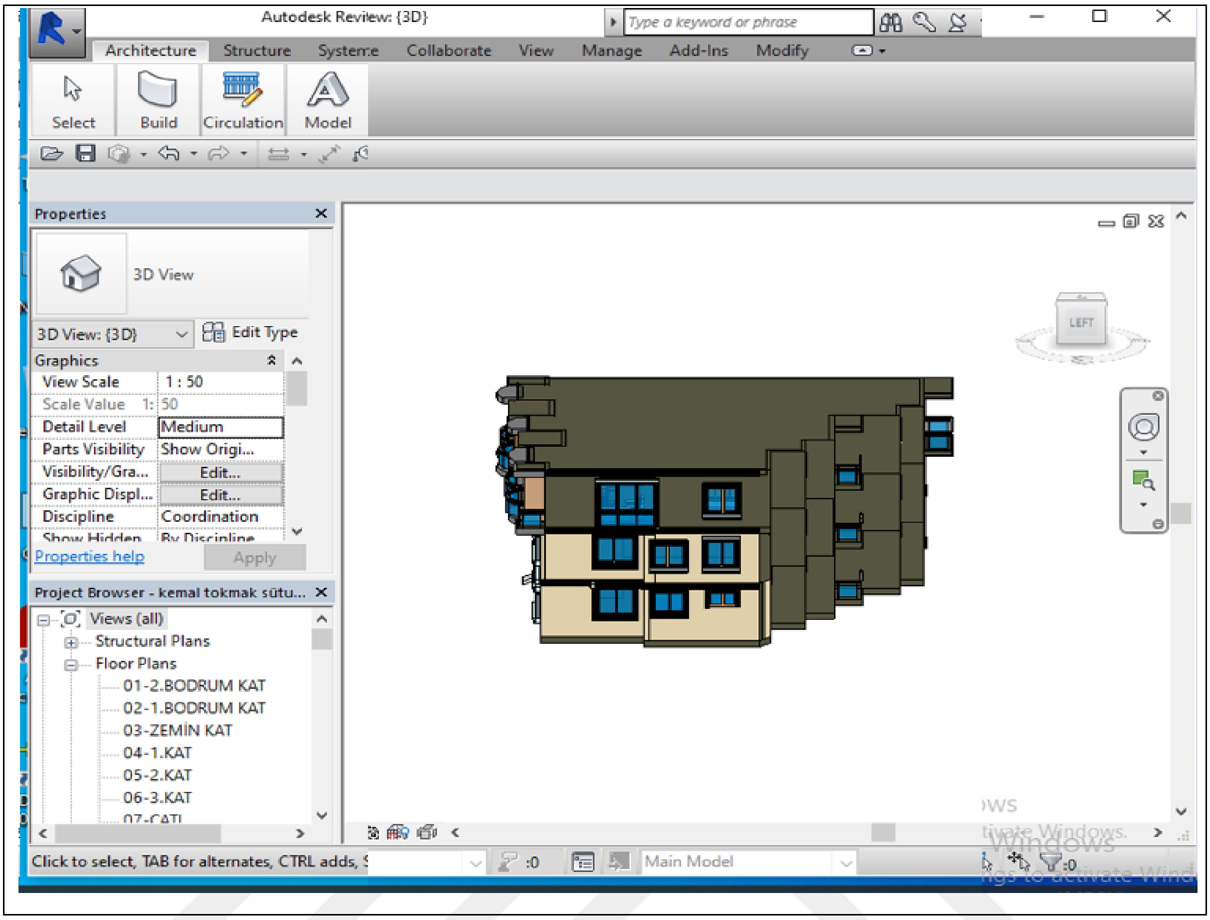


Figure 4.15: Side View Case Study Revit.

The BIM includes both Revit-created drawings and non-revised documentation (Building Information Model). Revit is the name of a piece of design software. Many architects and engineers who have used similar software to Revit should already have a basic understanding of its features. Bridge between 2D and 3D designs is created by Revit, the building information modeling (BIM) program It's enough to have a single model from which several drawings can be made. By far, the most notable difference between Revit and BOQ is that Revit is primarily targeted at architects. Revit, a software tool, is used to create project drawings and virtual models. Autodesk Revit was born out of the BIM revolution. It's as simple as that: Revit and BIM are compatible. It was built specifically for engineers and architects, unlike other systems, which cater to the needs of general model designers. In some capacity, BIM is incorporated into the curriculum. This degree of automation may be seen throughout Revit. It retains knowledge and may change with the times. Thus, the time that would have been required to thoroughly check the designs to verify that everything works as intended may be saved in this way. Specifically, we are interested in a two-story, 350 square meter residential construction. There is a model of the structure we're studying here. Figures 4.16 to 4.18 show the results of the model's construction results.

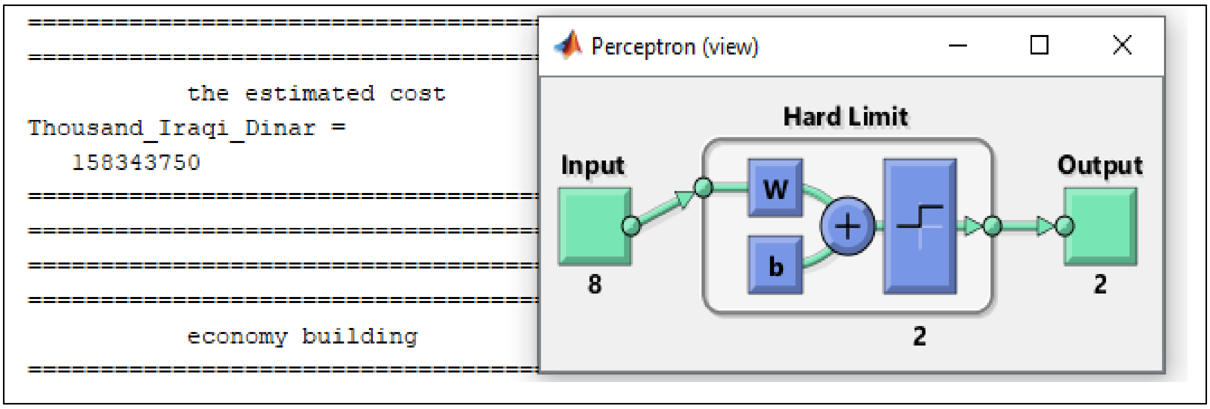


Figure 4.16: The Economy Option Result.

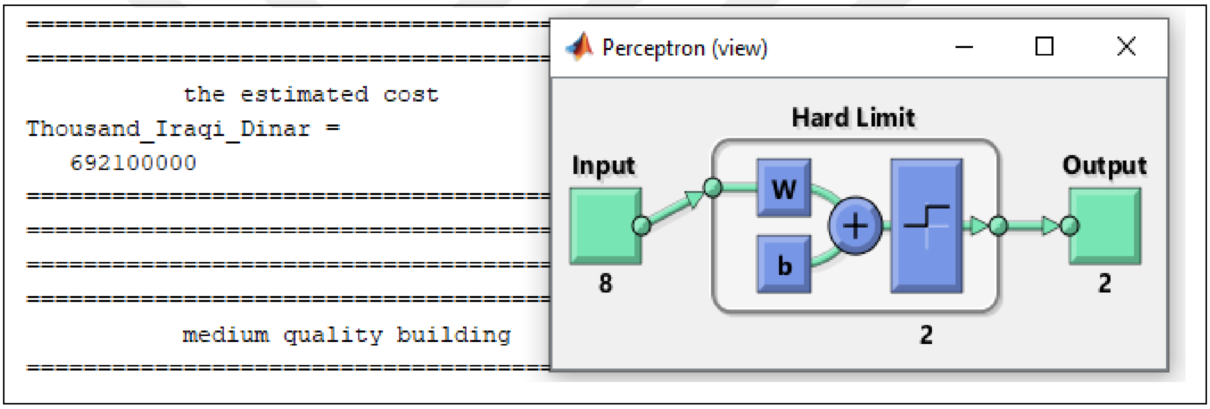


Figure 4.17: The Medium Quality Option Result.

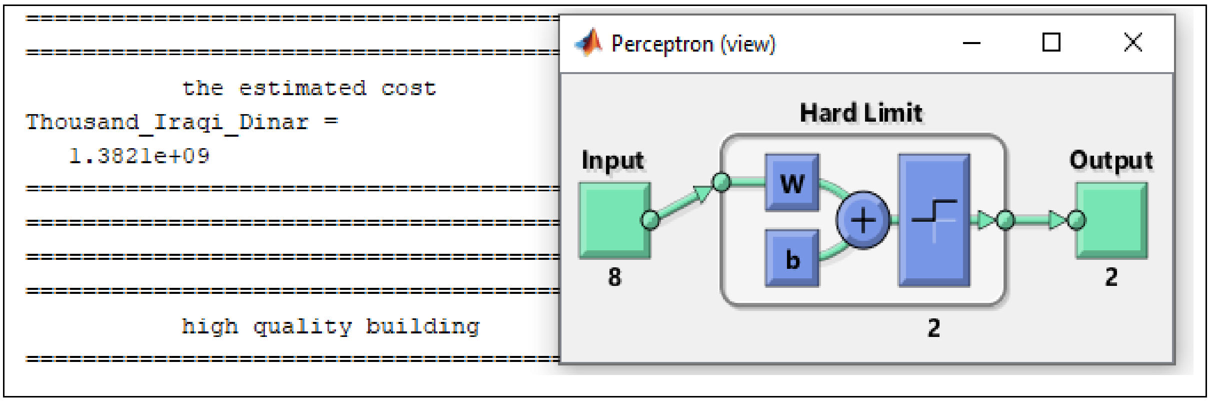


Figure 4.18: The High Quality Option Result.

The results propose a superior cost estimation model.

5. CONCLUSION AND RECOMMENDATION

This study aims to develop a cost prediction model for building construction projects using artificial neural networks (ANN). It focuses on Iraq's construction industry in particular in this research project. After the list of acts, further descriptions of the measures employed to achieve this goal are offered. The researcher used the variation in Iraqi zones owing to variances in the soil component building necessary area, the number of story in the structure, and the quality of the building construction to establish the cost of vital building construction materials. The MATLAB program will determine the type of foundation, the type of walls utilized, and the type of slab based on the findings of expert pricing and presenting their information. Finally, the ANN algorithm will be used to estimate the cost. As a result of the system's validation in a real-world case study, the MBI case study was used to assess how variances in construction costs may arise due to the interplay of numerous elements.

The created model was able to accurately predict project costs with high performance accuracy. For construction projects, the most cost-effective elements were picked after doing research and talking to industry experts.

a. an ANN method would be built using this application. The MATLAB software was used to estimate costs.

b. Validation of the ANN system's effective factors demonstrates that the cost model is relevant. The ANN method also has the advantage of providing precise estimates of project costs.

c. the generated rules for ANN cost models had to be related, and several elements had to be taken into account depending on the building area zones features.

d. Finally, the experts judged the system to be quite favorable and the performance forecast to be exceptionally accurate when it was evaluated.

5.1 RECOMMENDATIONS

The suggested future works are to develop hybrid ANN decision-makers in the project implementation which should give many options to the project builder.

REFERENCES

[1] D. Agoras, “Building Information Modeling (BIM) Adoption Barriers: An Architectural Perspective,” 2018, [Online]. Available: http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-230639.

[2] Y. Arayici, J. Counsell, L. Mahdjoubi, G. Nagy, S. Hawas, and K. Dewidar, *Heritage building information modelling*. 2017.

[3] I. Czmoch and A. Pękala, “Traditional design versus BIM based design,” *Procedia Eng.*, vol. 91, no. TFoCE, pp. 210–215, 2014, doi: 10.1016/j.proeng.2014.12.048.

[4] M. M. Tahir, N. A. Haron, A. H. Alias, A. T. Al-Jumaa, I. B. Muhammad, and A. N. Harun, “Applications of building information model (BIM) in Malaysian construction industry,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 291, no. 1, 2018, doi: 10.1088/1757-899X/291/1/012009.

[5] Chairperson and W. G. on R. for B. I. C. I. Council, “CIC Building Information Modelling Standards (Phase One),” no. September, 2015, [Online]. Available: www.hkcic.org.

[6] “Green Building a Sustainable Approach to Save Energy,” vol. 1, no. 3, pp. 14–20, 2017.

[7] A. Leśniak and K. Zima, “Cost calculation of construction projects including sustainability factors using the Case Based Reasoning (CBR) method,” *Sustain.*, vol. 10, no. 5, 2018, doi: 10.3390/su10051608.

[8] A. H. Ibrahim and L. M. Elshwadfy, “Assessment of Construction Project Cost Estimating Accuracy in Egypt,” *Open Civ. Eng. J.*, vol. 15, no. 1, pp. 290–298, 2021, doi: 10.2174/1874149502115010290.

[9] P. Alcineide, S. Gean, M. F. M. Luiz, C. A. Felipe, and de G. S. Débora, “Cost forecasting of public construction projects using multilayer perceptron artificial neural networks: A case study,” *Ing. e Investig.*, vol. 41, no. 3, pp. 1–11, 2021, doi: 10.15446/ing.investig.v41n3.87737.

[10] O. J. Oyebode, “Budget and Budgetary Control: A Pragmatic Approach to the Nigerian Infrastructure Dilemma,” *World J. Res. Rev.*, vol. 7, no. 3, pp. 1–8, 2018.

[11] Marsha Enrica, H. H. Purba, and A. Purba, “Risks Leading to Cost Overrun in Construction Projects : A Systematic Literature Review,” vol. 3, no. May, pp. 43–60, 2021.

[12] F. M. Githaiga, “An Investigation into Factors that Affect the Accuracy of Cost Estimates for Buildings: Case Study of Private Residential and Office Projects in the City of Nairobi,” no. August, pp. 1–76, 2006.

[13] S. Taheri and E. Shakeri, “Comparison of Project Cost Estimation with Conventional Method and Dynamic and Smart Model Based on BIM Based on List Price,” *مهندسی عمران*, vol. 0, no. 0, pp. 0–0, 2020, doi: 10.24200/j30.2019.51237.2382.

[14] M. W. Fazil, C. K. Lee, and P. F. Muhamad Tamyez, “Cost Estimation Performance in the Construction Projects: a Systematic Review and Future Directions,” *Int. J. Ind. Manag.*, vol. 11, no. January, pp. 217–234, 2021, doi: 10.15282/ijim.11.1.2021.6131.

[15] B. Challenge, “Labor , Equipment , Materials Solutions (LEMs) Case Study.”

[16] A. Wahane, “A Study on Detail Quantity & Cost Estimation of a Room,” no. February 2020, 2021, doi: 10.5281/zenodo.4817143.

[17] G. Ballard and A. Pennanen, “Conceptual estimating and target costing,” *21st Annu. Conf. Int. Gr. Lean Constr. 2013, IGLC 2013*, no. January 2013, pp. 1–10, 2013.

[18] Y. Wen, “Research on Cost Control of Construction Project Based on the Theory of Lean Construction and BIM: Case Study,” *Open Constr. Build. Technol. J.*, vol. 8, pp. 382–388, 2014.

[19] H. Bashir and V. Thomson, “Estimating effort and time for design projects,” *Des Stud*, vol. 22, no. June, pp. 141–155, 2001.

[20] P. Ballesteros-Pérez, M. C. González-Cruz, M. Fernández-Diego, and E. Pellicer, “Estimating future bidding performance of competitor bidders in capped tenders,” *J. Civ. Eng. Manag.*, vol. 20, no. 5, pp. 702–713, 2014, doi:

10.3846/13923730.2014.914096.

[21] R. M. SUM, “Formative evaluation of analytic hierarchy process as a risk prioritisation tool for risk management,” *J. Qual. Meas. Anal.*, vol. 12, no. 1–2, pp. 115–123, 2016.

[22] F. Fanny, “A Simple Method for Cost Estimating and Controlling,” *Int. J. New Media Technol.*, vol. 5, no. 2, pp. 58–61, 2019, doi: 10.31937/ijnmt.v5i2.833.

[23] F. J. Shiue, H. Y. Lee, M. C. Zheng, A. F. K. Khitam, and S. Assefa, “An estimation model of construction project segmentation for optimum project pricing,” *Eng. Constr. Archit. Manag.*, vol. 28, no. 9, pp. 2361–2380, 2021, doi: 10.1108/ECAM-08-2020-0596.

[24] M. Barakchi, O. Torp, and A. M. Belay, “Cost Estimation Methods for Transport Infrastructure: A Systematic Literature Review,” *Procedia Eng.*, vol. 196, no. June, pp. 270–277, 2017, doi: 10.1016/j.proeng.2017.07.199.

[25] ESSENCE on Health Research, “Research-costing practices,” no. February, 2012.

[26] A. T. H. Le, N. Domingo, E. Rasheed, and K. S. Park, “Building maintenance cost planning and estimating: A literature review,” *Proceeding 34th Annu. ARCOM Conf. ARCOM 2018*, no. September, pp. 697–706, 2018.

[27] B. Amade, E. Okon, and P. Akpan, “Project Cost Estimation: Issues and the Possible Solutions,” no. August, 2015.

[28] O. A. Oyedele, “Evaluation of Factors Affecting Construction Cost Estimation Methods in Nigeria,” *FIG Work. Week*, no. May, pp. 17–21, 2015.

[29] Elewe, Adel Muhsin, K. Bin Hasnan, and A. Bin Nawawi. "Hybridized firefly algorithm for multi-objective radio frequency identification (RFID) network planning." ARPN J Eng Appl Sci 12, no. 3 (2017): 834-840.

[30] Abdullah, H., N. H. Talib, A. M. Elewe, S. Tahir, and I. Campus. "An efficient algorithm for largscale RFID network planning." no. September (2019).

[31] Talib, Nihad Hasan, Khalid Bin Hasnan, Azli Bin Nawawi, Haslina Binti Abdullah,

and Adel Muhsin Elewe. "Monitoring large-scale rail transit systems based on an analytic hierarchy process/gradient-based cuckoo search algorithm (GBCS) scheme." Urban Rail Transit 6, no. 2 (2020): 132-144.

[32] bin Hasnan, Khalid, Adel Muhsin Elewe, Azli bin Nawawi, and Suhaidah Tahir. "Comparative evaluation of firefly algorithm and MC-GPSO for optimal RFID network planning." In 2017 8th international conference on information technology (ICIT), pp. 70-74. IEEE, 2017..

[33] O. M. Shehatto, "Cost estimation for building construction projects in Gaza Strip using Artificial Neural Network (ANN)," *CE-Unit cost*, no. June, p. 102, 2013.

[34] A. Erbe, "Cost estimate classification and accuracy for Major Industrial Plant Projects (MIPP) versus building construction in Germany," 2014.

[35] A. Challal and M. Tkiouat, "The Design of Cost Estimating Model of Construction Project: Application and Simulation," *Open J. Account.*, vol. 01, no. 01, pp. 15–26, 2012, doi: 10.4236/ojacct.2012.11003.

[36] H. Yaman and E. Taş, "A building cost estimation model based on functional elements," pp. 73–87, 2007.

[37] A. Awosina, R. Ndihokubwayo, and J. Fapohunda, "EFFECTS OF INACCURATE COST ESTIMATE ON CONSTRUCTION PROJECT STAKEHOLDERS," *J. Constr. Proj. Manag. Innov.*, vol. 8, no. 2, pp. 1886–1904, 2018.

[38] H. K. Doloi, "Understanding stakeholders' perspective of cost estimation in project management," *Int. J. Proj. Manag.*, vol. 29, no. 5, pp. 622–636, 2011, doi: 10.1016/j.ijproman.2010.06.001.

[39] T. J. Williams, "Relationships Between Cost Estimates, Scheduling and Project Success in the Construction Sector," *ProQuest Diss. Theses*, p. 174, 2020.

[40] M. F. Hussein, A. R. Shabib, and S. F. Abood, "Optimized Well Construction Cost Estimate in South of Iraqi Fields/ Case Study from Zubair Field," *J. Pet. Res. Stud.*, vol. 11, no. 1, pp. 168–185, 2021, doi: 10.52716/jprs.v11i1.438.

[41] Reihanifar, M., & Naimi, S. (2018). Evaluation of road construction projects by value engineering approach as a tool for sustainability. Int J Ecosyst Ecol Sci (IJEES), 8, 339-346.

[42] S. Naimi, H. Hrizi. "Risk Analysis of Slaving Floor in Construction Sites." International Journal of Electronics, Mechanical and Mechatronics Engineering, Vol. 9, no. 1, pp. 1637-1645, 2019.

[43] S. Amhaimedi, S. Naimi, and S. Alsallami, "Assessment of a Decision-Making Model for Monitoring the Success of a Project for Smart Buildings.", Civil Engineering Journal, 9(1), 127-142, 2023. doi: 10.28991/CEJ-2023-09-01-010.

[44] A. Khaleel, and S. Naimi, "Automation of cost control process in construction project building information modeling (BIM).", Periodicals of Engineering and Natural Sciences, 10(6), pp. 28-38, 2022.

[45] S. Naimi, M. Celikag, and A. A. Hedayat, "Ductility enhancement of post-Northridge connections by multilongitudinal voids in the beam web.", The Scientific World Journal, 2013.

[46] S. Naimi, and M. Celikag, "Problems of Reinforced Concrete Building Construction in North Cyprus.", 12th International Conference on Inspection, Appraisal, Repairs & Maintenance of Structures, pp. 23-25, 2010.

[47] S. Naimi and M. A. Karimi, "Pavement Management System Investigation in Case of Afghanistan," Cumhuriyet Science Journal, vol. 40, no. 1, pp. 221–232, Mar. 2019, doi: 10.17776/csj.471334.

[48] L. Al Musawi, and S. Naimi, "The management of construction projects in Iraq and the most important reasons for the delay.", Acta Logistica, 10(1), 61-70, 2023.

APPENDIX A

MATLAB CODE

```
clc;
clear ;
close all
format compact
% number of samples of each class
project_number = 30;
% define classes
q = .6; % offset of classes
qfoundatin_cost1=rand(1,project_number)+5;
wall_cost=rand(1,project_number)+15;
colum_cost=rand(1,project_number)+25;
roof_cost4=rand(1,project_number)+100;
flooring_cost5=rand(1,project_number)+40;
roffing_cost6=rand(1,project_number)+20;
qexxtrnal_work_cost7=rand(1,project_number)+50;
qinternal_work_cost8=rand(1,project_number)+50;
disp('=================================================');
disp('the code built by Zain Alabdine for Master degree');
disp('this code developed to find the cost estimation');
disp('           combine with tree decision            ');
disp('=================================================');

disp('                START                             ');
disp('please input the project position based on the zones in the map ');
disp('================================================================');
%$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
Iraqi_map =imread('C:\Users\user\Desktop\Iraq map.png');
image(Iraqi_map)
prompt = "specify the project zone (from 1 to 6) ";
zone = input(prompt);
prompt = "specify the building floors (from 1 to 5) ";
building_floors = input(prompt);
prompt = "specify the building area(from 100m2 to 600m2) ";%
building_area = input(prompt);
```

```
disp('                types of building construction quality in this code
');
disp(' for high quality insert 1');
disp(' for medium quality insert 2');
disp(' for economy quality insert 3');
disp('=========================================================================');
prompt = "spcify the building construction quality  ";%
building_qualiy = input(prompt);


high_quality = [qfoundatin_cost1; wall_cost; colum_cost; roof_cost4;
flooring_cost5; roffing_cost6; qexxtrnal_work_cost7;
qinternal_work_cost8];
medium_quality = [qfoundatin_cost1; wall_cost; colum_cost; roof_cost4;
flooring_cost5; roffing_cost6; qexxtrnal_work_cost7;
qinternal_work_cost8];
economy_quality = [qfoundatin_cost1; wall_cost; colum_cost; roof_cost4;
flooring_cost5; roffing_cost6; qexxtrnal_work_cost7;
qinternal_work_cost8];

% define output coding for classes
ahigh_quality = [0 1]';%high_quality
medium_qualityb = [1 0]';%medium_quality
ceconomy_quality = [1 1]';% bright_green_building
Properties = [high_quality medium_quality economy_quality];
% define targets
Target = [repmat(ahigh_quality,1,length(high_quality))
repmat(medium_qualityb,1,length(medium_quality)) ...
repmat(ceconomy_quality,1,length(economy_quality)) ];
net = perceptron;


E = 1;
net.adaptParam.passes = 1;
linehandle = plotpc(net.IW{1},net.b{1});
n = 0;
while (sse(E) & n<1000)
n = n+1;
[net,Y,E] = adapt(net,Properties,Target);
```

```
%linehandle = plotpc(net.IW{1},net.b{1},linehandle);
drawnow;
end
% show perceptron structure
% For example, classify an input vector of [0.7; 1.2]


%putting a zone factor
 if zone == 1
        add_zone_cost_effect= 1.5;
 end
     if zone == 2
            add_zone_cost_effect= 1.4; %rercentage
     end
         if zone == 3
               add_zone_cost_effect= 1.3 ; %rercentage
         end
             if zone == 4
               add_zone_cost_effect= 1.3 ; %rercentage
             end
                 if zone == 5
                     add_zone_cost_effect= 1.0 ; %rercentage
                 end
                     if zone == 6
                           add_zone_cost_effect= 1.2 ; %rercentage
                     end

%putting a building_floors  factor
 if building_floors == 1
    add_floor_cost_effect= 1.0;
 end
     if building_floors == 2
        add_floor_cost_effect= 1.015 %rercentage
     end
        if building_floors == 3
            add_floor_cost_effect= 1.035  %rercentage
        end
             if building_floors == 4
```

```
                add_floor_cost_effect= 1.047  %rercentage
            end
                if building_floors == 5
                   add_floor_cost_effect= 1.072  %rercentage
                end



%putting a building_qualiy
if building_qualiy == 1
       add_qualiy_cost_effect= 1.32;
       add_foundation_cost_effect= 1.03; %rercentage
       add_externa_finish_cost_effect= 1.08; %rercentage
end
        if building_qualiy == 2
            add_qualiy_cost_effect= 1.15; %rercentage
            add_foundation_cost_effect= 1.01; %rercentage
            add_externa_finish_cost_effect= 1.05; %rercentage
        end
                 if building_qualiy == 3
                     add_qualiy_cost_effect= 1.0;  %rercentage
                     add_externa_finish_cost_effect= 1.03; %rercentage
                end
```

APPENDIX B

RIVET RESULTS

Count	Door Panel Height	Family and Type	Level	Thickness	Width
1		Single-Glass 3: 36" x 84" 2	Level 1	0' - 2"	2' - 10"
1		Single-Glass 3: 36" x 84" 2	Level 1	0' - 2"	2' - 10"
1		Single-Glass 2: 36" x 84"	Level 3	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 3	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 2	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 2	0' - 2"	3' - 0"
1		Single-Glass 3: 36" x 84" 2	Level 1	0' - 2"	2' - 10"
1		Single-Glass 3: 36" x 84" 2	Level 1	0' - 2"	2' - 10"
1		Single-Glass 2: 36" x 84"	Level 3	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 3	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 2	0' - 2"	3' - 0"
1		Single-Glass 2: 36" x 84"	Level 2	0' - 2"	3' - 0"
1	6' - 6 3/4"	ExtDbl Louvre (2): 1810 x 2110mm	Level 0	0' - 1 23/32"	5' - 11 1/4"
1		Single-Flush: 36" x 80"	Level 0	0' - 2"	3' - 0"
1		Single-Flush: 36" x 80"	Level 0	0' - 2"	3' - 0"
1		Single-Flush: 36" x 80"	Level 0	0' - 2"	3' - 0"
1		Single-Flush: 36" x 80"	Level 0	0' - 2"	3' - 0"
1		Single-Flush: 36" x 80"	Level 0	0' - 2"	3' - 0"
1	6' - 6 3/4"	ExtDbl Louvre (2): 1810 x 2110mm	Level 0	0' - 1 23/32"	5' - 11 1/4"

Family	Family and Type	Level	Width	Sill Height

win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 1	2' - 6"	3' - 0"
ventilator 1'9 x 2'6.0003	ventilator 1'9 x 2'6.0003: ventilator 1'9 x 2'6.0003	Level 1	2' - 6"	6' - 2"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 2	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 2	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 3	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 3	2' - 6"	2' - 0"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 0"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 1	2' - 6"	3' - 0"
ventilator 1'9 x 2'6.0003	ventilator 1'9 x 2'6.0003: ventilator 1'9 x 2'6.0003	Level 1	2' - 6"	6' - 2"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"

win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 2	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 2	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 3	2' - 6"	2' - 0"
win2'6 x 5'.0004	win2'6 x 5'.0004: win2'6 x 5'.0004	Level 3	2' - 6"	2' - 0"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 3	2' - 0"	1' - 4"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 0"
Fixed	Fixed: 24" x 72"	Level 2	2' - 0"	1' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 2	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 3	6' - 0"	3' - 0"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 6 3/32"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 8 1/16"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 8 1/32"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 5 7/16"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 4 1/8"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 4 1/8"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 4 1/8"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 4 1/8"

2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 2 13/16"
2' x 4' fixed window.0004	2' x 4' fixed window.0004: 2' x 4' fixed window.0004	Level 1	4' - 0"	5' - 2 13/16"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
win 6' x 4'	win 6' x 4': win 6' x 4'	Level 1	6' - 0"	3' - 0"
ventilator 1'9 x 2'6.0003	ventilator 1'9 x 2'6.0003: ventilator 1'9 x 2'6.0003	Level 2	2' - 6"	6' - 6 29/32"
ventilator 1'9 x 2'6.0003	ventilator 1'9 x 2'6.0003: ventilator 1'9 x 2'6.0003	Level 3	2' - 6"	6' - 10 9/32"