

# Cost Evaluation of Constructions using Artificial Neural Network (ANN)

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## To Cite this Article

Sandhya W T, "Cost Evaluation of Constructions using Artificial Neural Network (ANN)", *International Journal for Modern Trends in Science and Technology*, Vol. 05, Issue 11, November 2019, pp: 109-114.

## Article Info

Received on 17-October-2019, Revised on 30-October-2019, Accepted on 02- November -2019, Published on 09-November-2019.

## ABSTRACT

Accurate cost estimation at the early stage of a construction project is the key factor in a project success. But it is difficult to quickly and accurately estimate construction costs at the planning stage, when drawings, documentation and the like are still incomplete. The aim of construction cost forecasting is to provide an estimate of a construction contract. Construction clients are interested in knowing their financial commitment before the completion of a detailed design. There are various methods used by estimators to forecast the construction cost of building and civil engineering projects. The objective of this study is to find the cost estimation by using Artificial Neural Network (ANN). Finally the accuracy of these models is identified with realistic estimated value. The method used to develop a neural network model analysis using Microsoft Excel Solver and trained in MATLAB software. This paper efforts are made to establish complete analysis of 20 papers published related to ANN in construction. This paper discusses different research papers, articles, case studies that have been published in this field. There is great scope for ANN in the constructions cost estimation in future.

**KEYWORDS:** cost estimation, Artificial Neural Network, MS Excel solver

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## I. INTRODUCTION

The accuracy of estimation of construction costs in a construction project is a critical factor in the success of the project. The cost estimation models which in the early stage estimate the construction costs with minimum project information are useful in the preliminary design stage of a construction project. Improved cost estimation techniques which are available to project managers, will facilitate more effective control of time and costs in construction projects. Despite the great importance of the task of cost estimation it is

neither simple nor straight forward because of the lack of information in the early stages of the project.

An alternative branch of artificial intelligence, neural network has appeared as available alternative for estimating construction cost during the 1990s. The application of NNs to construction is a relatively new research area. In particular NNs are available for predicting construction costs because this method eliminates the need to find a good cost estimating relationship that mathematically describes the cost of a system as a function of the variables that have the most effect

on the cost of that system. The purpose of this study was to estimating construction cost by using estimating techniques i.e, Neural Network. Finally the accuracy of these models is identified with realistic estimated value.

## II. NEURAL NETWORK MODEL

An artificial neuron is characterized by Architecture (connection between neurons), Training or learning (determining weights on the connections) and Activation function. ANN have been developed at the recent decades. ANN are particularly effective for solving complex problems, such as cost estimating problems, where the relationship between the variables cannot be expressed by a simple mathematical relationship. Basically the network consists of several layers, including an input layer, hidden layer, output layer and each layer contains neurons. Neurons determine the optimum value through a summation and transfer function. The set of inputs which is the outputs from another neuron in input layers are delivered by neurons. Each input data is multiplied by the connection weight and then the weighted inputs provide output value which is modified by the transfer function.

## III. SCOPE AND OBJECTIVE

The objective of this paper is to study various literatures about the cost estimation using Artificial Neural Network and identified the accuracy of this model with realistic estimated value.

The Scope of this paper includes:

To study the better design of ANN models for cost estimating at the pre-design stage when there is insufficient definition of scope and characteristics for detailed estimating. This paper applies ANN to forecast the construction duration of buildings at the pre-design stage.

To test the accuracy of estimates made by using the ANN in terms of the mean squared error (MSE). The model can serve as a framework for further development of construction management decision support systems.

Further research seeks to develop a proper and realistic model for accurately estimating construction costs of projects.

## IV. LITERATURE REVIEW

A literature review is a detailed report of information obtained from the literature that are related to our topic of study. The review describe, summarize, evaluate and clarify this literature. It

gives a base for the research and helps in determining the nature of the study. This section represents the review of literature collected from various journals and articles that are most relevant to the study.

1.Pre-design stage Construction Cost Prediction of building projects using Artificial Neural Network: Vinayak R. Ambrule (2017)

This project is highlighting the study of Application of Artificial neural network (ANN) for pre design cost estimation of building projects to investigate and overcome problems caused in estimating project cost at pre-design stage of building projects. As well as to develop & test a Graphical User Interface (GUI) model of cost estimating for building projects in the early design phase using MATLAB software. In this study, a detailed analysis of data and results will be presented and elaborated. The data used in this study was collected from 12 project estimates in the past three years. A data sheet was prepared and used to extract all useful information from each project. The accuracy performance of the adopted model for "Grand Total of the Project" recorded 86.11% where average percentage for all other parameters is 77.55% between the output obtained from model and the actual budget value of the project.

2. Cost Estimation Model (Cem) for Residential Building using Artificial Neural Network: Richa Yadav(2016)

In this study, data of last twenty three years has been collected from Schedule of rate book (SOR) and general studies. Eight input parameters, namely, cost of cement, sand, steel, aggregates, mason, skilled worker, non-skilled worker and the contractor per square feet construction were selected. The parameters were simulated in NEURO XL Version 2.1 for developing ANN architecture. The resulting ANN model reasonably predicted the total structural cost of building projects with correlation factor R-0.9960 and RSquared-0.9905 giving favorable training and testing phase outcomes.

3.Estimating the Final Cost of Construction Project Using Neural Networks: A Case of Yemen Construction Projects: Asem Ali Ahmed Alshahethi (2018)

In this study investigation, two stages were carried out to achieve the objectives. Data collection and analysis, and developing ANN model have been done. Fifteen NNs models were built to predict the cost of the project by using neural network Tool Box software by MATLAB program Through five

attributes were taken as predictor variables namely; collect data, preprocessing data, architecture the network, training the model, and testing the model using excel sheet and MATLAB. RMSE, MSE, MAPE, and R2 were calculated and compared for all 15 models to show the best model. It is observed the error from Bayesian Regularization- back propagation shown the best convergence towards minimum error compared to other algorithms. Among those models is 13- 17- 1 model as its percentage of error is 6% which is the least mean absolute percentage error and its coefficient of determination is 0.9998 for models that have already been tested. The findings clearly provide a good indicator for predicting the construction costs in the future with high degree of accuracy by using artificial neural network method.

#### 4. Prediction of Cost of Quality Using Artificial Neural Network in Construction Projects: Chinchu Mary Jose

This paper is to develop a neural network model that will enable the construction firms to access cost of quality for any future building project. The different sequences of the model development will be investigated. Moreover, the validity of the proposed model will be evaluated using case study applications. The main 29 factors affecting the expected cost of quality were identified. By using Microsoft Excel, relative importance index of the factors are obtained and the factors with important index more than 70% was selected for a second stage questionnaire survey. Second stage questionnaire survey was conducted among construction experts from different construction industries and the result obtained was used as the input parameters of the proposed cost of quality model. The results of the testing indicated an accuracy of 100%.

#### 5. Construction Cost Prediction using Neural Networks: Smita k. Magdum (2017)

This paper presents construction cost prediction as multiple regression model with cost of six materials as independent variables. The objective of this paper is to develop neural networks and multilayer perceptron based model for construction cost prediction. Different models of NN and MLP are developed with varying hidden layer size and hidden nodes. MLP with ten and eight hidden nodes gives best training results. But, MLP models fail to give better results than NN with 8 hidden nodes on testing dataset. These methods are compared with statistical multiple regression

method. RMSE values of NN and MLP models are consistently low for training data set.

#### 6. Cost Estimation Model (CEM) of Buildings by ANN (Artificial Neural Networks) – A Review: Bipin Pal (2018)

The results of the trained models indicated that neural network reasonably succeeded in estimating the Total construction cost of building projects at the planning stage itself. The average error of test dataset for the adapted model was largely acceptable and can perform as a good indicator regarding the ability of the proposed model to predict the total construction cost of any future construction project at an appreciated degree of accuracy. This paper gives a clear review of implementing the ANN tool in prediction of total cost of building construction projects and the relevant factors affecting it.

#### 7. An Artificial Neural System for Cost Estimation of Construction Projects: T.M.S. Elhag and A.H. Boussabaine

This paper demonstrates the development of a cost estimation model using artificial neural networks and a back-propagation algorithm. Determinants of building project cost were identified, and their pertaining data was extracted from the BCIS database. In this study, two models for cost estimation of school buildings are developed using artificial neural networks. For the first model 13 influencing factors are used, whereas in the second model only 4 determinant variables are provided. These models achieved overall average accuracy of 82. 2% and 79.3% respectively.

#### 8. Comparative study in the use of Neural Networks for order of Magnitude Cost Estimating In Construction: Hany El-Sawah (2014)

The study considered Back Propagation Neural Network (BPNN), Probabilistic Neural Network (PNN) and Generalized Regression Network (GRNN) as well as regression analysis. Models were developed for order of magnitude cost estimating of low-rise structural steel buildings and short-span timber bridges. The study was conducted on actual data for 35 low-rise structural steel buildings and their respective cost was estimated using the developed regression and ANN models. The results showed that the PNN network was the most stable network among all the other estimating models as the maximum difference in MAPE percentage was only 2.46%. However, the maximum difference in MAPE was 19.47%, 17.91%, and 61.45% for BPNN, GRNN and regression models respectively. Therefore, it is recommended to use the PNN

network for cost estimating when there is a small number of input data.

9. Product Life Cycle Cost Estimation at Early Design: A Review on Techniques and Applications: Siva Prasad Darla (2017)

Several studies indicated that 70-80% of product cost committed during design and development stage. In this paper, the ever-increasing importance of methods and approaches to forecast the life cycle cost for a new product in the early design stage with accuracy are reviewed. Also, this paper provides a review of hybrid approaches developed in recent years. The review paper presents application areas of techniques along with advantages and limitations.

10. A Neural Network Model for Construction Projects Site Overhead Cost Estimating in Egypt : Ismaail ElSawy (2011)

The analysis of the collected data gathered from fiftytwo real-life building construction projects from Egypt illustrated that project's duration, total contract value, projects type, special site preparation needs and project's location are identified as the top five factors that affect the value of the percentage of site overhead costs for building construction projects in Egypt. The results of the testing indicated an accuracy of (80%).

11. Application of Artificial Neural Network to forecast construction duration of buildings at the pre-design stage: Sdhabhon bhokha

This paper addresses the forecasting of construction duration at the early stage of project development when only a few project parameters are known and designs are not yet well developed. The comparison yielded low value of R<sup>2</sup> suggesting that there is no relationship between forecasting errors from the network and project duration. This shows that the network is equally good at forecasting the duration of both long and short duration projects.

12. A Neural Network Model for Building Construction Projects Cost Estimating: Nabil Ibrahim El-Sawalhi (2014)

The purpose of this paper is to develop a model for forecasting early design construction cost of building projects using ANN. The neural network model reasonably succeeded in estimating building projects cost without the need for more detailed drawings. The average percentage error of tested dataset for the adapted model was largely acceptable (less than 6%).

13. Cost Estimation of High Performance Concrete (HPC) High rise Commercial Buildings by Neural Networks: C. F. Fang

Neural network approach is applied to establish relationships between the quantities/cost of the concrete/formwork, which is required for the structural elements of tall buildings using high performance concrete (HPC), and the design variables. Hybrid and hierarchical strategies are proposed for the cost estimation, where the feed-forward networks are adopted. The two strategies are compared and it is confirmed that the hybrid model is less accurate but easy to be trained, while the hierarchical models are more accurate but more complicated in implementation.

14. Using Neural Networks with Limited Data to Estimate Manufacturing Cost: Gary R. Weckman (2010)

The neural network process was compared with results produced by the current conventional cost estimation software and linear regression methods. Due to the complex nature of the parts and the limited amount of information available, data expansion techniques such as doubling-data and data-creation were implemented. This research showed that a neural network was able to achieve a superior R value when compared to the current cost estimation software.

15. Modelling of Construction Project Management Effectiveness by Applying Neural Networks: R. Apanaviene

The paper presents modelling of construction project management effectiveness from the perspective of construction management organization. Construction project management effectiveness model (CPMEM) was established by using artificial neural networks (ANNs). The model allows construction project managers to focus on the key project management effectiveness factors, reduce the level of construction management risk and provide substantial savings for construction management company. The model can serve as a framework for further development of construction management decision support systems.

16. Artificial Neural Networks in Construction Engineering and Management: Baba Shehu Waziri (2017)

The study revealed successful applications of ANNs in cost prediction, optimization and scheduling, risk assessment, claims and dispute resolution outcomes and decision making. It was observed that ANN have been applied to problems that are difficult to solve with traditional mathematical and

statistical methods. The study provides comprehensive repute of ANN in construction engineering and management for application in different areas for improved accuracy and reliable predictions.

17. Feasibility of Artificial Neural Network in Civil Engineering : Vikash Singh (2019)

It is clear that ANNs have been successfully applied to many civil engineering areas like prediction, decision-making, risk analysis, resources optimization, classification and selections etc. Based on the results, it is that ANNs perform better than other conventional methods. In civil engineering many problems are very complex and not well understood. ANNs are based on only input and output data by which model can be trained easily. ANNs can always be updated to obtain better output by showing new training examples as new data become available.

18. Neural Network Model for Construction Cost Prediction of Apartment Projects in Vietnam: Van Truong Luu (2009)

This paper presents the application of artificial neural networks (ANNs) in estimating TCC of apartment projects. A program was constructed using Visual C++ in order to apply the neural network to realistic projects. The results suggest that this model is reasonable in predicting TCCs for apartment projects and reinforce the reliability of using neural networks to cost models. It facilitates systematic predictions in early phases of construction projects.

19. Artificial Neural Networks for Construction Management- A Review: P.S.Kulkarni (2017)

This paper reviews application of ANNs in construction activities related to prediction of costs, risk and safety, tender bids, as well as labor and equipment productivity. The review suggests that the ANN's had been highly beneficial in correctly interpreting an inadequate input information. The review confirms the usefulness of ANNs in carrying out a variety of prediction, classification, optimization and modelling related tasks in areas of CM. ANN thus has significant benefits that make it a powerful tool for solving many problems in the field of CM.

20. Application of Neural Network in the Cost Estimation of Highway Engineering: Wang Xin-Zheng (2010)

Based on the BP neural network, this paper sets up the model of cost estimation of highway engineering. The BP neural network model is trained by a sample data obtained from some

performed typical engineering to come true quick cost-estimating . It is sure that the method is practical and the estimating results are reliable according to lots of examples . It shows the promising perspective of BP Neural Network in cost estimate of construction engineering.

## V. CONCLUSION

This paper considers that wide literature and knowledge about artificial neural network was obtainable and gives a wide idea of foregoing practices and techniques used in estimating the construction cost and researches carried across the world. ANN is the best way to evaluate the forecast model is comparison between its actual and predicted results. The outcome of our research is models for predicting the cost of construction projects. Several papers have been presented on ANN it is used to determined the cost estimation. This research is carried out to show various techniques and more research work is required in this field. In this papers, I have studied several journal papers about cost estimating using ANN in constructions. Thus, it is concluded that the Neural Network is provide a good indicator for predicting the construction costs with high degree of accuracy.

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