Predicting the Required Duration for Construction Activities Using Artificial Neural Networks

HAMED GOLIZADEH

A project report submitted in partial fulfillment of the
requirement for the award of the degree of
Master of Science (Construction Management)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

January 2013

To my family,

Who is the sole being inculcating commitment, cultivating ambition, injecting passion, and raising undying spirit in me. Whatever I am today is because of them, thank you for giving me reason to live.

To all my friends,

Their undying faith on me gives me lots of encouragement to do well every time and every day.

ACKNOWLEDGEMENT

First of all I would like to thanks Allah Al-Mighty

I would like to acknowledge my parents and family members, teachers, friends and people in professional organizations who helped me in materializing my inspiration, actualizing my aspirations and shaping my ideas into concrete efforts.

I include in this list of people whose works I have been reading for many years now and made it possible for me to appreciate and recognize the world as it is now, today, with all its intricate complexities and how it came to be this way.

All these people, through their art, forced me to rethink about everything around us and made me see the same old things critically in a new light, that I never would have thought possible, changing my perspective and increasing my perceptiveness manifolds, and specially the total impact of all on my thinking and attitude of which this work is and others in future will be a resultant.

More emphatically, the acknowledgement goes to my project supervisor Prof. Dr Muhd Zaimi Abd Majid for helping and guiding this work. Without his special attention and interest in this work, it would not possible to complete on time, and also to all the Professors of Faculty, who helped me broaden my vision and gaining an in depth perspectives of theories pertaining to life and studies.

Hamed Golizadeh

ABSTRACT

The duration of a construction project is a key factor to consider before the project starts, as it can determine the success or failure of the project. Difficulties in estimating the duration of activities that can also lead to error if manually estimate it. The main purpose of this study is to develop a model to estimate the duration of construction's major activities in the structural part of concrete frame of buildings. In this study, available methods and models have been investigated and this is achieved through reviewing the previous literatures. It is argued that using Artificial Neural Network (ANN) is the most proper method to achieve the aim of this study. Consequently, through literature investigation and experts interviewing, those factors which can critically influence the activity duration have been opted. Four different buildings in two different regions of Malaysia are selected as case for the project. Finally, the collected data and variables implemented into the models and nine ANN models have been trained, tested and validated. Contractors and firms can utilize these models in the planning phase of their project to avoid the errors made by human beings and producing more accurate estimations of activity durations.

ABSTRAK

Tempoh projek pembinaan merupakan faktor utama yang perlu dipertimbangkan sebelum projek bermula, kerana ia boleh menentukan kejayaan atau kegagalan projek. Kesukaran dalam menganggarkan tempoh untuk aktiviti-aktiviti yang juga boleh membawa kepada kesilapan jika manual menganggarkan ia. Tujuan utama kajian ini adalah untuk membangunkan satu model yang tepat untuk menganggarkan tempoh aktiviti utama pembinaan di bahagian struktur bangunan rangka konkrit. Dalam kajian ini, kaedah yang disediakan dan model telah dibincangkan dan ini boleh dicapai melalui mengkaji kesusasteraan sebelumnya. Ia diperdebatkan bahawa menggunakan Rangkaian Neural Buatan (ANN) adalah kaedah yang paling sesuai untuk memenuhi matlamat kajian ini. Oleh itu, melalui penyiasatan kesusasteraan dan menemuramah pakar, faktor-faktor yang kritikal boleh mempengaruhi tempoh aktiviti telah memilih. Empat bangunan berbeza di dua kawasan yang berlainan di Malaysia telah dipilih untuk membekalkan data yang diperlukan. Akhir sekali, data yang dikumpul dan pembolehubah yang dilaksanakan ke model dan sembilan model ANN telah dilatih, diuji dan disahkan. Kontraktor dan firma boleh menggunakan model ini dalam fasa perancangan projek mereka untuk mengelakkan kesilapan yang dibuat oleh manusia dan menghasilkan anggaran yang lebih tepat jangka masa aktiviti.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1. Background:

Estimation is an important activity in construction management. It includes cost (bid preparation, budget), time (productivity, project schedule), or quality estimation.

The estimation is complicated, intuitive and approximate. In case of duration, if a project is not completed with the stipulated period then the building contractor suffers losses due to escalated costs and penalties and clients suffer because their time minimization objectives cannot be achieved. Therefore, just as keeping a project within budget and quality is important, so is the accurate estimation of construction duration for the successful completion of a project.

Construction project management is defined as managing time, material, personnel, and cost in order to meet objectives in time, resources, and technical results (Hendrickson, et al., 1987).

Planning site activities for civil engineering and building construction projects requires considerable personal skill and expertise. Many problems arising in

planning are usually solved in an intuitive way, based on the project engineer's experiential knowledge.

Examples of this type of typical problems are:

1. Determination of work breakdown structures;
2. Determination of dependencies between site activities;
3. Resource selection;
4. Site activity durations estimation;
5. Risk analysis; and
6. Interpretation of project data.

Few tools and techniques exist to assist the planner in the vital task of project planning and control. Consequently, the accomplishment of such a task can be time-consuming and cumbersome even for experienced project managers.

The estimation of site activity durations provides a useful example of how demanding manual techniques can prove. When preparing schedules, a project engineer or site foreman attempts to collect together all factors having an effect on the duration of an activity. For instance, site activity duration depends upon the size of the gang, physical condition of tools and equipment and the effects of other activities which may be going on simultaneously. Furthermore, gang productivity and, thus, the actual activity duration is affected by external factors like weather and procurement of materials (Ergan and Akinci, 2012).

1.2. Problem Statement:

Understandably, schedule overrun brings about project cost overrun. Although the industry participants are aware of the importance of duration in the

construction phase of projects, it was observed that significant part of the contracts had not met the stipulated period.

Completed projects lasting much longer than the original schedule results in various disadvantages such as: additional cost, reduced contractor's profit, loss of reputation, and delay of client's operating plan. Many provoking disputes emanated from the various reasons of construction delay (Ng et al. 2001). The construction duration overrun is problematic in the construction industry and generates much concern. These statues of delay are still universal in the performance of building projects (Aibinu, Odeyinka 2006).

Since 1960's, according to Bromilow's research report, only 12.5% of building contracts were completed within the scheduled completed dates and the overall average actual time is more than 40% longer than the original schedule(Bromilow, 1969). After four decades, the inability to complete on time is still a prevailing problem.

Al-Khalil and Al-Ghafly (1999) reported that completed public projects overrun approached 70% of the original schedule through a comparison of the outcomes for projects with their original schedules. Odusami and Olusanya (2000) concluded that projects executed an average delay of 51% of a planned duration for most projects in the metropolis. Blyth (2004) stated that 50% of contracts were completed after stipulated durations longer than schedules. Iyer and Jha (2006) observed that over 40% of construction projects were behind original schedule and delay lasted for months. Table 1.1 shows the history of delays in the construction projects.

Table 1.1: The history of delays in the construction projects

Bromilow, 1969	In, only 12.5% of building contracts were completed within the scheduled completed dates and the overall average actual time is more than 40% longer than the original schedule
Al-Ghafly, 1999	Completed public projects overrun approached 70% of the original schedule through a comparison of the outcomes for projects with their original schedules.
Odusami and Olusanya, 2000	Projects executed an average delay of 51% of a planned duration for most projects in the metropolis.
Blyth et al., 2004	50% of contracts were completed after stipulated durations longer than schedules.
Iyer and Jha, 2006	Over 40% of construction projects were behind original schedule and delay lasted for months.

The construction duration has been observed as one of the main criteria for assessing the performance of building projects in the construction industry (Bromilow 1969; Dissanayaka, Kumaraswamy 1999; Kaka, Price 1991; Love et al. 2005; Ng et al. 2001; Ogunsemi, Jagboro 2006; Walker 1995). A project will be considered successful if it is completed on time, is within budget, and meets the specified quality standards (Chan, Kumaraswamy1995).

In practice, most methods estimating activity duration in the industry depends on the subjective skill and cognition of the estimators and planners, rather than on objective assessment.

Khosrowshahi and Kaka (1996) stated that forcing the project into a desired time mold can lead to adverse consequences, giving rise to a chain reaction which affects the performance of the organization in other areas. Underestimation of the project duration raises additional events of penalty, disputes, etc. for the contractors and clients. On the other hand, overestimation of the project duration may lose organizational competitiveness in the industry. Both of these could have undesirable effects on project performance and achievement of project objectives.

Part of inaccuracies happen in planning stage might be attributed to inaccurate estimation of activity duration, usually overestimation (Goldratt 1997).Assuming that each activity in average has given 20 percent more time for executing, will end up by 20 percent of inaccuracy of whole project.

For activity duration estimation, average productivities are usually available as an aid for estimation, but these averages must often be modified in light of the special conditions of a job or site. Activity durations are typically estimated as the planned quantity of work divided by the expected productivity. A similar approach may be used for activity cost estimation (Diekmann, J. E., 1983).Forecasting construction operation productivity is experience-based due to the complexity involved according to experience, an estimator can intuitively adjust the standard rates in productivity books to estimate for an operation in given project conditions. However, such practices do not guarantee a consistent estimate due to the lack of a binding mechanism that relates the present case to past patterns. Mathematical and statistical models have been applied to productivity forecasting. However, the application of such models has to be based on arbitrary assumptions to simplify the mathematics, which limits their use in complex situations. Mathematical models only deal with operation efficiency and rely on input from the user of operation attributes such as the labour skills. They themselves do not address the impacts of environment factors and incorporate such effects on a productivity estimate.

To give a specific example, when estimators estimate the production rate for a wall formwork installation activity, they would look at the production rates of the same activity executed at different locations and achieved in past projects. Even for a given past project, an estimator would be faced with multiple, highly fluctuating production rates for the same formwork activity executed at different times and locations (Kiziltas and Akinci 2009).

1.3. Aim and Objectives:

This study was initiated with the aim of developing a model that can be used to predict the construction duration of major structural elements in the concrete skeleton buildings in a reliable and practical way. Contractors can thus use structural element characteristics, as given in the worksheets, and other data which are available and predictable in the planning stage to estimate the actual amount of time it would take skeleton of the building to be completed and constructed. To successful accomplishment of this, the following stages are identified:

1. To study the an appropriate and applicable methods of activity duration estimation;
2. To Identify the factors affecting the structural activities;
3. To develop a prediction model for activity duration estimating.

1.4. Scope and Limitation

The scope of this project limited to most recurrence and major structural elements in the concrete skeleton building listed by beam, column and slab. Also the time of activities will be calculated separately for each element’s Formwork installation, reinforcement installation and concreting works.

Since this study is looking for a comprehensive model which could be applicable in the regular construction projects, some factors such as delay of payments, methods of procurements and other factors which are not predictable in the planning stage of the construction project, will be ignored.

In Addition, data collection will be held in the Malaysia, so the model will be suitable for Malaysian construction projects.

1.5. Brief Research Methodology

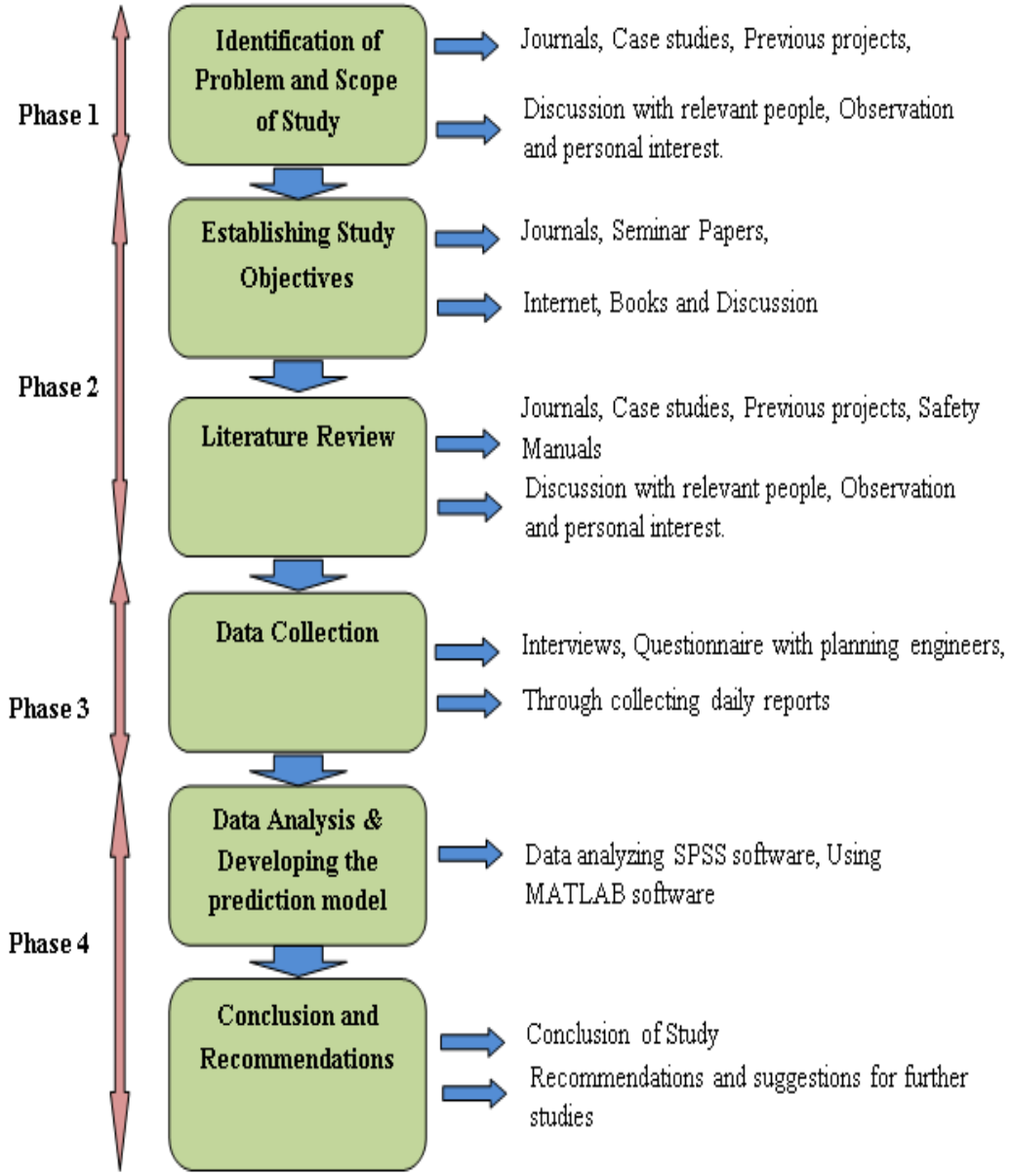

Figure 1.1 Research Methodology flow chart

1.6. Summary of Chapters

Chapter one consists of introduction to issues of the estimating and its importance for the construction industry, stating the problem of having no accurate model for predicting of construction activities, aiming to develop a model that can be used to predict the construction duration of major structural elements in the concrete skeleton buildings, scoping the project for the Malaysian construction sites and giving a summary bar chart for the research methodology.

In chapter two the literatures of predicting models which have been successfully implemented is studied. Consequently, an argument is held in order to select the most reliable and applicable one. Then, factors which have the possibility to affect the duration of construction activities is discussed.

In chapter three the methodologies that have been used in this research to fulfill the objectives of this project are discussed. Also the required software for this project are mentioned.

In chapter four, firstly, the data collected from construction sites and international websites. Then, several interviews are held to find out the affecting factors in duration of construction activities. These factors are being incorporated in developing ANN models. Finally, the models tested and their accuracy measured due to some of collected data.

In chapter five the achievements of this project are discussed and the findings are explained. The recommendations and the future studies which can improve this project or this type projects are stated in this chapter.

REFERENCES

Adeli H. and Wu M., 1998. Regularization neural network for construction cost estimation. Journal of Construction Engineering and Management. 124(1), pp.18-24.

Akintoye, A. and Fitzgerald, E., (2000) A Survey of Current Cost Estimating Practices in the UK. Construction Management and Economics, 18, pp.161-172.

Al-Khalil, Mohammed I. Mohammed A. Al-Ghafly, 1999. Delay in public process: An application of the social marketing perspective to environmental policy deployment. International journal of project management, 17(2), pp.101-106.

Al-Tabtabai H., Kartam N., Flood I. and Alex A.P., 1997. Expert judgment in forecasting construction project completion. Engineering Construction and Architectural Management. 4(4), pp.271-293.

Al-ZwainyFaiq M. S., 2008. The Use of Artificial Neural Network for Estimating Total Cost of Highway Construction Projects. A thesis submitted to the Civil Engineering Department, College of Engineering, Baghdad University, Iraq.

Al-ZwainyFaiq M. S., 2012. The Use of Artificial Neural Networks for Productivity Estimation of finishing Stone works for Building Projects. Journal of Engineering and Development. 16(2), pp.42-60.

B. Dragan, J. Dragica, K. Miloš, 2012. Application of neural networks in determination of compressive strength concrete, Romanian Journal of Materials, 42 (1), pp.16.

BCIS, 2004. Time and Cost Predictability of Construction Projects: Analysis of UK Performance, Technical Report.

BCIS, 2004. Guide to Building Construction Duration. MFK Chiltern Press, England.

Bhokha, S. and Ogunlana, S. O., 1999. Application of Artificial Neural Network to Forecast Construction Duration of Buildings at the Predesign Stage. Engineering, Construction and Architectural Management, 6, pp.133-144.

Blyth, R.E., 2004. Implications of a zoned fishery management system for marine benthic communities.Journal of Applied Ecology, 41, pp.951-961.

Boussabaine, A. H., 2001. Neuro fuzzy Modelling of Construction Projects' Duration II: Application. Engineering, Construction and Architectural Management, 8, pp.114- 129.

Bromilow, F. J., Hinds, M. F., and Moody, N. F., 1980. AIQS Survey of Building Contract Time Performances.Building Economics, 19, pp.79-82.

Chan, D. W. M. and Kumaraswamy, M. M., 1999.Forecasting Construction Durations for Public Housing Projects: A Hong Kong Perspective. Building and Environment, 34, pp.633-646.

Chan, D. W. M. and Kumaraswamy, 1995. M. M.A Study of the Factors Affecting Construction Durations in Hong Kong.Construction Management and Economics, 13, pp.319-333.

Chao L.C. and Skibniewski M.J., 1994.Estimating construction productivity: neural network-based approach. Journal of Computing in Civil Engineering ASCE. 8(2), pp.234-251.

Chris Hendrickson, David Martinelli and Daniel Rehak., 1987. Hierarchical rule-based activity duration estimation. Journal of Construction Engineering and Management, 113(2).

Chua D.K.H., Kog Y.C., Loh P.K. and Jaselskis E.J., 1997. Model for construction budget performance-neural network approach. Journal of Construction Engineering and Management. 123(3), pp.214-222.

Clark, CE., 1962. The PERT model for the distribution of an activity time. Operations Research, 10, pp.405-406.

Diekmann, J. E., 1983. Probabilistic Estimating: Mathematics and Applications. Journal of Construction Engineering and Management, ASCE, 109(3), pp. 297-308.

Dissanayaka, S. M. and Kumaraswamy, M. M., 1999. Comparing Contributors to Time and Cost Performance in Building Projects. Building and Environment, 34, pp.31- 42.

Dissanayaka, S. M. and Kumaraswamy, M. M., 1999. Evaluation of Factors Affecting Time and Cost Performance in Hong Kong Building Projects. Engineering, Construction and Architectural Management, 6, 287-298.

Elazouni A.M., Nosair I.A., Mohieldin Y.A. and Mohamed A.G., 1997. Estimating resource requirements at conceptual design stage using neural networks.Journal of Computing in Civil Engineering ASCE. 11(4), pp.217-223.

G. Panchal, A. Ganatra, Y.P. Kosta, D. Panchal, 2011. Behavior analysis of multilayer perceptrons with multiple hidden neurons and hidden layers, International Journal of Computer Theory and Engineering, 3, pp.332-338.

Goldratt, E. M., 1997. Critical chain, North River Press, Great Barrington, Mass.

Grubbs, FE., 1962. Attempts to validate certain PERT statistics or 'picking on PERT. Operations Research, 10, pp.912-915.

Hadipriono, Fabian C. and Sun, Kerning., 1990. Angular fuzzy set models for linguistic values. Civil Engineering and Environmental Systems, 7(3), pp.148–156.

Hegazy T. and Ayed A., 1998. Neural network model for parametric cost estimation of highway projects. Journal of Construction Engineering and Management. 124(3), pp.210- 218.

Hegazy T. and Moselhi O., 1994. Analogy-based solution to markup estimating problem. Journal of Computing in Civil Engineering ASCE. 8(1), pp.72-87.

Helvacı, A., 2008. Comparison of Parametric Models for Conceptual Duration Estimation of Building Projects. M.Sc. Dissertation, Department of Civil Engineering, Middle East Technical University, Turkey.

Hoffman, G. J., Thal Jr., A. E., Webb, T. S. and Weir, J. D., 2007. Estimating Performance Time for Construction Projects. Journal of Management in Engineering, 23, pp.193-199.

Iyer, K. C. and Jha, K. N., 2006. Critical Factors Affecting Schedule Performance: Evidence from Indian Construction Projects, Journal of Construction Engineering and Management, 132(8), pp.871-881

J.A. FLORES, 2011. Focus on artificial neural network, Nova Science Publishers, New York.

Kaka, A P and Price, A D F.,1991. Net cash-flow models: are they reliable? Construction Management and Economics, 9(3), pp.291–308.

Kamarthi S., Sanvido V.E. and Kumara R.T., 1992. NEUROFORM-Neural Network System for Vertical Formwork Selection. Journal of Computing in Civil Engineering ASCE. 6(2), pp.178-199.

Kanoğlu, A., 2003. An Integrated System for Duration Estimation in Design/Build Projects and Organizations. Engineering, Construction and Architectural Management, 10, pp.272-282.

Khan A.I., Topping B.H.V. and Bahreininejad A., 1993. Parallel training of neural networks for finite element mesh generation. Neural Networks and Combinatorial Optimization in Civil and Structural Engineering (eds B. H. V. Topping and A. I. Khan). Civil-Comp Press, Edinburgh, Scotland, pp. 81-94.

Khosrowshahi, F. and Kaka, A. P., 1996). Estimation of Project Total Cost and Duration for Housing Projects in the U.K. Building and Environment, 31, pp.373-383.

Kiziltas, S., and Akinci, B., 2009. "Contextual information requirements of cost estimators from past construction projects." J. Constr. Eng. Manage., 135(9), pp.841–852.

Kumar, V. S. S. and Reddy, G. C. S., 2005. Fuzzy Logic Approach to Forecast Project Duration in Construction Projects, Construction Research Congress.

Lippmann R.P., 1988. An introduction to computing with neural nets. In: Artificial Neural Networks; Theoretical Concepts. (Ed. V. Vemuri). The Computer Society, Washington, USA. pp. 36-54.

Love, P. E. D., Tse, R. Y. C. and Edwards, D. J., 2005. Time–Cost Relationships in Australian Building Construction Projects. Journal of Construction Engineering and Management, 131, pp.187-194.

M. Shahidehpour, H. Yamin, Z. li, 2002. Market Operation in Electric Power Systems, Wiley-IEEE Press, New York.

Malcolm D.G., Roseboom J.H., and Clark C.E., 1959. Application of a technique of research and development program evaluation, operations research, 7, pp.646-669.

Mawdesley M.J. and Carr V., 1993. Artificial neural networks for construction project planning. Neural Networks and Combinatorial Optimization in Civil and Structural Engineering (Eds B. H. V. Topping and A. I. Khan). Civil-Comp Press, Edinburgh, Scotland, pp.39-46.

McKim R., Adas A. and Handa V.K., 1996. Construction firm organizational effectiveness: a neural network-based prediction methodology. The Organization and Management of Construction Shaping and Practice (Eds D. A. Langford and A. Retik). E and FN Spon, London, U.K. 3, pp.247-256.

Moderi, J.J. and Rodgers, E.G., 1968. "Judgment estimates of the moments of PERT type distributions", Management Science, 15, pp.76-83.

Murtaza M. and Deborah F., 1994. NEUROMODEX Neural Network System for Modular Construction Decision Making. Journal of Computing in Civil Engineering ASCE. 8(2), pp.221-233.

Ng, S. T., Mak, M. M. Y., Skitmore, R. M. and Varnam, M., 2001. The Predictive Ability of Bromilow's Time-Cost Model. Construction Management and Economics, 19, pp.165-173.

Nkado, R. N., 1995. Construction Time-Influencing Factors: the Contractor's Perspective. Construction Management and Economics, 13, 81-89.

O. Shariati, A.A.M. Zin, M.R. Aghamohammadi, 2011. Application of neural network observer for on-line estimation of salient-pole synchronous generators' dynamic parameters using the operating data. Modeling, Simulation and Applied Optimization (ICMSAO), 2011 4th International Conference, Malaysia.

Odusami, K.T. &Olusanya, O.O., 2000. Client's contribution to delays on building projects. The Quantity Surveyor, January/March 30, pp.30-34.

Ogunsemi, D. R. and Jagboro, G. O., 2006. Time-Cost Model for Muilding Projects in Nigeria. Construction Management and Economics, 24, pp.253-258.

Ravi Shankar N., and Sireesha V., 2009. An Approximation for the Activity Duration Distribution, Supporting Original PERT ,Applied Mathematical Sciences, 57(3), pp.2823-2834.

Saraç, S., 1995. A Time Information System for the Construction Industry.M. S. Dissertation, Department of Architecture, İstanbul Technical University, Turkey.

Sasieni, M.W., 1986. A note on PERT times, Management Science, 32,1652-1653.

Semiha Kiziltas Ergan, and Burcu Akinci., 2012. Automated approach for developing integrated model-based project histories to support estimation of activity production rates. Journal of computing in civil engineering, ASCE, 26(3), pp.309-318.

Sezgin, Y., 2003. Developing A General Predicting Model For Construction Duration Of Buildings. M. S. Dissertation, Department of Architecture, İstanbul Technical University, Turkey.

Skitmore, R. M. and Thomas Ng, S., 2003. Forecast Models for Actual Construction Time and Cost. Building and Environment, 38, pp.1075-1083.

Smith M., 1993. Neural Networks for Statistical Modeling. Van Nostrand Reinhold, New York, USA.

Soemardi B.W., 1996. Fuzzy neural network models for construction group decision making. Computing and Information Technology for Architecture, Engineering and Construction, Proceedings (Eds H. K Lye, C. Y. Sang and H. Adeli). pp. 333-340.

Trigueiros and Berry, 1991. The application of Neural Network based methods to the extraction of knowledge from accounting reports. Organizational Systems and Technology: Proceedings of the 24th Hawaii International Conference on Systems Sciences (HICSS), pp. 136-146.

Walker, D. H. T., 1995. An Investigation into Construction Time Performance. Construction Management and Economics, 13, pp.263-274.

Walker, D. H. T. and Vines, M. W., 2000 . Australian Multi-Unit Residential Project Construction Time Performance Factors. Engineering, Construction and Architectural Management, 7, pp.278-284.

William T.P., 1993. Neural networks to predict construction cost indexes. Neural Networks and Combinatorial Optimization in Civil and Structural Engineering (Eds B. H. V. Topping and A. I. Khan). Civil- Comp Press, Edinburgh, Scotland. pp.47-52.

Wu X. and Lim S.Y., 1993. Prediction of maximum scour depth at spur dikes with adaptive neural networks. Neural Networks and Combinatorial Optimization in Civil and Structural Engineering (Eds B. H. V. Topping and A. I. Khan). Civil Comp Press, Edinburgh, Scotland, pp.61- 66.

Wu, R. W. and Hadipriono, F. C., 1994. Fuzzy Modus Ponens Deduction Technique for Construction Scheduling. Journal of Construction Engineering and Management, 120, pp.162-179.

Z. Gou, C. Fyfe, 2004. A canonical correlation neural network for multicollinearity and functional data, Neural Networks, 17, pp.285.