# Chapter 2

# Literature Review

This chapter will summarize literature survey, which are employed in this research including background of ready mixed concrete, multiple regression analysis (MR), artificial neural network (ANN), hybrid model, and related work in this area.

## 2.1 Ready mixed concrete

Ready mixed concrete is used as a building material because of two main advantages. The first one is cheaper than other materials such as steel, wood and so on. The second is that ready mixed concrete allows great diversity in design and function, which can be poured into molds of any shape. Ready mixed concrete is a perishable product that needs delivery within 1.5 to 2.5 hours before it becomes too stiff to be workable (Dewar and Anderson, 1992).

Ready mixed concrete is consumed by the construction sector to build infrastructure, commercial and residential building, factories, and so on. Demand of ready mixed concrete is inelastic because it is small part of construction cost. Concrete cost is around 10 % of materials cost for any sector of construction. The other substitution products such as precast concrete, prefabrication concrete and asphalt are major threat for ready mixed concrete business. Therefore, the ready mixed concrete market substantially affects the volume of the construction activity.

Ready mixed concrete is produced by blending cement, aggregate, additives and water which is produced in a factory, and then delivered to construction site by truck mounted transit mixers. Ready mixed concrete is also referred as the customized concrete products for commercial purpose and different specific applications. The process of ready mixed concrete production and delivery directly affects to total cost. In high competition market like Thailand, companies in the ready mixed concrete industry are facing the several problem e.g. peak period scheduling, long delivery distance, fluctuated demand, low selling price, high raw material cost and transportation cost, long credit term, high marketing cost, cost-effective manner and so on. The risk of ready mixed concrete goods is that should be laid in the period without any loss of time to avoid the reduction in workability, setting and stiffening of concrete. The time interval in between batching and pouring concrete is very critical. The delay in delivery process reduces the workability of ready mixed concrete, which effect to the difficulty in placement of ready mixed concrete. At the same time, the delay lead to the initial setting and stiffening of concrete, that effect to be unusable goods. So, the transportation of ready mixed concrete must be performed as rapidly as possible.

## 2.2 Research methodologies

### 2.2.1 Multiple regression analysis

Multiple regression (MR) approach is a statistical method to investigate the relationship between one dependent variable and two or more independent variables (Pindyk and Rubinfeld, 1991). The independent variables are also called the predictors. Relationships may be nonlinear, independent variables can be continuous, categorical or both and one can examine the effects of a single variable or multiple variables with or without the effects of other variables taken into account (Cohen et al., 2003).

$$y_i = \beta_0 + \beta_1 x_{i,1} + \beta_2 x_{i,2} + \ldots + \beta_k x_{i,k} + \varepsilon_i \qquad (2.1)$$

Where $\beta_0$ = regression constant

$\beta_k$ = coefficient on the $k^{th}$ predictor

$k$ = total number of predictors

$x_{i,k}$ = value of the $k^{th}$ predictor

$\varepsilon_i$ = random error in Y for observation i

The model of equation *(2.1)* is estimated by least squares method, which yields parameter estimates such that the sum of squares of errors is minimized. The prediction equation is

$$\hat{y}_i = \hat{\beta}_0 + \hat{\beta}_1 x_{i,1} + \hat{\beta}_2 x_{i,2} + \ldots + \hat{\beta}_k x_{i,k} + \varepsilon_i \qquad (2.2)$$

Where "^" = estimated values

The error term in equation *(2.1)* is unknown because the true model is unknown. Once the model has been estimated, the regression residuals are defined as follows:

$$\varepsilon_i = y_i - \hat{y}_i \qquad (2.3)$$

Where $y_i$ = the observed value of the dependent variable for observation i

$\hat{y}_i$ = the predicted value of the dependent variable for observation i

The residual or estimated error measures the closeness of fit of the predicted values and actual predictor in the calibration period. The algorithm for estimating the regression equation (solution of the normal equations) guarantees that the residuals have a mean of zero for the calibration period. The variance of the residuals measures the "size" of the error and is small if the model fits the data well.

#### 2.2.1.1 R, R Square, Adjusted R Square

R is a measure of the correlation between the observed value and the predicted value of the criterion variable. A partial coefficient of determination ($R^2$) is a measure of the strength of the relationship between the dependent variable and independent variable, when the linear effect of the rest of the variables is being eliminated. $R^2$ indicates the variation in Y that is explained by the independent variable X in the simple regression model (Berenson et al., 2006). However, $R^2$ tends to rather over estimate the success of the model when applied to the real applications, so an Adjusted R Square value is calculated which takes into account the number of independent variables in the model and sample size. This Adjusted R Square value gives the most useful measure of the success of the model. For example, if Adjusted R Square value is equal to 0.85, it implies that the model has accounted for 85% of the variance in the criterion variables (Osborne, 2000).

#### 2.2.1.2 Multicollinearity

The term multicollinearity (or collinearity) is used to describe the situation when a high correlation is occurred between two or more predictor variables. Such high correlations cause problems when trying to draw inferences about the relative contribution of each predictor variable to the success of the model (Osborne, 2000).

### 2.2.2 Artificial neural network

Artificial neural network (ANN) is a mathematical structure designed to mimic the information processing functions of a network of neurons in the brain (see Figure 2.1). ANN that respond to inputs through modifiable weights, thresholds, and mathematical transfer functions that process information through many interconnected units are highly parallel systems. Each unit processes the pattern of activity it receives from other units, and then broadcasts its response to still other units. ANN is particularly well suited for problems in which large datasets contain complicated nonlinear relations among many different inputs (Minsky and Papert, 1988).

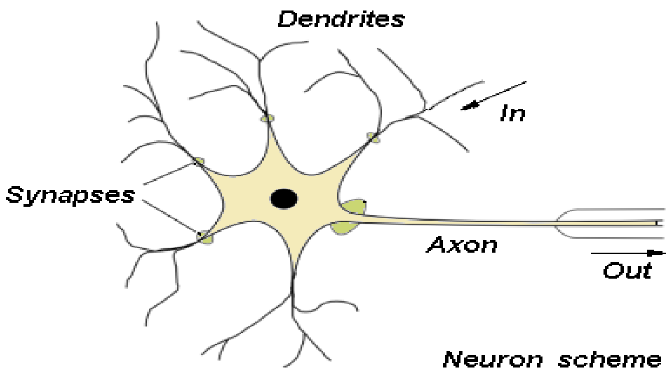


**Figure 2.1:** Schematic of biological neuron

**Source:** http://home.agh.edu.pl/~vlsi/AI/intro/

ANN is flexible nonlinear model capability that can approximate a large class of functions with a high degree of accuracy. The prediction of this experiment is used multi-layer perceptron (MLP). MLP consists of a large class of feed forward neural network with hidden nodes between the input and output nodes. All nodes in a layer are connected to all nodes in the adjacent layers through unidirectional links and all links are represented by connection weights. ANN architecture encompasses three nodes, input, hidden, and output node, which shown in Figure 2.2.

The input-output elements are trained by using a back propagation learning algorithm. The data feed forward is the relationship between input and output presented as following;

$$y_i = f(\sum_{j=1}^{N_h}(\mu_{ij} f(\sum_{k=1}^{N_i} w_{jk} x_k + \theta_j) + \lambda_i)). \quad (2.4)$$

Where $y_i$ = the output of *i-th* node

$x_k$ = the input of *k-th* node

$\mu_{ij}$ = the connective weight between hidden node and output node

$w_{ij}$ = the connective weight between input node and hidden node

$\theta_j$ or $\lambda_i$ = bias term, which is the threshold of the transfer function

$N_i$ = the number of nodes in input

$N_h$ = the number of nodes in hidden node

$N_o$ = the number of nodes in output node

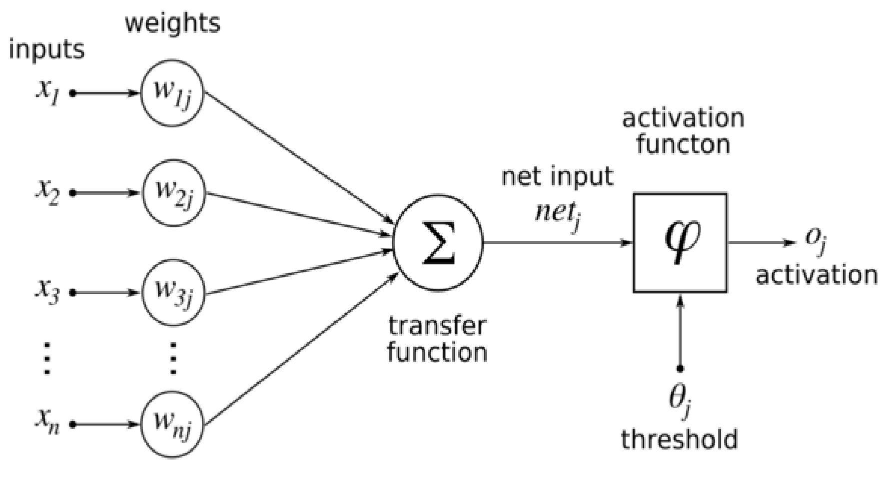


**Figure 2.2:** Structure of artificial neural network model

**Source:** http://en.wikibooks.org/wiki/Artificial_Neural_Networks/Activation_Functions

The hidden node transfer function *f* is selected as sigmoid function. Figure 2.3 shows graph of a sigmoid function The sigmoid function has the property of being similar to the step function, but with the addition of a region of uncertainty. It is given by the relationship as follows:

$$f(x) = 1/[1 + \exp(-x)] \tag{2.5}$$

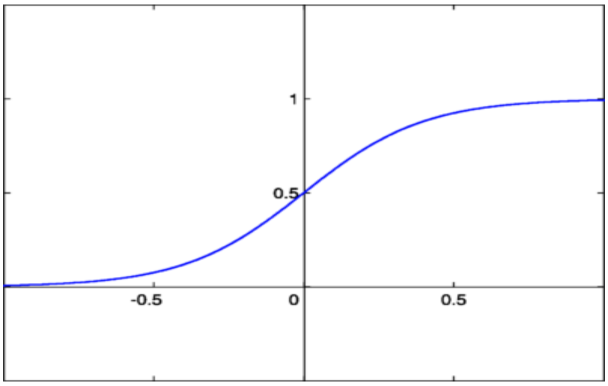


**Figure 2.3:** Graph of a sigmoid function

**Source:** http://en.wikibooks.org/wiki/Artificial_Neural_Networks/Activation_Functions

The system has error back-propagation during trained network. To monitor the performance of the network, the system is used error function as following;

$$E(w) = \sum_{p=1}^{P} (\sum_{i=1}^{N_o} (y_i^p - o_i^p)^2 \tag{2.6}$$

Where *E (w)* = the system error function

$y_i^p$ = the actual value of output node *i* for training pattern *p*

$o_i^p$ = the predicted value of output node *i* for training pattern *p*

*P* = the number of sample

The ANN model procedure starts from collecting the related data. The architecture and parameter are architecture, learning rate, momentum, and epoch. All weights are selected randomly to train. The minimum error is employed to predict the future outcome (Witten and Frank, 2005).

### 2.3 Literature review

Graham et al. (2006) presented a neural network methodology in ready mixed concrete delivery by comparing two main architectures i.e. a feed-forward network and an Elman network.Many combinations of layers, training algorithms, number of neurons, activation functions and format of data were considered in the study. The results were validated using an independent validation data set with five goodness-of-fit tests. The results indicate that two- and three-layer feedforward networks provide the best estimates of concrete placing productivity and that the Elman network

Fernandes and Teixeira (2008) presented the artificial neural network methodology for forecasting the tourism time series. This study developed models and apply them to sensitivity studies in order to predict the demand. It provided a deeper understanding of the tourism sector in Northern Portugal and contributes to already existing econometric studies by using the artificial neural networks methodology. This work focused on the treatment, analysis, and modeling of time series representing "Monthly Guest Nights in Hotels" in Northern Portugal recorded between January 1987 and December 2005. The model used 4 neurons in the hidden layer with the logistic activation function and was trained using the resilient back propagation algorithm. Each time series forecast for 12 preceding values. The analysis of the output forecast data of the selected ANN model showed a reasonably close result compared to the target data.

Pao (2008) proposed a comparison of neural network and multiple regression analysis in modeling capital structure of the high-tech and traditional industries in Taiwan, respectively. Results of this study showed that the determinants of capital structure are different in both industries. The major different determinants are business-risk and growth opportunities. Based on the values of RMSE, ANN models achieved a better fit and forecast than regression models for debt ratio, and ANN models are able of catching sophisticated non-linear integrating effects in both industries.

Lu and Lam (2009) presented simulation and optimization of computer system, which provided decision support making the best operation strategy for plant managers in order to deliver concrete to multiple site customers. The computer system can be used in practical to serve as a useful parallel to the actual system for enhancing performance, optimizing the best concrete production scheduling, planning truck fleet resources and arranging the pouring time.

Schmid et al. (2009) presented hybrid solution approach for ready mixed concrete delivery which integrated optimization and heuristic techniques. The information of multi-commodity flow component and variable neighborhood search component are considered to find the reasonable time. The high quality solutions of both components are acceptable of producing feasible solution. On the other hand, the integrated approach is more effective which outperformed 6% more than an average.

Areekul et al. (2010) presented an approach for short-term price forecast based on combination of ARIMA and ANN. The linear ARIMA model and the nonlinear ANN model were used to analyze different forms of relationship in the time-series data. They verified the predictive ability of the proposed method by simulations three different cases price forecasting of ARIMA, ANN, and hybrid model approach. The results showed that hybrid model method could provide overall forecasting capability improvement of the price forecasting accuracy and gives better predictions than either ARIMA or ANN.

Delijaicov et al. (2010) synthesized a model for peen forming process planning. Statistical methods based on MR and ANN were applied to a data set generated by peen forming designed experiments with aluminum alloy plates, aiming to synthesize quantitative models relating the highest displacement of the plate with the respective variables of the process. The results showed that the estimated displacements from both models comply reasonably well with the experimental data, the obtained results exposed the superiority of the regressive model concerning accuracy.

Ján and Katarína (2010) conducted hybrid ARIMA-neural network model to predict aggregate water consumption. The hybrid model can complement each other in capturing patterns and internal dependencies of time series. The hybrid prediction method was used for prediction of water consumption based on time series collected and the hybrid ANN outperforms the individual forecasting model.

Liu et al. (2010) proposed combinatorial predict model of enterprise profit based on stochastic partial elasticity theory and ANN. Nonlinear model was established to solve the combinatorial weighted coefficients by advance the predict accuracy to get a new predict value. Numerical simulation results showed that the new predict model of enterprise profit has strong generalization ability and could improve the predict accuracy effectively.

Merh et al. (2010) developed hybrid models ANN and ARIMA for forecasting the future index value and trend of Indian stock market. Simulation have been done using prices of daily open, high, low and close of SENSEX, BSE IT, BSE Oil & Gas, BSE 100 and S& P CNX Nifty. Simulation results of hybrid models were compared with results of ANN based models and ARIMA based models.

Zheng and Zhong (2010) proposed a hybrid methodology that combines both radial basis function (RBF) neural network and auto regression (AR) model based on binomial smoothing (BS) technique which is efficient in data processing. This method was examined by using data of Canadian Lynx. Empirical results indicated that the over-fitting problem can be eased to improve forecasting accuracy by using hybrid methodology.

Zhang et al. (2011) presented mathematical model in order to improve the operation of ready mixed concrete production as well as to decrease the dispatching cost of the whole delivery process. They considered both trucks and pump dispatching. Genetic algorithm was proposed to solve the large size of solution space.

Aladag et al. (2012) presented a new hybrid model approach combining ARFIMA and feedforward neural network (FNN) to analyze long memory time series by applying in tourism data in Turkey. Data were collected fro the number of tourists coming to Turkey during 1995-2005. Mean absolute percentage error (MAPE), and root mean square error (RMSE) were employed to compare the performance accuracy. The best forecast models were obtained by using ARFIMA and FNN2 (1-1-1). The results showed that via using only FNN model are ineffective for long time series data.

Chanprasopchai and Atthirawong (2012) proposed EBITDA calculation methodology based on commercial margin (CM) prediction by hybrid ANNs - regression and hybrid multiple regression (MR) - ANNs models for ready mixed concrete (RMC) business, which both hybrid models are suited to evaluate EBITDA. The CM accuracy performance was measured by mean absolute percentage error (MAPE), and root mean square error (RMSE), that can imply to calculate EBITDA. Commercial margin from both models was conducted to calculate EBITDA and compared for business proposed. The EBITDA results revealed that mean absolute deviation (MAD), and tracking signal of hybrid MR-ANNs model is lower than another model. Therefore, it can be claimed that hybrid MR-ANNs model is more suitable approach to evaluate EBITDA based on commercial margin prediction in RMC business between two techniques.

Anyaeche and Ighravwe (2013) conducted artificial neural network, Back Propagation Artificial Neural Network (BP-ANN), as an alternative predictive tool to multi-linear regression, for establishing the interrelationships among productivity, price recovery and profitability as performance measures. A 2-20-20-1 back propagation artificial neural network was proposed to predicting performance measures. Productivity and price recovery were used as independent variables while profitability was used as dependent variable in the BP-ANN architecture. It was indicated that BA-ANN model has mean square error (MSE) lower than multiple linear regression. The study concluded that artificial neural network is more efficient tool for modeling interrelationships among productivity, price recovery and profitability. This approach can be help to predict performance measures of firms.

To sum up, simulation, optimization, and heuristics techniques have been widely considered in a number of studies on ready mixed concrete delivery problem, for instance: Lu and Lam (2009); Schmid et al.(2009) and Zhang et al. (2011) and so on. At the same time, multiple regression (MR) and artificial neural network (ANN) are widely applied in many applications but it is still rare in ready mixed concrete business. According to the former studies, it has been claimed that over-fitting problem can be eased to improve forecasting accuracy by using hybrid methodology. In the light of these gaps, this research will employ hybrid models based on MR and ANN for modeling ready mixed concrete transportation productivity. Two hybrid models will be compared their accuracy for the target data in RMC. The benefit of the estimate model will be useful for the management in this business to plan an operation and its resources, thus avoiding shelf-life problem.