Chapter 3

Research Methodology

3.1 Ready mixed concrete transportation

Ready mixed concrete has a shelf life roughly around one and a half hour (ASTM International, 2004). As a result, both a batching plant and customers need to rely on time restriction constraint. Ready mixed concrete batching is operated at plants that mixing ingredients to be concrete and then load concrete into the mixer truck. The quality and quantities are fully control by computer system, which can be automated or semi-automated procedure. The concrete batching time is measured in order to optimize operation plan. Concrete is transited to construction site by using mixer truck that is considered by their volume, delivery distance and traveling time. In many cases, the construction site is not ready to pour concrete into customer’s construction structure. Therefore, it is necessary to wait at job site until pouring process can be fixed. The main effects of pouring time are the difference of experience, equipment and behavior of customers. The last step is return mixer truck to the batching plant. Figure 3.1 shows a whole concrete delivery process starting from batching plant transformed raw material into concrete, truck mixer traveling to construction site, waiting time in order to pour concrete at job site, pouring concrete, until returning truck to batching plant respectively. According to the whole process of concrete delivery, Table 3.1 demonstrates the specific variables employed in this research in order to measure transportation performance of ready mixed concrete business.

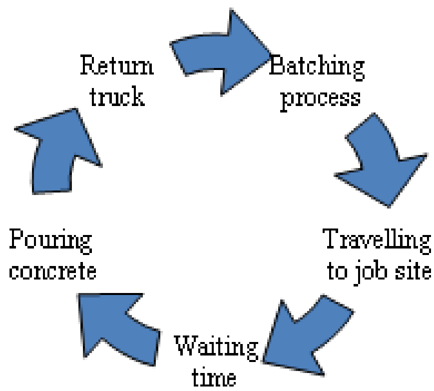

Figure 3.1: Ready mixed concrete delivery process

Table 3.1: Dependence variables employed in this research

Variables	Descriptions	Unit
Concrete volume	The amount of ready mixed concrete is placed at the construction job site.	Cubic mater
Delivery distance	The length of transportation route is measured between batching plant and construction job site.	Kilometer
Batching time	The time is needed to blend raw material to be concrete including unload into mixer truck.	Minute
Travelling time	The duration is used during transit concrete from batching plant and construction job sit.	Minute
Waiting time	The period is measured from mixer truck arrived at construction site until unload concrete.	Minute
Pouring time	The period is determined unloading concrete from mixer truck to the construction site.	Minute
Returning time	The duration is used during return truck from construction site and batching plant.	Minute
Productivity	The transportation productivity is calculated to measure the performance.	Cubic meter per minute

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.

3.2 Proposed model

This research presents two approach hybrid models in order to optimize ready mixed concrete transportation modeling, which are (1) hybrid artificial neural network-regression (ANN-regression) model and (2) hybrid multiple regression-artificial neural network (Multiple

Regression-ANN) model. The experimental procedure of two hybrid models is demonstrated in Figure 3.2.

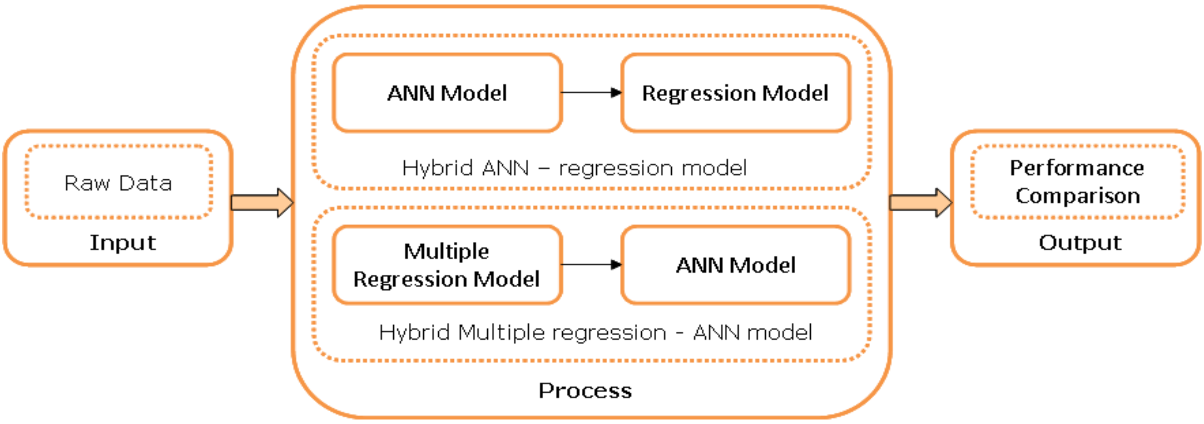

Figure 3.2: Experimental framework of two hybrid models

Hybrid models have been proposed to predict transportation productivity. Regression /multiple regression models have achieved successes based on linear relationship. On the other hand, ANN model is more suitable for non-linear relationship. However, neither regression/multiple regression nor ANN is suitable for all aspects. Hybrid model can combine the strength of regression/multiple regression and ANN models to capture both linear and non-linear relationship. The hybrid model can be written as following:

$$Y_t = N_t + L_t \tag{3.1}$$

Y_t is the hybrid model at time t,

N_t is the non-linear component at time t, and

L_t is the linear component at time t.

Hybrid ANN-regression model is the combination of ANN with regression model. The non-linear and linear component can solve and analyze the data in order to evaluate transportation productivity. The proposed hybrid ANN-regression scheme is displayed in Figure 3.3.

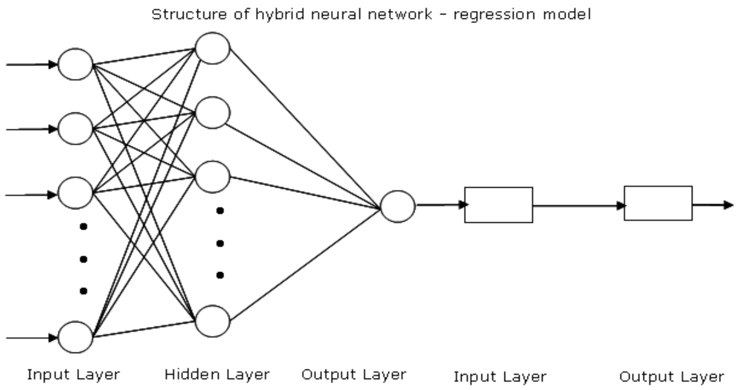

Figure 3.3: Structure of hybrid ANN-regression model

The hybrid multiple regression with ANN model is combined multiple regression with ANN model, which has the same component as hybrid ANN-regression model. The proposed hybrid multiple regression-ANN model is demonstrated in Figure 3.4.

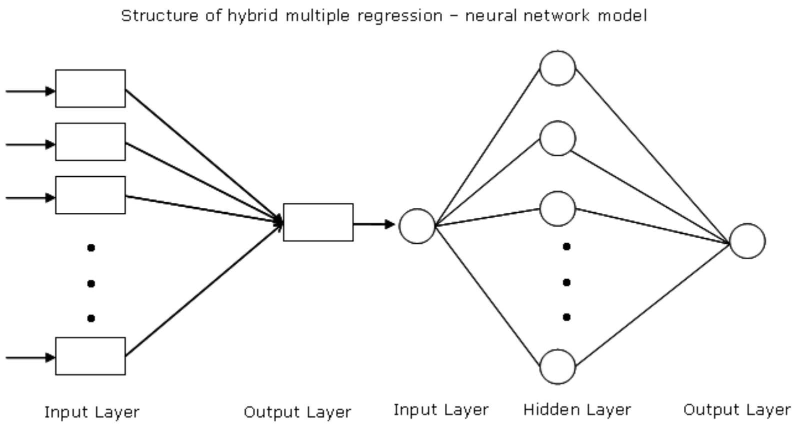

Figure 3.4: Structure of hybrid multiple regression-ANN model

In this research, the back propagation neural network learning algorithm is utilized to train the networks using WEKA software. The related parameters including learning rate, learning momentum, training epochs and hidden node are determined to obtain the optimum solution (Atthirawong and Chatchaipun, 2005). The experimental design presented in Table 3.2 was developed to generate ANN model. The parameters have been determined by trial and error in order to evaluate the optimal solution.

Table 3.2: The experimental design for ANN model

Parameters	Experimental design
Number of layers	3 layers (Input: 1, Hidden: 1, Output 1)
Activation function	Sigmoid
Learning rate	0.1 - 0.9
Momentum	0.1 - 0.9
Number of iteration	500, 1000, 5,000, 10,000 and 50,000
Number of instance	843

3.3 Data collection

The study area is located in greater Bangkok, which has traffic congestion. The mixer truck has capacity only 6 cubic meters because of law and regulation. The total 843 trips of ready mixed concrete delivery with all relevant variables were recorded during October to December 2012 in order to develop both hybrid models. Table 3.3 shows statistical information values, which were collected from the field.

Table 3.3: The statistical values of ready mixed concrete delivery

Variables	**Unit**	**Min**	**Max**	**Mean**	**Median**	**SD**
Concrete volume	m^3	0.25	6.00	4.66	5.00	1.30
Distance	Kilometer	0.10	23.15	7.49	6.50	6.27
Batching time	Minute	2.22	46.22	14.85	14.17	6.32
Travelling time	Minute	1.00	95.00	17.80	16.02	10.94
Waiting time	Minute	0.02	97.12	12.52	7.05	14.47
Pouring time	Minute	0.47	155.78	27.45	28.43	25.53
Returning time	Minute	1.00	92.02	15.26	13.00	12.14
Productivity	m^3/min	0.28	12.24	3.75	3.28	1.98

3.4 Performance comparison of two hybrid models

The actual and predicted data are then compared performance accuracy. In this research, the performance accuracy of both models are evaluated using mean absolute percentage error (MAPE) and root mean square error (RMSE), which are calculated by equations (3.2) and (3.3) respectively.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right| \times 100 \tag{3.2}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2} \tag{3.3}$$

The value of MAPE and RMSE will be compared in order to evaluate the performance. The model, which has the lower MAPE and RMSE, will be superior and then used in prediction transportation productivity.