CHAPTER SEVEN

CONCLUSION & RECOMMENDATIONS

7.1. Summary

This research deals with predicting compressive strength (fcu) of High Strength Concrete using ANN modeling technique.

Basic ingredients of HSC are generally the same as Normal Strength Concrete “NSC” (i.e. cement, fine aggregate, coarse aggregate, water), although, higher material quality may be needed in HSC. Cement with high ratio of C_2S and low fineness is recommended for HSC. Typical cement content for HSC range from (390 to 560 Kg/m^3). Aggregate particles used in HSC should not have weak planes that would cause the aggregate to fail in brittle manner as the concrete is loaded. Crushed aggregate produce higher compressive strength than gravel aggregate. Fine aggregate consisting of rounded particles and having fineness modulus in the range (2.5 to 3.2) generally recommended for HSC. Beside the better quality for traditional materials, some additional special materials may be used in HSC production such as; High Range Water Reducing Admixtures “HRWR” and supplementary cementitious materials. HRWRA are surface active agent that adsorbed on the cement particles. The overall result is that the cement particles are deflocculated and dispersed, hence, the water trapped inside the flocks gets released. This gives the concrete adequate workability at low water/cement ratios, leading to concrete with greater strength. Supplementary cementitious materials such as silica fume, contribute significantly to the strength of concrete, due to the filler effects which reduces voids created by free water in the cement paste matrix, also the excellent pozzolanic reaction with free lime calcium hydroxide which translate into a stronger transition zone at the paste – aggregate interface and as result, the ultimate concrete strength is improved. In this research one ANN Model was developed to predict the compressive strength of high strength concrete. Three layers feed-forward ANN Model with back propagation system, using 164 set of actual and reliable data which were carefully collected from the previous studies, is built by utilizing the Optimization Modeling System "Solver" in the Microsoft Office Excel (2010). The ANN model has seven input nodes representing cement (*C*), silica fume (*SF*), fly ash (*FA*), water (W), coarse aggregate(CA), fine aggregate or sand (S), super plasticizer*(SP)*, and one output node representing the compressive strength (fcu). The developed ANN Model was also used to perform a parametric study to evaluate the effect of the parameters governing compressive strength of High strength concrete.

According to the evaluation made, the developed ANN Model gives better performance which reflects the potential of ANNs as a good computing modeling technique.

7.2 The research conclusion

In this research the beneficial properties of ANN were used and one multilayer Artificial Neural Network was developed in order to predict compressive strength of High Strength Concrete at age 28 days. In the model developed in ANN method, a multilayered feed forward neural network with a back propagation algorithm was used. In ANN model, one hidden layer was selected. In the hidden layer seven neurons were determined. The model was trained with input and output experimental data. Correlation coefficients, MSE, are statistical values that are calculated for comparing experimental data with ANN model.

- The correlation between $(f_{cu})_{\text{experimental.}}$ With $(fcu)_{\text{predicted.}}$ Results of ANN model for training set was found to be 0.9592.
- The correlation between $(f_{cu})_{\text{experimental.}}$ With $(f_{cu})_{\text{predicted.}}$ Results of ANN model for testing set was found to be 0.9102.
- The effects of known parameters were matched with literature, and was found to be in a good agreement. Furthermore the ANN was used to study the impact of factors toward compressive strength.

7.3 Recommendations for further studies

The Artificial Neural Network model in this study for the predicting compressive strength of High Strength Concrete gives good results. The recommendations for the future studies can be suggested as follow:

- Large scale tests should be done to build ANNs Models with more distributed varied and reliable database.
- Different net architecture and activation functions of Artificial Neural Networks are to be used in order to increase efficiency.
- More parameters are required such as different size of aggregate.
- More than one model is to be used so as to choose the best.
- Using more professional software to build ANNs Models such as MATLAB and Neuroshell.