Ministry of Higher Education

and Scientific Research

Al-Muthanna University

College of Engineering

Department of Civil Engineering

# Predicting Axial Compressive Capacity of Concrete Filled Steel Tube Columns Using Artificial Neural Networks

A thesis submitted to the council of the College of Engineering at Al-Muthanna University in partial fulfilment of the requirements of for the degree of Master of science (M.Sc.) in Civil Engineering

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October 2023 Rabi al-Awwal 1445

## Abstract

In the recent decades, Concrete filled steel tube (CFST) columns have been widely utilized in construction due to their high strength, ductility, energy absorption, fire resistance, and cost reduction due to the absence of formwork. Estimating the axial compressive capacity (ACC) of CFST columns has been the subject of numerous experiments. In this study, artificial neural network (ANN) is used to make predictions regarding the ACC of CFST columns. The first type is Multilayer fed forward back propagation (MFFBP). It has a variety of six transfer functions, a variety of hidden layer numbers from 1 to 4, and a variety of neuron counts from 5 to 40 in each hidden layer. The second type is sugeno type of Adaptive neuro fuzzy inference system (ANFIS) with gaussian membership function and subtractive clustering to generate the rules for system. 2982 experimental tests have been collected from the literature. The experimental data is divided into 10 groups based on the cross-section shape, loading type, and column type. Based on its shape, the data is classified as rectangular or circular, the loading type is either concentric or eccentric, and the column type is either short or long. About 1000 models for MFFBP and 100 for ANFIS have been trained and tested for each group. The width and height for the rectangular group, the diameter for the circular group, the steel tube thickness, the length, the yield strength of steel, the compressive strength of concrete, the top eccentricity, and the bottom eccentricity have been the main input parameters. The ACC of CFST columns as output of ANN. ANN models are evaluated using statistical analysis to validate and test the prediction models. The best models are selected by the root mean square error (RMSE) and coefficient of determination ($R^2$). Using the RMSE, $R^2$, and mean absolute percentage error (MAPE), the best models have been compared to six design code formulas. As a result, the MFFBP models trained using the back propagation method could accurately estimate the ACC of CFST columns under concentric and eccentric loading when compared with the ANFIS models. The performance of the MFFBP best models was noticeably better across the board, with a greater range than the application limitations for existing design standards, and its behavior with input parameters was acceptable. The results of RMSE, $R^2$, and MAPE for Group 1 are 238.13, 0.989, and 9.88, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (Eurocode 4) of 451.88, 0.964, and 12.05, respectively. The results of RMSE, $R^2$, and MAPE for Group 2 are 197.02, 0.964, and 10.45, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AISC360-16) of 345.08, 0.95, and 14.52, respectively. The results of RMSE, $R^2$, and MAPE for Group 3 are 243.66, 0.984, and 10.39, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AISC360-16) of 423.2, 0.971, and 14.17, respectively. The results of RMSE, $R^2$, and MAPE for Group 4 are 119.11, 0.985, and 9.58, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AS5100) of 844.89, 0.706, and 66.42, respectively. The results of RMSE, $R^2$, and MAPE for Group 5 are 210.78, 0.985, and 10.48, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AISC360-16) of 704.1, 0.845, and 34.08, respectively. The results of RMSE, $R^2$, and MAPE for Group 6 are 222.39, 0.997, and 8.43, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (Eurocode 4) of 636.12, 0.993, and 11.27, respectively. The results of RMSE, $R^2$, and MAPE for Group 7 are 179.86, 0.987, and 12.37, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (Eurocode 4) of 302.33, 0.965, and 14.56, respectively. The results of RMSE, $R^2$, and MAPE for Group 8 are 179.43, 0.996, and 10.47, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (Eurocode 4) of 482.28, 0.989, and 12.99, respectively. The results of RMSE, $R^2$, and MAPE for Group 9 are 81.89, 0.989, and 12.47, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AIJ-2001) of 931.3, 0.67, and 51.25, respectively. The results of RMSE, $R^2$, and MAPE for Group 10 are 215.68, 0.995, and 13.02, respectively, compared with the least RMSE, MAPE, and higher $R^2$ for design codes group (AIJ-2001) of 1072.1, 0.912, and 36.52, respectively. For interested users and researchers, a graphical user interface has been created using the best models for MFFBP. All the work has been performed on MATLAB R2020a using the live script codes.

**وزارة التعليم العالي والبحث العلمي**

**جامعة المثنى**

**كلية الهندسة**

**قسم الهندسة المدنية**

# تخمين قدرة الضغط المحوري لأعمدة الأنابيب الفولاذية المملوءة بالخرسانة باستخدام الشبكات العصبية الاصطناعية

رسالة مقدمة الى مجلس كلية الهندسة في جامعة المثنى وهي جزء من متطلبات الحصول على درجة الماجستير في علوم الهندسة المدنية

من قبل

**علي عبدالله حسوني**

بكالوريوس هندسة مدنية / 2012

بإشراف

**أ.د حسين يوسف عزيز**

تشرين الاول 2023 ربيع الاول 1445