Chapter 14
Determination of Pull Out Capacity of Small Ground Anchor Using Data Mining Techniques

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ABSTRACT

The determination of pull out capacity (Q) of small ground anchor is an imperative task in civil engineering. This chapter employs three data mining techniques (Genetic Programming [GP], Gaussian Process Regression [GPR], and Minimax Probability Machine Regression [MPMR]) for determination of Q of small ground anchor. Equivalent anchor diameter (D_{eq}), embedment depth (L), average cone resistance (q_c) along the embedment depth, average sleeve friction (f_s) along the embedment depth, and Installation Technique (IT) are used as inputs of the models. The output of models is Q. GP is an evolutionary computing method. The basic idea of GP has been taken from the concept of Genetic Algorithm. GPR is a probabilistic non-parametric modelling approach. It determines the parameter from the given datasets. The output of GPR is a normal distribution. MPMR has been developed based on the principal mimimax probability machine classification. The developed GP, GPR, and MPMR are compared with the Artificial Neural Network (ANN). This chapter also gives a comparative study between GP, GPR, and MPMR models.

INTRODUCTION

The determination of pullout capacity (Q) of small ground anchor is an imperative task in civil engineering. Due to temporary use of small ground anchor, engineers do not put much effort for collecting engineering properties of soils for designing small ground anchor. Researchers use different methods for determination of Q of small ground anchor(Meyerhof and Adams, 1968; Meyerhof, 1973; Rowe and Davis, 1982a; Rowe and Davis, 1982b; Murray and Geddes, 1987; Subba Rao and Kumar, 1994; Basudhar and Singh, 1994; Koutsabeloulis and Griffiths, 1989; Vesic, 1971;

Das and Seeley, 1975; Das, 1978; Das, 1980; Das, 1987; Vermeer and Sutjiadi, 1985; Dickin, 1988; Sutherland, 1988). Shahin and Jaksa (2006) successfully adopted Artificial Neural Network (ANN) for determination of Q of small ground anchor. But, ANN has some limitations such as black box approach, arriving at local minima, low generalization capability, overtraining, etc (Park and Rilett, 1999; Kecman, 2001).

This chapter examines three data mining techniques {Gaussian Process Regression (GPR), Genetic Programming (GP), Minimax Probability Machine Regression (MPMR)} for prediction of Q of small ground anchor based on soil properties and geometry of small ground anchor. GPR is formulated as a Bayesian estimation problem. Researchers have successfully used GPR for solving different problems in engineering (Stegle *et al*., 2008; Sciascio and Amicarelli, 2008; Yuan *et al*., 2008; Pal and Deswal, 2010; Zhao et al., 2012; Chen et al., 2013). GP is a non-parametric method. It has been successfully applied to a large number of difficult problems (Hernández and Coello, 2004; Guven et al.,2009, Guven and Kisi, 2011; Azamathulla and Zahiri, 2012; Garg and Jothiprakash, 2013). MPMR is developed based on the principal mimimax probability machine classification (Lanckriet et al.,2002). It has been successfully applied for solving different problems (Sun, 2009; Sun et al., 2011; Yu et al., 2012; Zhou et al., 2013). This chapter uses the database collected by Shahin and Jaksa (2006). The dataset contains information about equivalent anchor diameter (D_{eq}), embedment depth (L), average cone resistance (q_c) along the embedment depth, average sleeve friction (f_s) along the embedment depth and installation technique (*IT*). This chapter has the following aims.

- To examine the capability of GPR, GP, and MPMR for prediction of Q of small ground anchor.

- To develop equation for prediction of Q of small ground anchor.
- To make a comparative study between the developed GPR,GP, MPMR and ANN models(Shahin and Jaksa, 2006).

DETAILS OF GPR

This section will describe GPR for prediction of Q of small ground anchor. In GPR, the relation between input(x) and output(y) is given by

$$y = f(x) + \varepsilon \tag{1}$$

where ε is Gaussian noise with zero mean and variance $\sigma2$. In this chapter, Deq, qc,fs, L and IT have been used as input. The output of GPR is Q. So,

$x = [D_{eq}, q_c, f_s, L, IT]$ and $y = [Q]$.

GPR treats f(x) as random variables.

The distribution of output y_{N+1} for a new input (x_{N+1}) is given by

$$\begin{pmatrix} y \\ y_{N+1} \end{pmatrix} \sim N\left(0, K_{N+1}\right) \tag{2}$$

with covariance matrix

$$K_{N+1} = \begin{bmatrix} K & K\left(x_{N+1}\right) \\ K\left(x_{N+1}\right)^T & k\left(x_{N+1}\right) \end{bmatrix}$$

where $K(x_{N+1})$ is covariances between training inputs and the test input and $k(x_{N+1})$ is the auto-covariance of the test input and T is transpose.

The distribution of y_{N+1} is Gaussian with mean and variance:

$$\mu = K(x_{N+1})^T K^{-1} y \tag{3}$$

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