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ScienceDirect
Engineering Applications of Artificial Intelligence 21 (2008) 883–894
Engineering Applications of ARTIFICIAL INTELLIGENCE
www.elsevier.com/locate/engappai

The use of neural network to predict the behavior of small plastic pipes embedded in reinforced sand and surface settlement under repeated load

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Received 18 November 2006; received in revised form 7 July 2007; accepted 2 September 2007
Available online 5 November 2007

Abstract

This paper presents a feed forward back-propagation neural network model to estimate the vertical deformation of high-density polyethylene (HDPE) small diameter flexible pipes buried in reinforced trenches and settlement of soil surface (SSS) subjected to repeated loadings to simulate the heavy vehicle loads. The experimental data show that the vertical diametral strain (VDS) of pipe embedded in reinforced sand and SSS are dependent on relative density of the sand, number of reinforced layers and height of embedment depth of pipe. Therefore in this investigation, the value of VDS and SSS are related to the above parameters. In the developed neural network, the neurons of the input layer represent the relative density of the sand, number of reinforced layers and height of embedment depth of pipe. One neuron is used in the output layer to represent the value of VDS or SSS. In the entire test, the intensity of applied repeated loads is constant (5.5 kg/cm^2, equal to maximum traffic load).

A database of 72 experiments from laboratory tests were utilized to train, validate and test the developed neural network. The results show that predictions of VDS and SSS using the trained neural network are in good agreement with experimental results. A comparative evaluation of artificial neural network (ANN) and regression model show that the predictions obtained from the neural network are better than regression model compared to those obtained with the experimental results.

Keyword: Neural network; Soil reinforcement; Buried pipe; Vertical diametral strain; Settlement of soil surface

1. Introduction

The buried pipes are gaining popularity for use as buried underground conduits for roadway and highway gravity-flow applications. In these applications, the pipes must support soil overburden and loads applied at ground surface due to vehicular traffic. Many researchers have focused on this topic and developed the soil–pipe interaction experimentally, numerically or presented the mathematical relations or empirical equations. The original work was carried out by Marston and Anderson (1913), and a theory for calculating diametric change under soil overburden, was used by Spangler (1941) to obtain a formula for calculating the horizontal deflection of buried pipes under soil overburden. Masada (2000) was revisited the classical work of Spangler to derive a modified Iowa formula for estimating vertical deflection of flexible pipe under soil overburden.

These design methods, whether developed from empirical or theoretical bases, deal with predicted loading experienced by embedded flexible pipes as a result of static stress. Hence, study of pipes behavior under temporary or permanent repeated load similar to heavy vehicles is an important case. Rogers et al. (1995, 1996) investigated the influence of the installation procedure on the subsequent performance of a buried flexible pipe. Faragher (1997) and Faragher et al. (2000) carried out a full-scale controlled field test to investigate the behavior of embedded flexible pipes under repeated loading in real installation conditions. Mir Mohammad Hosseini and Moghaddas Tafreshi (2002) presented a laboratory work on small-diameter thin steel pipes subjected to repeated loads. Arockiasamy et al. (2006) performed field tests on polyethylene, PVC, and metal large diameter pipes subjected to highway design truck loading.

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0952-1976/$ - see front matter
doi:10.1016/j.engappai.2007.09.001