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Predicting Lateral Wall Deflection in Top-down Excavation by Neural Network

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Deep excavation is widely undertaken in the construction of high-rise building foundations in urban areas. Measurement of diaphragm wall deflection is so important in deep excavation that monitoring data are always adopted to evaluate construction performance so as to avoid failures of the supporting system. This paper attempts to predict the diaphragm wall deflection in deep excavations by using a back-propagation artificial neural network (NN) learning model. Case histories of deep excavations (with 4 to 8 excavation stages) from the construction projects in Taipei Basin are collected for training and verification. From the results of this research, it is shown that the artificial NN can reasonably predict both magnitude and location of the maximum deflection of the braced wall in deep excavations.

NOMENCLATURE

B: width of excavation (m)
c: cohesion intercept (KN/m^2)
H: excavation depth (m)
L: length of diaphragm wall (m)
t: wall thickness (cm)
D/H_f: ratio of embedment to final excavation depth
N: standard penetration test blow count
w_n: moisture content (%)
LL: liquid limit
PI: plasticity index
E: Young's modulus (KN/m^2)
I: moment of inertia (m^4)
ϕ: friction angle (degree)
γ: total unit weight (KN/m^3)
N_{L1}: average N value between ground surface and $H_f/3$
N_{L2}: average N value between $H_f/3$ and 2/3 H_f
N_{L3}: average N value between 2/3 H_f and H_f
N_H: overall average N value considering layer thickness as weighted factor
N_{H1}: average weighted N value of 1/3 excavation depth
N_{H2}: average weighted N value between $H_f/3$ and 2/3 H_f

INTRODUCTION

In recent years, high-rise buildings and underground facilities have become so congested in urban sites that deeper underground excavations are needed for new buildings. Among many underground excavations, the top-down method is generally applied to deep excavation in soft soil, where lateral diaphragm wall deflection is usually a major concern. Excessive ground surface settlement induced by a large wall deflection may severely damage adjacent buildings (Ou et al., 1998, 2000; Hwang and Moh, 2007). How to conduct a safe excavation and minimize deformation in the surrounding ground is of utmost importance in a deep excavation project.

Since Peck (1969) employed an observational method to ensure safe construction, the estimation of lateral wall deflections and ground settlements has received substantial attention from practicing engineers and researchers. Finite element analyses are commonly applied to estimate wall deflections in deep excavation (Clough and Hansen, 1981; Powrie and Li, 1991; Hashash and Whittle, 1996). The accuracy of ground movement prediction through finite element analyses heavily depends on the soil parameters predominantly obtained from laboratory tests that are often not representative of the in-situ soil behavior due to sample disturbance, change of in-situ environment and effects of construction. To minimize the effect of soil parameters and construction factors, back analysis procedures are proposed by many researchers (Gioda and Sakurai, 1987; Whittle et al., 1993; Ou and Tang, 1994; Chi et al., 1999) to obtain modified soil parameters so that computed wall deformations will match field measurements. Although back analysis combined with the finite element provides engineers with an effective numerical approach to estimating wall deflections and surface settlements in excavations, the back analysis technique is limited to soil parameters used and the soil model applied (Jan et al., 2002).

The feasibility of using artificial neural networks (NN) for assessing geotechnical engineering problems has been examined by many researchers (Goh, 1994; Ni et al., 1996; Chern et al., 2002; Juang et al., 1999; Jan et al., 2002; and Kung, 2003). NN are computer models whose architectures essentially mimic the biological system of the brain. They have been found to be useful for analyzing complex relationships involving a multitude of variables, in place of a conventional mathematical model. In NN, the mathematical relationship between the variables does not have to be specified; instead, they learn from examples and feed to them.

This paper attempts to predict the diaphragm deflection in deep excavation by using a back-propagation NN model. The training data collected from 9 construction projects in Taipei Basin are used to develop a forecast model. Table 1 presents a summary of 9 case histories. For comparison, the finite element analysis models RIDO and TORSA are also applied to evaluate diaphragm wall deflections in deep excavation of the TNEC project. Case TNEC (Taipei National Enterprise Center) used the top-down method and a 0.9-m-thick and 35-m-deep diaphragm wall as the earth-retaining structure. Ou et al. (1998) describe detailed subsurface

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