3-D evaluation of displacements generated in ground due to tunnel boring using TBMs

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Abstract

In this paper, several analyses have been performed to determine displacements especially vertical displacements of ground surface using Plaxis 3D Tunnel and factors influencing on displacement and the way they influence have been evaluated. Since low depth ground, loose urban soils, large span, and existence of tall buildings on urban tunnels are some of their specification which makes it difficult to control superficial displacement and stability of these underground spaces. Settlements and displacement generated due to tunnel boring may damage neighboring buildings significantly. Numerical and finite element methods are one of approaches for determining displacement on the ground surface. In this paper ground settlement profile is obtained using analytical method and numerical modeling and it is proved that numerical method can be used as an alternative for analytical approaches which has more simplicity.

Keywords: tunnel, settlement, 3D, finite element.

1. INTRODUCTION

Due to expansion of urbanism and less places on ground surface in megalopolises, it is necessary that public transportation systems to be extended in the form of underground lines. Practicing the tunnels in megalopolises has a lot of challenges such as a lack of space for site equipment, constructing of shafts, local traffic leading, convergence of lines with urban facilities, and etc. Settlement of tunnels during tunnel boring and its destructive effects on surface structures is another problem of tunnel boring. Although applying a pressure to front of work can omit some part of this settlement, applying significant pressures has some other undesirable effects on sewerage system and will cause abnormal heave in loose areas which alters the underground water regimes. Therefore, amount of settlements due to underground tunnel boring and its consequent effects are considered by researchers during the times to estimate it previous to beginning of construction using appropriate methods. By a review on literature in this field, it can be found that extended methods can be categorized in three approaches: empirical methods, analytical methods, and numerical methods.

Exponential Gaussian correlation suggested by Peck & Schmidt 1969 which has been presented for all results of settlement due to tunnel boring all over the world is one of extended empirical methods. In continuance, analytical correlation for surface settlement based on ground loss and reduction of tunnel radius in boring situation is presented by Rankin & Kasali 1983. This new approach has more accurate results than the previous one. An empirical correlation for predicting of the maximum surface settlement has been presented by Wang et al. 2000. This approach is an extended version of previous methods and undrained strength of soil is entered in accounts, as well. Closed solution of Sagaseta 1987 for isotropic and homogenous and uncompactable soils is one of analytical methods based on elasticity theory which is obtained from general balancing equations and is used for estimation of superficial settlement. Verruijt & Booker 1996 assumed a circular deformation around the tunnel and by the use of virtual image technique, and presented a modified method from previous approaches for homogenous and semi –infinite elastic and uncompactable soils. All these methods were unable in acceptable estimation of settlement which is comparable with measured values. In continuance, they entered analytical correlation presented by Poulos & Loganthan 1998 and equivalent ground loss concept in their analytical method in which the parameter introduced by Lee et al. is used. Also, area of boring effect with 45 degree inclination angle, based on Cording & Hansmire 1975 assumption, was considered. Elliptic gap due to nonlinear ground movement was considered in accounts. Based on this approach, obtained case studies results for hard clays were acceptable,