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Control of surface settlements with Earth pressure balance method (EPB) for Istanbul metro

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ABSTRACT

Regarding urban development, metro tunnels are increasingly being excavated in soft ground conditions. In metro tunnel excavations, it is important to control surface settlements observed before and after excavation, which may cause damage to surface structures. Construction of tunnels induces a state of strain in the soil around the excavation that could cause damaging differential displacements in existing structures near the tunnel. This paper reports the results of a study carried out to estimate the values of the surface settlements induced by the excavation of twin tunnels, which have been excavated between the Otogar and Kirazlı stations of the Istanbul Metro line namely a length of 5.77 km. Authors of the paper have not carried out field studies at the tunnel; data related to tunnel were taken from Mahmutoğlu (2010), Ocak (2009) and Ercelebi et al (2010). In this paper only numerical modeling has been performed on obtained data. In particular, the purpose of this study has been to compare the vertical surface displacements monitored during the advancing excavation and the settlements estimated by using 3D Finite Difference model. For numerical analyses, FLAC3D program is used. Geology in the study area is composed of fill, stiff clay and dense sand and hard clay. Tunnels are excavated by using two Earth Pressure Balance Tunnel Boring Machines with a 6.5 m diameter as twin tubes with 14 m distance from center to center. Ground settlement results obtained by numerical modeling are in good agreement with field measurements.

KEYWORDS

Numerical modeling, Surface settlement, Face pressure, FLAC *3D*.

1. INTRODUCTION

Many tunnels must be built in weak materials such as sands and clays. These tunnels tend to be at shallow depths and near urban infrastructures; consequently the construction method must minimize surface settlements. Ground loss at the tunnel is consequentially translated into an equivalent surface depression especially in cohesive soil and tunneling in shallow ground (Attewell et al., 1986). Effects of settlement due to shallow and soft ground tunneling are hazardous to nearby buildings, infrastructures and existing services. Problems related to tunnel-induced settlements have interested many researchers in the last 40 years. The surface settlements can be estimated by using empirical or semiempirical methods Peck (1969), Atkinson (1977), Attewell (1982), Mair (1983), New (1991), Einstein (1981), Oteo (1979), analytical methods Sagaseta (1987), Verruijt (1996), Loganathan (1998), Bobet (2001), Chou (2002), Park (2005), and numerical methods Suwansawat (2006), Mroueh (2006), Melis (2002). Many innovations have been introduced to improve tunneling in soft ground. At present, the earth pressure balance (EPB) Shield Tunneling Method, which was first developed in Japan (Stack, 1982 and Maidl et al., 1996) has become one of the most popular methods for soft ground tunneling. With this tunneling technique, ground movement can be, in theory, controlled by balancing the pressure inside the earth pressure chamber relative to the outside ground pressure during excavation. To achieve ground movement control, there are many operational parameters involved such as face pressure, penetration rate, pitching angle, and grouting quality. Shield–ground interaction is complex due to variety of these factors.

This paper reports the results of a study carried out to