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An Innovative Method of Large Space Underground Construction in Soft and Shallow Ground Using Concrete Arch Pre-Supporting System, CAPS Method

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ABSTRACT

Construction of underground structures in urban areas is a very challenging work. There are generally two methods of their construction, an open cut-and-cover and underground method. To eliminate the subsurface and surface disturbance and street traffic problems, underground method is preferred. The stress redistribution caused by underground excavation induces movements in the earth mass and ultimately at the ground surface. This is more pronounced in large space excavations. Generally pre-supporting system is used to control ground deformation and thus enhance its stability. In this paper an innovative pre-supporting system is presented. *Concrete Arch Pre-supporting System (CAPS)* is introduced in Tehran Metro in 2002. This method has roots in construction method of an Old Iranian small water tunnels, called *Quanat*. *CAPS* is an efficient method for stabilizing large span underground spaces constructed in shallow and soft ground. In this technique underground reinforced concrete elements are constructed around the proposed underground space prior to main excavation. This method is used successfully in over 50 large span underground structures in Tehran Metro. *CAPS* has a potential to be used to pre-support the large span underground spaces at any weak ground condition in an urban area.

KEYWORDS

Large Span Underground Spaces, Subway Stations, Concrete Arch Pre-Supporting System, CAPS, Numerical Modeling

1. INTRODUCTION

Underground subway stations can be constructed either by open cut-and-cover or underground construction. Due to the presence of subsurface utilities and street traffics in urban areas, underground are preferred to eliminate relocation of the subsurface utilities, and other city disturbance.

Underground construction in an urban area is a very challenging effort. In a weak and shallow ground and large span underground structures, the complexity is more pronounced. The stress redistribution caused by underground excavation induces movements in the earth mass and ultimately at the ground surface causing damage to adjacent structures.

The need to control ground surface settlements in urban area is widely recognized and new construction methods are continuously developed. Settlements induced by underground excavation may cause serious damages to nearby structures and subsurface underground utilities, (Sekimoto et. al. 2001).

Various ground treatment techniques to improve stability of underground excavation and reduce settlements are presented in recent literature, Carrieri, et.al. (2002), and Ocaik (2008). Different forepoling, grouting methods and pre-supporting the main tunnel by concreted small horizontal tunnels were introduced, (Johnson, et.al., 1983).

Concrete Arch Pre-supporting System (CAPS) is introduced in Tehran Metro in 2002, (Sadaghiani, Gheysar, 2003). This pre-supporting system is a very effective method for stabilizing large span underground spaces in shallow and soft ground and reducing the ground deformation and subsequently the surface settlement. In this technique underground reinforced concrete elements, including piles and curved beams (arches), are constructed around the proposed underground space prior to main excavation in order to support the ground during the excavation of the underground section, Figure 1.

Subsequent to pre-supporting, excavation can be executed in variety of methods. Generally multi-stage excavation and supporting is used to finalize the construction of the desired section.