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# Effects of face excavation patterns on time dependent behavior of tunnel

**Mohammad Maleki[1], Mohsen Mousivand[2]**

**1- Associate Professor, Department of Civil Engineering, Bu-Ali Sina University, Hamedan, Iran**
**2- PhD student, Department of Civil Engineering, Islamic Azad University, Science and Research Branch, Tehran, Iran**

Maleki@basu.ac.ir
Mohsenmousivand@gmail.com

**Abstract**

A number of numerical analyses were performed to investigate the effect of different patterns of tunnel face excavation, in NATM, on the time-dependent behavior of ground due to tunneling. For achieving this aim an elastoplastic-viscoplastic constitutive model implemented in FLAC code was used. Towheed tunnel which was constructed in accordance with the principles of the New Austrian Tunneling Method (NATM) as a case study is analyzed by three different face advance techniques. Three type of excavation patterns studied in the present work are; twin sidewall excavation (Method-a), crown, invert face excavation (Method-b), and crown, bench, and invert face excavation (Method-c). The obtained Results shows that Method-a presents a less ground settlement, and can be considered as more proper method for tunnel excavation.

**Keywords: sequential excavation, NATM, elastoplastic-viscoplastic, constitutive model, FLAC 2D.**

## 1. INTRODUCTION (with two 9 pt lines space from the keywords)

Due to recent city developments with limited available land to build on, more and more public facilities are developed under the ground surface (Chou and Bobet 2002). For obvious practical reasons such as accessibility, serviceability, and economy, these tunnels are often constructed at shallow depths through soft soil (Chungsik 2002). Underground construction, including tunneling, causes both vertical and lateral ground movements. For existing structures, the ground movements induced by activities such as tunneling may cause a reduction in bearing capacity of the foundations as well as the development of additional settlements, differential settlements, and lateral movements (Surjadinata 2006). In most conditions, the excavation of an underground tunnel with large section is composed of several phases. When such a tunnel is excavated in soft grounds, all intermediate excavation phases have to be considered in the stage of design, or else possible failure during intermediate phases would be neglected, causing serious problems during construction. This parameter will strongly influence the initial and long-term deformations in the vicinity of a tunnel and on the ground surface (Purwodihardjo and Cambou 2005). One of the ability of numerical methods allows the possibility of simulating the different phases of advance in geotechnical works, being able to identify critical situations at the design stage. It is suggested that should use various staged construction modeling by numerical methods, in order to avoid those vulnerabilities, especially for tunnels excavated in soils.

The arrangement of underground openings and their excavation sequence depend on the necessary operations to be conducted in them (excavation method, installation and construction of temporary and permanent support, short-term and long-term use, etc.), the nature of the rock mass or soil, and the soil pressure conditions encountered. Therefore, there is a practical need to simulate the different phases of underground construction and, if possible, find the optimal construction procedure considering not only rock mechanics issues but also construction time and cost (Kim et al. 1999; Szechy 1967).

In this paper, numerical simulation results of different sequences of excavation and installation of support with emphasis on the time delay between excavation and support lining is presented. The elastplastic-viscoplastic constitutive model is used to identify suitable method of tunnel excavation pattern with less ground settlements.