



Comparison of Two Main Techniques in Staged Tunneling Using Numerical Simulations and Design Charts

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Abstract

Tunneling techniques with their own advantages and disadvantages have been applied all around the world depending on site conditions and economy of the task. In the present work, 2D numerical simulations of an arch shaped tunnel considering two traditional techniques (Cut and Cover and NATM) have been presented. The study focused upon the stresses induced in the lining due to the two different construction procedures and the results were obtained in terms of the moments and displacements borne by the structural system. Imposed loadings in the two techniques are assessed and finally engineering judgment on the overall performance of the tunnel is discussed. The comparison shows that more emphasis should be put on strength properties of tunnels made via NATM. Less axial forces in conjunction with more bending moments for NATM tunnels are another observation made in the current study which highlights prominent effect of moments in NATM procedure.

Keywords: Tunneling, NATM, Cut and Cover, Numerical simulation, Bending moment.

1. INTRODUCTION

The development of metropolitan areas in recent decades has increased demands regarding efficient use of land. The rising trend of traffic congestions and environmental concerns in dense populated areas are the main motives for developing new methods and technologies in underground operations which seem to partly relax traffic along with highway constructions. The limitations of construction sites in urban areas due to the existence of lifeline facilities and high rise buildings are of major importance in planning such projects. Since the application of the most efficient approach in a project is of high priority, different parameters such as the availability of technology, inherent site characteristics, time required for completion of the task and its economic return should be considered.

Various methods in tunnel excavation such as cut and cover tunneling, sequential excavation or New Austrian Tunneling Method (NATM), drill and blast and bored tunneling by use of tunnel boring machines (TBM) have been proposed; the pros and cons of which suit best different circumstances engineers come across in practice. In addition, properties of the material to be cut through are another factor that determine the stage at which the most severe conditions are to be expected. Whilst excavation in soft ground is easy, its stabilization is of major concern. This holds vice versa for cutting through hard rock in which the most challenging part of the project is the excavation phase. Cut and Cover tunneling is a suitable method in constructing shallow tunnels of depths roughly up to 15m. However, the relative environmental impacts due to construction and demolition (C&D) waste produced during different stages and their disposal are a drawback in such projects. Furthermore, other implications such as noise and dust due to construction add to its adversity. Although such effects are reduced in the drill and blast approach, NATM seems to lower such drawbacks the most. Despite the more environmental friendliness of NATM, one should note the slow progress of the work might increase the potential of any environmental effects at a local level. The disadvantage of drill and blast tunneling technique is that the storage of explosives in magazines could be hazardous and such operations demand great caution. The most mechanized type of tunnel construction is of bored tunnels in which excavation, stabilizing the excavation face, lining and transportation of the excavated material are all handled by TBM. Such machines provide engineers with the ability to excavate tunnels in the most unfavorable ground conditions. Albeit such benefits, one has to notice that the expensive machine is of high mechanical complexity and therefore not economic for every project. Furthermore, it is usually designed for one specific project with planned geometry and its usage is mostly restricted to the project it has been specifically defined for. As a result, although use of tunnel boring machines is at first very desirable for tunnel construction, its usage is usually limited for one project after which the machine efficiency does not justify further maintenance costs. Numerous research on tunnel design and excavation with focus on Cut and