Tunnelling and Underground Space Technology 73 (2018) 15–25

Contents lists available at ScienceDirect

Tunnelling and Underground Space Technology

journal homepage: www.elsevier.com/locate/tust

A comparative study on evaluation of steady-state groundwater inflow into a circular shallow tunnel

Arash Nikvar Hassani[a], Hadi Farhadian[b], Homayoon Katibeh[a,*]

[a] Department of Mining and Metallurgical Engineering, Amirkabir University of Technology (Tehran Polytechnic), Hafez Ave., P.O. Box 44113-15875, Tehran, Iran
[b] Department of Mining Engineering, Faculty of Engineering, University of Birjand, Birjand, Iran

ARTICLE INFO

Keywords:
Groundwater inflow
Steady state
Analytical formula
Empirical method
Numerical modeling
Tabriz metro

ABSTRACT

The objective of this study is to make a comparison among different methods used for evaluation of steady state groundwater inflow to a shallow circular cross section tunnel. These methods include: analytical solutions, empirical methods and numerical modelling. Analytical formulas provide an estimation of inflow rate based on some simplifying assumptions which are somehow unrealistic. Therefore, their results are over/underestimated. Empirical methods are presented based on the experiences of different tunnel projects and they mostly provide an appropriate qualitative estimation; while, their quantitative predictions are not desirable. Despite analytical and empirical approaches, numerical modelling is a suitable tool for solving complex geomechanical and hydrogeological conditions. Hence, their results are more reliable and precise for designation of efficient drainage systems. In this study, groundwater inflow into Tabriz Metro-Line 2 (*TML2*) is evaluated by means of these methods and their results were compared. The results indicated that all of the methods provide consistent results, however, it is inferred that in the absence of sufficient data, Raymer equation can provide more reliable estimation of inflow rate for shallow tunnels in comparison to other analytical and empirical solutions due to its higher correlation with numerical results.

1. Introduction

One of the most challenging issues in underground operations like tunneling is groundwater inflow which has severe consequences such as instabilities, life loss of workers, ground settlements and environmental disasters (Pujades et al., 2012; Farhadian et al., 2016a,b; Farhadian et al., 2017). In some of the tunneling projects in Iran, there have been inflow problems like Ghomroud, Semnan and Kuhrang with the maximum inflow rate of 80, 750 and 1200 l/s, respectively (Zarei et al., 2013). This phenomenon, in economical point of view, leads to impediment in construction progress and heavy financial losses. Moreover, the application of TBMs (Tunnel Boring Machines) in underground tunneling especially in urban areas has been significantly increased due to its rapid advance and safe operation. The efficiency of TBMs can greatly decrease in adverse geological conditions (presence of water bearing formation can greatly influence TBM performance) (Coli and Pinzani, 2014; Gong et al., 2016; Rostami, 2016; Culí et al., 2016). Hence, comprehensive assessment of groundwater inflow to tunnel is necessary for designing of efficient drainage systems.

Various methods have been developed in the last decades for investigation of groundwater inflow to the tunnels like analytical, empirical and numerical methods. Analytical solutions are based on Darcy's law and conservation of mass. These methods were presented based on some simplifying assumptions like homogeneous and isotropic rock mass permeability, steady state flow, circular tunnel cross section held at a constant hydraulic potential. Empirical methods like IMS, SGR (Site Groundwater Rating) and TIC (Tunnel Inflow Classification) are also presented to qualitatively and quantitatively estimate groundwater inflow to the tunnel. These methods using geological and geomechanical parameters provide qualitative and quantitative estimation of groundwater inflow to the tunnel. Moreover, numerical methods like finite element method and discrete element method have been widely used by the advancing of faster computers.

The aim of this study is to compare different methods used for estimation of steady-state groundwater inflow to a circular tunnel. To this end, a review of the methods are provided in each section and then steady-state groundwater inflow into Tabriz metro-line2 (*TML2*) is predicted using analytical, empirical and numerical methods, respectively. Finally, a comparison has been made. The results of this study can be used for identification of the capabilities of the methods.

* Corresponding author.
E-mail addresses: a.nikvar@aut.ac.ir (A. Nikvar Hassani), farhadian@birjand.ac.ir (H. Farhadian), Katibeh@aut.ac.ir (H. Katibeh).

https://doi.org/10.1016/j.tust.2017.11.019
Received 26 August 2016; Received in revised form 30 August 2017; Accepted 5 November 2017
0886-7798/ © 2017 Elsevier Ltd. All rights reserved.

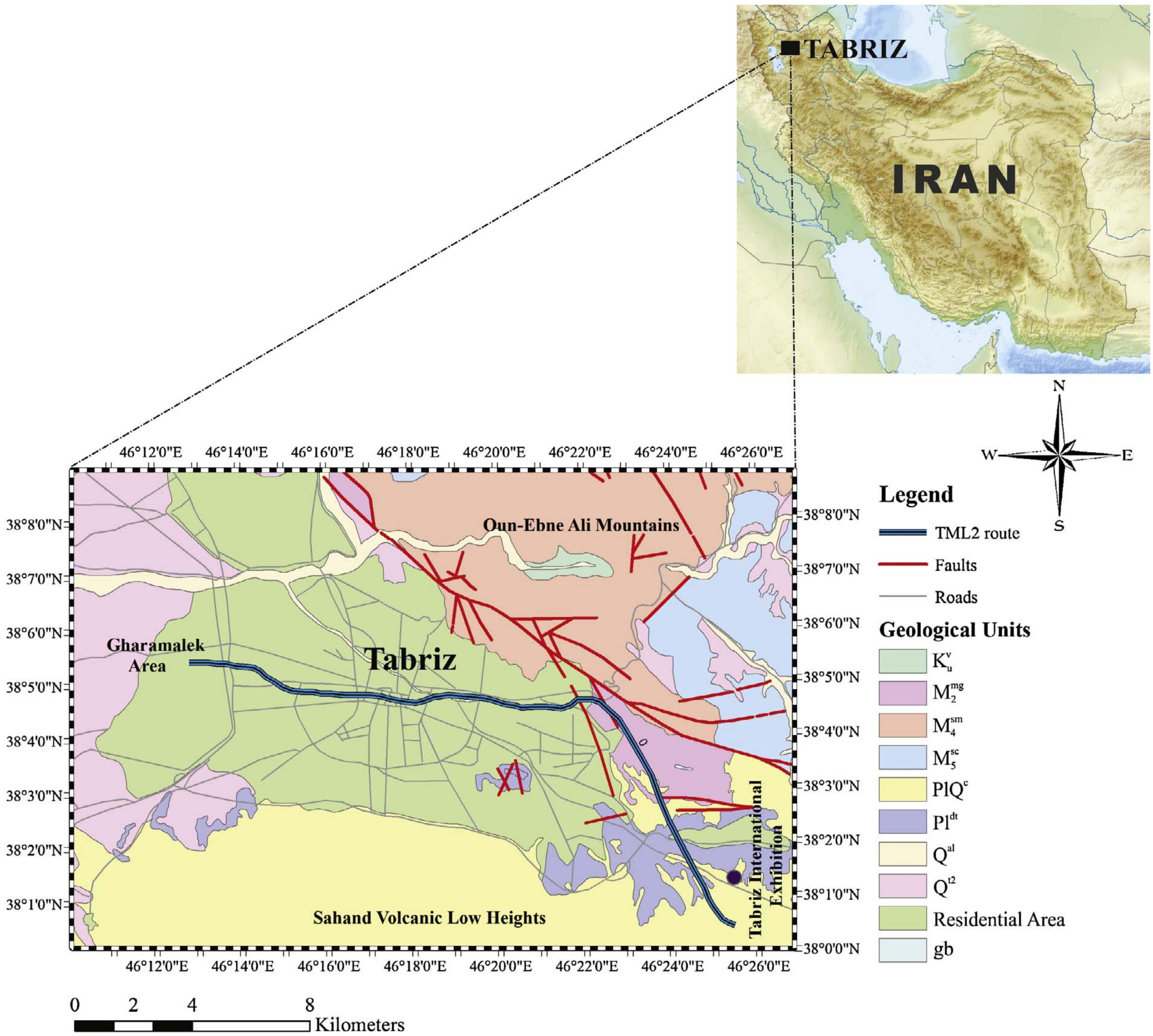

Fig. 1. Map of Tabriz area. *TML2* route is shown with blue line which links Gharamalek area in west of the city to Tabriz International Exhibition in southeast of Tabriz (Nikvar Hassani et al., 2016). Description of the geological units are as follow; K_u^v: Basic and ultrabasic rocks, M_2^{mg}: Alternation of greengrey and red marl with intercalation of gypsiferous and salutiferous sandy, M_4^{sm}: Red sandstone with marl, M_5^{sc}: Red conglomerate with alternation of sandstone and red marl, PlQ^c: Conglomerate, moderately consolidated with intercalation of sandstone pumice and pyroclastic, Pl^{dt}: Fine clastic sediments, tuff with diatomite and fishbed, Q^{al}: Recent alluvium, Q^{t2}: Younger terraces and gravel plain (Dasht), *gb*: Gabbro (Geological survey of Iran, 1993).

2. Site investigation

2.1. Geological settings

The approximately 22 km long Tabriz metro-line 2 tunnel (*TML2*) is constructing in Tabriz, East-Azerbaijan province, north west of Iran. *TML2* with E-W trending links Gharamalek area in west of Tabriz to International Exhibition Center in south east of the city (Fig. 1). The rock cover varies between 10 and 30 m along *TML2* (P.O.R Co, 2011).

TML2 passes through red clastic continental sediments (middle Miocene) and Quaternary alluvial sediments in west of Oun-Ebne Ali mountains. These red clastic sediments are named as Red Bed Formation by Rieben in 1935 and constitute layers of gypsum and salt and mainly comprise of Sandstone, Marl, Siltstone and Conglomerate (P.O.R Co, 2011). Generally, lithology of *TML2* route between Gharamalek and Baghmisheh area is mainly alluvial sediments, whereas from Baghmisheh to the east lithology of the tunnel path is predominantly marl, claystone and siltstone. Geologically, *TML2* route is divided into 5 zones as following (Asghari-Kaljahi et al., 2015):

Zone 1, in west of the city from Sanat square in Gharamalek to Jahad square up to the studied depth (almost 30 m), is comprised of alluvial deposit consist of fine grain and sand alternation. Also, variation of groundwater table is between 5 and 18 m.

Zone 2 is from Jahad square to Selab-Aghzi in Abbasi Street. Coarse grain alluvial sediments (gravel and sand) with rock fragments (boulder and cobble) floated in them are constituted the surface layers of this zone. In addition, among coarse grain sediments interlayer fine grain alluvial exist, however, *TML2* mainly passes through coarse grain sediments. Groundwater table varies between 6 and 30 m.

Zone 3 is from Selab-Aghzi to Shahid Fahmideh square in where week rock layers of claystone, mudstone, sandstone and marlstone underlain with surface alluvial sediments of 5–15 m thickness. Also, fine and coarse grain alluvial deposits form the surface alluvial sediments. *TML2* passes through rock layers in this zone. Moreover, groundwater table variation is between 3 and 32 m.

Zone 4, distance between Shahid Fahmideh square and east of Baghmisheh, is mainly formed of coarse grain (sand-gravel) and fine grain (clay-silt) alluvial. *TML2* passes through these sediments in this section. In addition, groundwater varies between 2 and 20 m.

Zone 5 is from Baghmisheh to Tabriz International Exhibition center

Download English Version:

https://daneshyari.com/en/article/6782657

Download Persian Version:

https://daneshyari.com/article/6782657

Daneshyari.com