Influence of various geomechanical and geometrical parameters on the rate of ground loss and surface subsidence in EPB tunneling by numerical modeling

Mahdiye Khademi Dehkordi, Saeed Mahdavi*, Mohamadreza Choubineh
Department of Mining Engineering, Isfahan University of Technology, Isfahan, 8415683111, Iran
*Corresponding author, smahdevari@iut.ac.ir

Abstract
As a result of rapid urbanization and population growth, the demand for underground infrastructure, particularly tunnels, has risen sharply. Tunnel excavation induces in-situ stress changes in the surrounding rock mass and soil, often leading to surface subsidence, which is a critical concern for surface and subsurface structures. Accurate prediction of surface subsidence remains a challenge due to the complex relationship between ground loss and subsidence. This study aims to develop an equation to estimate the ground loss in EPB tunneling and establish a correlation between ground loss and surface subsidence using numerical modeling and field data. The finite difference approach was employed to simulate ground behavior during excavation, followed by validation applying field data. A series of 27 numerical models were developed and analyzed using the Taguchi method to evaluate ground loss rates in different tunnel sections. Sensitivity analysis and multiple regression were performed to identify key influencing factors. Results indicated that geomechanical parameters, including deformation modules, cohesion, Poisson's ratio, and internal friction angle, inversely affect ground loss, while geometric parameters like tunnel diameter and overburden height have a direct effect. A mathematical model with a determination coefficient of 89% was derived to predict ground loss, while another model with an 81% determination coefficient was developed to relate ground loss to surface subsidence. Among the tunnel's geometrical parameters, the tunnel diameter, and among its geomechanical parameters, cohesion and internal friction angle have the greatest impact on the ground loss rate.

Keywords: EPB tunneling, Surface subsidence, Ground loss rate, Numerical simulation, Taguchi, Multiple regression

Highlights

- *Among the geomechanical and geometric parameters, the tunnel diameter has the greatest impact on the ground loss.*
- *Cohesion has the most significant effect on the ground loss among geomechanical parameters.*
- *An equation is developed to predict the subsidence with an 81% determination coefficient based on the geomechanical and geometrical tunnel parameters.*
- *A mathematical model with a determination coefficient of 89% was derived to predict ground loss.*

Abbreviations

SPT	Standard Penetration Test
DOE	Design of Experiments
ANOVA	Analysis of Variance
$V_{L\text{-}rate}$	Ground loss rate
$V_{L\text{-}total}$	Total ground loss
Vf	Total ground loss at tunnel face
Vs	Ground loss along shield
Vt	Ground loss along backup
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
S_{max}	Maximum surface subsidence

1. Introduction

Because of the rapid growth of urbanization and the development of underground infrastructure, particularly tunnels, surface subsidence caused by tunnel excavation has emerged as a significant challenge in geotechnical engineering. Subsidence can adversely affect both surface and subsurface structures, making the accurate prediction of this phenomenon essential during the design and