Ain Shams University
Faculty of Engineering
Department of Structural Engineering

Behavior of Bored Tunnels in Egypt Soft Clays

A THESIS
Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN CIVIL ENGINEERING

Submitted by

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Thesis Title : **Behavior of Bored Tunnels in Egypt Soft Clays**
Degree : **Master of Science in Civil Engineering (Structural)**

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This dissertation is submitted to Ain Shams University for the degree of Master of Science in Civil Engineering (Structural Engineering). The work included in this thesis was carried out by the author in the Department of Structural Engineering, Faculty of Engineering, Ain Shams University, Cairo, Egypt. No part of this thesis has been submitted for a degree or qualification at any other university or institution.

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Supervisors: **Prof. Fathalla M. El-Nahhas** and **Dr. Mohamed F. Mansour**

Title: **Behavior of Bored Tunnels in Egypt Soft Clays**

ABSTRACT

The primary objective of this research study is to investigate the behavior of a typical bored tunnel crossing Suez Canal at the south of Port-Said City, referred to as Port-Said Tunnel (PST). The tunnel is constructed in a deep very soft to firm clay deposit lying in El-Tina Plain and is known as Port-Said Clay. The Port-Said Clay characterization is based on the results of recent research studies. The available information on the bored tunnel was limited to the method of tunneling which is TBM with slurry support and compensation grouting through the tail, geometric configuration and boring diameter. No field measurements were available for use in this research study.

The interaction between PST and Port-Said Clay is investigated by numerical analysis. The finite difference-based program FLAC 7.0 is utilized in the analyses. The constitutive behavior of Port-Said Clay is described using the modified cam clay (MCC) model. Due to the absence of field measurements for the typical bored tunnel under investigation, verification of the numerical model results is carried out by simulating the behavior of a bored tunnel in similar ground conditions in eastern Canada (Thunder Bay Tunnel) using the same numerical method and the same constitutive model. The numerical analysis results are compared with the available field measurements.

The parametric study on the behavior of PST in Port-Said Clay involved investigating the effects of different face and grouting pressures on the short and long-term behaviors. A hybrid tunneling modeling approach is adopted. The Gap approach is utilized to simulate the volume loss due to shield advance, and the grout pressure method is used to simulate the application of annular grouting. The tunneling behavior is investigated during three phases simulating the shield advance, application of grouting, and long-term behavior.

The results of the analysis are presented in terms of the stress fields, pore pressure response, strain fields, displacement fields, ground displacement and lining straining actions.

The results of the analysis showed a significant effect of the variation of the face and grouting pressures on the tunnel's short and long-term behaviors. The grouting pressure is the primary factor that governs the long-term behavior. The results are compared to some published field measurements and show a reasonable match.

Keywords: *Bored tunneling, soft clay, Port-Said Clay, numerical analysis, Gap approach, long-term behavior*

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