Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 172 (2017) 31 – 41

Procedia Engineering

www.elsevier.com/locate/procedia

Modern Building Materials, Structures and Techniques, MBMST 2016

Experiences gathered from the construction of Napoli underground

Alessandro Mandolini[a], Giulia M.B. Viggiani[b]

[a] *Seconda Università degli Studi di Napoli – DIcDEA, Via Roma 29, 81031 Aversa (CE) – Italy*
[b] *Università degli Studi di Roma Tor Vergata – DICII, Via Politecnico 1, 00133 Roma – Italy*

Abstract

The design of a deep excavation must address a number of issues such as, for instance, the choice of an adequate support system, the definition of the sequence of construction phases, the computation of the stresses in the structural members, and the evaluation of the magnitude and distribution of ground displacements connected to the construction phases and to possible changes of groundwater pressures connected with the excavation. Under these premises, in the paper it is presented a summary of the main results obtained by an intense monitoring program carried out in the occasion of the construction of deep excavations in the densely urban environment of Napoli (Italia) for the completion of the existing Underground Line 1.

Peer-review under responsibility of the organizing committee of MBMST 2016

Keywords: Artificial Ground Freezing, Case Histories, Deep Excavation, Monitoring, Underground.

Nomenclature

B	station width
L	station length
H	total excavation depth
H_s	thickness of granular cohesion-less soils
H_w	water table above maximum excavation depth
e_0	soil void ratio
γ, γ_d	soil density at natural water content, dry soil density
φ'	soil angle of shearing resistance or friction angle
k	soil permeability to water
N_{SPT}	SPT number of blows
q_c	CPT cone resistance

Peer-review under responsibility of the organizing committee of MBMST 2016
doi:10.1016/j.proeng.2017.02.014

1. Introduction

The design of a deep excavation must address a number of issues such as, for instance, the choice of an adequate support system, the definition of the sequence of construction phases, the computation of the stresses in the structural members, the evaluation of the magnitude and distribution of ground displacements connected to the construction phases and to possible changes of groundwater pressures connected with the excavation. The importance of all the aspects listed above are enhanced in urban environment: the ability to predict correctly ground movements around excavations is indeed a crucial aspect for a successful design in order to prevent potential damage to adjacent structures and services.

The increased availability of computer programs has made the prediction of ground movements using numerical analyses relatively common. However, many factors affect the numerical prediction of ground movements associated with excavations: the choice of an adequate constitutive model for the soil, the correct definition of the soil profile, the selection of representative physical and mechanical properties for each layer, the definition of appropriate ground water conditions and initial stress states, the representation of the structural geometry and boundary conditions, and (last but not least) the modeling of the sequence of construction phases. Each stage of the process requires approximations and simplifications of the physical problem under examination, which will affect the results of the analyses to a greater or lesser extent.

The matter becomes very complex if deep excavations have to be inserted in a very densely urbanized environment like the Napoli historic city centre, listed by UNESCO as a World Heritage Site because of the existing structures of monumental and historical value, where poor subsoil conditions are found. In this area, the new City Transport Plan approved by the Municipality of Napoli in 1997 included the extension of Line 1, that is a closed ring connecting the North outskirts of the city, the area of the hills, the historical centre, the administrative district and the airport, for a total length of about 30 km and 25 stations. About one half of the line, the so called *Tratta Alta*, between Piscinola and Dante stations (orange and yellow lines in Fig. 1(a)), has been constructed in the period 1998-2002, with a very positive impact on the traffic at surface. The construction of the so called *Tratta Bassa*, between Dante and Garibaldi stations (green line in Fig. 1(a), about 6 km long), is not yet completed for the reasons later reported. At present time, Toledo, Municipio, Università and Garibaldi Stations are open to the public, bringing the number of operating stations on Line 1 to a total of 18. In an ordinary working day, about 135.000 passengers already travel on the line; this should increase to an estimated 500.000 people per day, or 40.000 people per hour in rush hour, once the line will be completed by the dashed stretch in Fig. 1(a).

It is worth of mention that two out four stations have received the attention of the international community: Toledo Station was voted the most beautiful European Station by the Daily Telegraph and by CNN, while, in 2011, Università Station won the Emirates Leaf International Award in London.

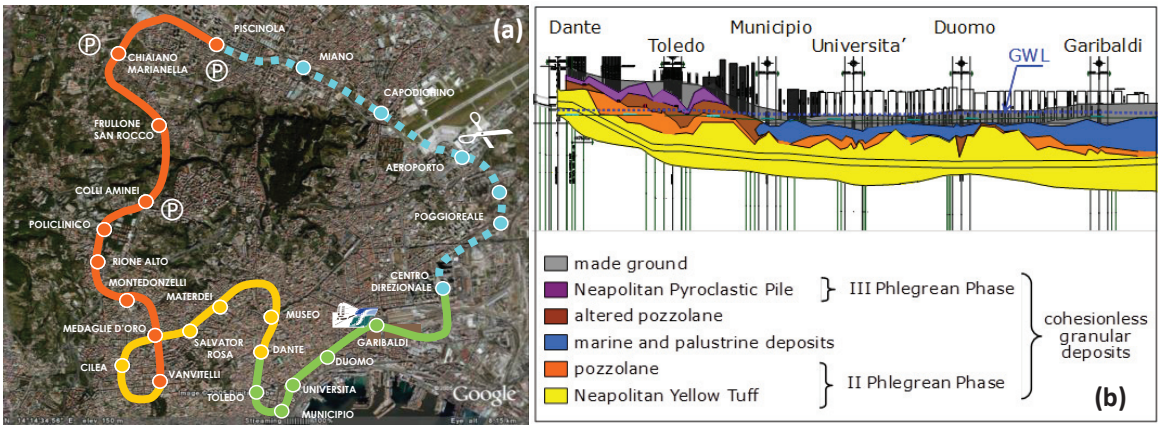

Fig. 1. Line 1 – (a) Route; (b) soil profile and groundwater conditions.