Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 158 (2016) 9 – 14

Procedia Engineering

www.elsevier.com/locate/procedia

VI ITALIAN CONFERENCE OF RESEARCHERS IN GEOTECHNICAL ENGINEERING – Geotechnical Engineering in Multidisciplinary Research: from Microscale to Regional Scale, CNRIG2016

Experimental study of coarse soil properties influencing soil abrasivity

Diego Sebastiani[a,*], Daniele Passeri[b], Girolamo Belardi[b], Salvatore Miliziano[a]

[a] *Dept. of structural and geotechnical engineering - Sapienza University of Rome, via Eudossiana, 18 – 00184 Rome - Italy*
[b] *Institute for Environmental Geology and Geo-Engineering - National Research Council – P.le Aldo Moro, 7 - 00185 Rome - Italy*

Abstract

The paper reports selected results of a study on tool wear for mechanized tunnelling in coarse soil. Several laboratory soil abrasion tests were performed and the results correlated with mineralogical composition, shape and surface roughness of the grains and the grain size curve of the soils. The analysis of the results clearly confirms the well-known correlation between soil abrasivity and quartz content and, for the soils tested, can quantify the relevant influence of grain size and grain roughness. We also report and discuss results useful for quantifying the positive effect of the addition of different chemical agents, injected as foams in a process known as soil conditioning, commonly performed in mechanized tunnel excavation using tunnel boring machines whit earth pressure technology to minimise tool consumption.

Peer-review under the responsibility of the organizing and scientific committees of CNRIG2016

Keywords: Abrasivity; tunneling; mineralogy; tools wear; TBM; conditioning effects

1. Introduction

The ability to predict and control the consumption of excavation tools is one of the decisive aspects for the success of a mechanized excavation. Wearing on cutters of tunnel boring machine equipped with earth pressure balanced technology (TBM-EPB) may be critical in terms of construction duration and costs. To tackle this problem

* Corresponding author. Tel.: +39 0649915335.
E-mail address: ing.diego.sebastiani@gmail.com

Peer-review under the responsibility of the organizing and scientific committees of CNRIG2016
doi:10.1016/j.proeng.2016.08.397

chemical additives are often employed with a lubricant effect when injected and mixed in the soil during the excavation phase.

Tool consumption has to be predicted and consequently substitution designed to avoid the risk of unplanned stops of the TBM. Be able to reach a station, as in the case of a metropolitan line, the overhaul activities of the cutter head could be made easier, safer and faster. On the contrary, to have to replace the cutters without the assurance of the station bulkheads would require injections and other forms of protection for the workers involved in this unsafe activity, somewhat expensive in terms of time and costs.

The wear recorded on the excavation tools and all the different surfaces designed for excavation is widely defined as “primary” [1]. All these elements, in fact, are commonly replaced at appropriate intervals. The wear recorded on all the elements made to support the excavation tools and on the structural elements composing the TBM machines is defined as “secondary”. Usually the wear on these elements is not anticipated by the designers and manufacturers and may become a serious issue in the excavation process.

Primary consumption depends on several factors: soil characteristics, which are the size and shape of particles, such as its mineralogical composition, as well as aspects of the digging tools, such as shape and material, number and geometrical disposition.

This study aims to analyze in detail the effects of each characteristic of a coarse soil and how it influences the primary consumption of the excavation tools. This document will also provide information to help assess and quantify the positive effect of the addition of conditioning agents, injected as foams, in reducing tool consumption. During the last decade a variety of methods for determination and prediction of abrasivity of soil and soft rock has been published [1-4]. Jakobsen [5] proposed an exhaustive summary of several different methods used in Europe to evaluate the abrasiveness of a coarse-grained soil. In our study, a large number of abrasion tests were carried out using the apparatus available in the Geotechnical Laboratory of the Department of Structural and Geotechnical Engineering, Sapienza University of Rome. Samples of coarse soil were used, each differing with regard to mineralogical composition, shape and surface roughness of the grains and grain size distribution. The study also focused on the effectiveness of the injection of chemical foaming agents in the soil, actually performed in mechanized excavation carried out using TBM-EPB. A comparison is made between soil properties before and after treatment as well as between the performance of different foaming agents.

2. Abrasion test and tested soil samples

The equipment employed to perform the abrasion test in this research consists of a metal cylinder with a cover where is placed a rotation axis of a drill press with an aluminum disk inserted.

During the test the disk rotates in the soil at a constant speed and the torque is continuously recorded. At the end of the test, the disk is removed, accurately cleaned and the weight reduction is evaluated. Other detailed information and typical results for this test are presented by Vinai et al. in [4].

Fig.1. a) abrasion test apparatus; b) cylindrical container; c) aluminium disk; d) detail of disk consumption.

The test duration is fixed at 10 minutes. This is a good compromise between the need to have a duration sufficient to produce an appreciable reduction in the disk’s weight, as well as reduce the duration as much as