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Planning the handling of tunnel excavation material – A process of decision making under uncertainty

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ABSTRACT

Success in tunneling nowadays also depends on a sustainable tunnel design, which considers social, environmental, and economic issues. Planning the handling of excavated materials for a tunnel construction project will possibly avoid waste deposits, save mineral resources as well as energy, and reduce some of the project costs. Hence, planning the handling of excavation materials contributes to a sustainable tunnel design. However, this planning process is affected by many uncertainties and, thus, is a challenge. This paper introduces an approach, which uses the Decision Aids for Tunneling (DAT), a computer based tool, to assess uncertainties affecting tunnel excavation material handling (TEMH). In this approach the emphasis is placed on representing the individual steps in the material handling process starting with excavation and ending with the reuse or final depositing of the material. An application to a tunnel construction project, namely a part of contract section Wolf of the Brenner Base Tunnel, concludes this paper. The results obtained in such simulations can be used for decision making and can optimize the design of a tunnel construction project.

1. Introduction

Growing awareness exists that the Earth has limited non-renewable natural resources such as mineral raw materials. On the other hand, the construction of underground projects is increasing worldwide and produces vast amounts of excavated material. There is, therefore, an increasing effort in recent and planned tunnel construction projects to consider a possible reuse of excavated materials. However, successful reuse of excavated materials requires a systematic handling of the excavated materials. This so-called tunnel excavation material handling (TEMH) has to be considered in a sustainable tunnel design to manage underground projects more effectively.

Tunneling, more than other areas of civil engineering, is characterized by high degrees of uncertainties. These uncertainties affect cost and time of any tunnel construction project. Additionally, these uncertainties also influence the excavated materials and their subsequent treatment such as, for example, the reuse of recycled excavated material in concrete applications. Hence, the TEMH is subject to uncertainties which have to be considered when planning the TEMH.

This paper will first review the basics of TEMH and the DAT. It will then introduce an approach, which uses the DAT, and allows one to simulate the individual steps in the TEMH process starting with the excavation and ending with the reuse or final depositing of the material. Most importantly, uncertainties affecting the TEMH can be considered in the simulation model, which allows one to express the effect of these uncertainties on the construction time, costs and the resources. The simulation model will then be applied to a tunnel construction project. The paper will end with conclusions.

2. Tunnel excavation material handling

During the construction of tunnels large quantities of excavated material are produced. For example, about 13.3 million m^3 of excavated material were handled at the Gotthard Base Tunnel (Kruse, 2002). Most of the excavated material of tunnel projects have so far been used to refill excavated zones (e.g., old quarries) close to the construction site or have been transferred to repositories (Resch et al., 2009). However, reusing tunnel excavation material can save non-renewable resources, avoid waste deposits, limit negative effects on the population in the vicinity of the construction site, and possibly save energy due to reduced transportation. Hence, such a recycling process is a sustainable development which jointly considers the society, economy, and environment. Common possibilities to recycle excavated material are to reuse

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