Fighting against tragedies induced by misconducted underground construction: a book review on *Engineering Geology for Underground Works*

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Abstract

This book review presents the merits and drawbacks of *Engineering Geology for Underground Works* edited by Gattinoni *et al*. and published by Springer in 2014. This book summarizes most of the problems an engineer may encounter in underground design, construction and operation.This book is useful for students and professionals in engineering geology and is also referable for scholars in relevant fields.

Keywords: Book review, Underground works, Hydrogeology, Engineering geology, Geologic hazards.

Recently, I watched a Russian movie which tells a story that thousands of people died during a tragedy happened in the subway of Moscow. The tragedy was caused by river water leakage through the fractures in the tunnel. Finally, the tunnel collapsed and the river water poured into the tunnel, resulting in the deaths of thousands of people. Although it is only a movie for recreational purpose, it reminds us that proper underground construction of the tunnel is important for the safety of people. For proper underground construction of tunnel, it requires a careful analysis of all geological and geo-environmental issues. Recent years, many cities in the world are constructing subways. During the design and construction phases, many geologists and engineering geologists from institutes and universities are invited to do research to deal with geological and geo-environmental issues. Problems associated with the construction of underground works are countless, and the experience and knowledge solving these problems are also rich. Therefore, they need to be summarized and presented to the world.

Engineering Geology for Underground Works is edited and published to address the above concerns (Fig. 1). It is coauthored by Paola Gattinoni, Enrico Maria Pizzarotti and Laura Scesi, three Italian scientists, and published by Springer in 2014 (Gattinoni *et al*., 2014). This book has 305 pages, comprises 8 chapters, and contains 291 illustrations with 115 in color. There are references at the end of each chapter, which allows readers to gain additional information on specific topics. There is also an Index at the end of the book which makes it easy for indexing terms interested. The book can serve as a reference for practicing engineering geologists or geotechnical engineers. Students and professors may also find it useful in their study and teaching. Readers who are interested in but are not specialists in engineering geology may also find it easy to read and understand, because this book is in plain English without too many arcane words.

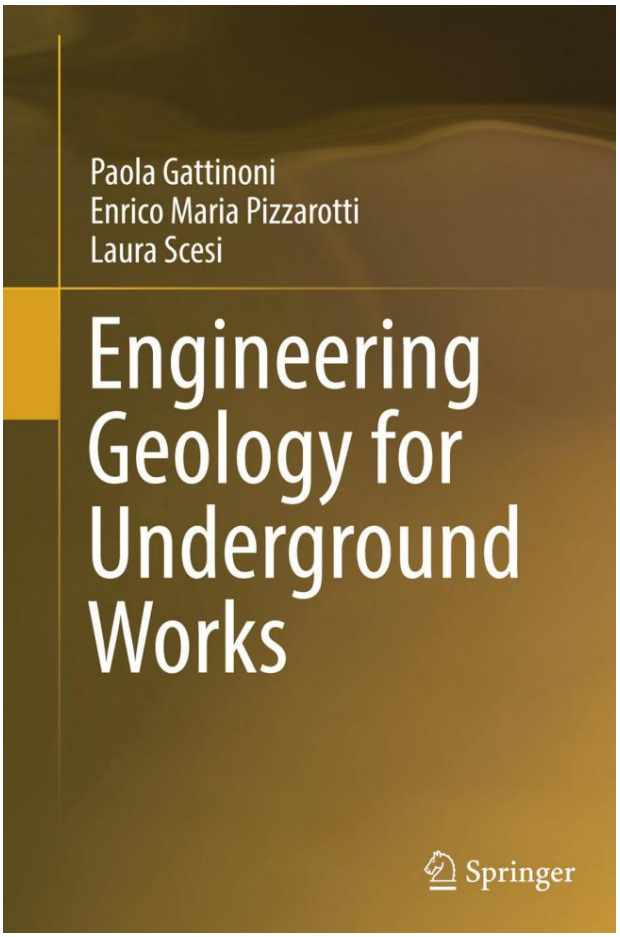

Figure 1) Book cover of Engineering Geology for Underground Works © Springer.

Stability of underground works is influenced by a variety of factors, such as lithological and structural features, tectonic setting, morphological conditions, hydrogeological conditions, weathering and swelling of materials, geothermal gradient, seismic effects and stress state before and after the construction. Chapter 1 discusses all these factors as well as their potential influences on the stability of constructed underground works. This chapter introduces the basic knowledge of engineering geology to readers with plain English, which enables readers who are unfamiliar with engineering geology to grasp some basic information about underground work construction. Especially, I found Figs. 1.5 to 1.8 illustrating the relationships of tunnel direction with layer thickness, layer direction and fold type quite informative and useful. With these figures, readers can get an easy understanding of the texts.

The construction of underground works can cause some geo-environmental problems such as surface settlements, structural collapses, slope instabilities, groundwater drying up and pollution, construction waste disposal and noise. Understanding these problems caused by underground work construction and finding proper preventive measures are important for establishing a sustainable development mode. Chapter 2 discusses these problems in the aim of providing potential measures to cope with them. I'm quite interested in section 2.4 in which the interaction of tunneling with surface water and groundwater is delineated. The tragedy depicted in the Russian movie was caused by surface water leakage through the fractures in the tunnel, which reminds us that water is probably one of the most important factors affecting the safety and stability of underground works. Adequate attention, therefore, should be given to its potential connection with underground works. Color pictures showing surface settlements induced by tunneling (Fig. 2.1 in the book) are shocking, warning us that the consequences and damages of improper underground construction are quite serious. Advanced methodologies and techniques, therefore, are mandatory during the design, construction and operation phases.

The recognition and analysis of geological and geo-environmental problems requires knowledge of reference models for decision-making in design. The geological models generated from geological studies and investigations are the first fundamental step in the construction of underground works. Chapter 3 introduces the conceptual geological models for underground work design. Rock Mass Rating (RMR) and Rock Mass Excavability (RME) Index proposed by Bieniawski are introduced in detail. The most widely used criteria to determine the shear strength of discontinuities including Patton criterion,

Barton equation, and Ladanyi and Archanbault criterion are introduced in the last section of this chapter. This chapter presents readers a lot of basic knowledge of assessing rock mass quality which is helpful and useful for engineers and students.

Chapter 4 provides an overview of the methods for foreseeing the excavation behavior. The basic concepts such as the choice of the medium (equivalent continuum or discontinuous medium) to be used as a reference, the convergence-confining relationship, and the difference between low and high overburden are introduced. Especially, groundwater impacts on underground works are discussed in the last section of this chapter.

The geological and geo-environmental problems can produce unforeseen risks. Chapter 5 introduces some methodologies for geological risk assessment of underground works, including qualitative methods such as risk matrixes and the rock engineering system (RES) method, and quantitative methods which are based on probability distribution. Risk evaluation can be performed after the geological risk assessment, which will be critical for the selection of the risk mitigation and control techniques.

Chapter 6 introduces some risk mitigation and control techniques such as selecting advanced excavation methods, using injection and freezing techniques, adopting the cutter soil mix (CSM) technique and proper anchors, establishing suitable draining system, and applying reinforced protective umbrella methods and linings. All these methods are useful in migrating and even eliminating risks of underground construction, and they have been recorded in literature and widely used by engineers. This chapter contains many interesting color photos and figures, but some of the white and black figures are of poor quality, especially Figs. 6.23, 6.32, 6.40, 6.43 and 6.68. The fonts in these figures are not clear and are difficult to read.

As various structures have to be used to maintain the stability of underground works, it is important and necessary to gain a good understanding of the interaction between ground and the structures. Chapter 7 introduces some simple methods of analyzing ground structure interaction including the Rabcewicz method and the hyperstatic reactions method, and the methods of assessing the loads acting on the lining are discussed in detail in section 7.3. The methods for analyzing the interaction between ground and nailing, spilling, fore poling and linings are discussed in the following several sections. These methods are analytical methods which have strong assumptions, whereas numerical methods introduced in section 7.9 are superior in that they can handle more complex situations without so many assumptions. Influences of earthquake on underground works are discussed in section 7.10 and finally in section 7.11 the authors mention some other necessary aspects that should be considered. I found the “strength” principle and “escape” principle mentioned in the last section quite interesting. The two principles have their advantages and disadvantages, and the best result may be obtained when combining both the methods.

Chapter 8 describes the characteristics and the equipment of the monitoring activities for underground excavation. Monitoring for hydrogeological and engineering geological purposes is always necessary, because these activities are closely related to the development of human society and safety of human lives. This chapter introduces some basic principles of determining the monitoring position and monitoring frequency. Equipment for main surveys, measurements and controls required for the monitoring is described. Monitoring, according to my experience, is probably the most important work in any hydrogeological

and engineering geologic project. It can aid the design, construction and operation.

With the development of society and growth in population, cities and roads are expanding, bringing many underground constructions, especially in mountainous regions and developing cities. The land creation projects underway in China (Li *et al*., 2014) will need numerous underground works so that the groundwater whose level is elevated by the mountain top removal can be discharged properly. The subway construction in Xi'an, China is facing many engineering geologic problems owing to the intensive occurrence of ground fissures in and around the city. Ground subsidence caused by groundwater over-exploitation is also a serious constraining factor in subway construction in this city. The world largest tunnel construction in the Qinling Mountains, China for the purpose of water diversion is also facing numerous technical and practical problems, and thus requires cooperation and sharing of experiences from the world. Besides in China, many developed and developing countries in the world are carrying out underground work constructions. All these constructions require the publication of a book reporting the latest and advanced methods and techniques in underground constructions. It is the right time that the book *Engineering Geology for Underground Works* was published. It will surely serve as a general guidance for these underground construction projects.

This book is a nice summary of the advances in engineering geologic methodologies and techniques in underground work construction. However, there are some typeset errors in it. For example, "affects its" in the penultimate line of page 2 (Chapter 1) should be replaced by "affects its", and the word "as" in the first line of paragraph 3 in page 55 (Chapter 3) is superfluous and should be deleted. In the penultimate line of page 71 (Chapter 3), "be volume unit" should be changed into "per volume unit". These typeset errors do not constrain the understanding of the contents, but the book would have been more readable and perfect if they had been corrected in the proof phase.

In spite of some defects mentioned above, this book is worth reading, especially for students and professionals in engineering geology. Scholars in hydrogeology, environmental science and hazard prevention may also find it useful in their studies and practices. This book summarizes most of the problems an engineer may encounter in underground design, construction and operation. As no one wants to see the tragedies depicted in the Russian movie, designers, constructors and decision makers must work closely together to make sure that proper analysis is done before, during and after the construction, and advanced methodologies and techniques are adopted to reduce all kinds of risks. If the methodologies and techniques introduced in this book are adopted in practical underground construction, less risk will hopefully be accomplished. I, therefore, recommend this book to engineering geologists, engineering practitioners, hydrogeologists, students in engineering geology and hydrogeology, decision makers and many others who have an interest in this topic.

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