

Engineering Geology

A Fundamental Guide for Engineering Students

Authors:

Mohd Firdaus Md Dan@Azlan

Aziman Madun

email:

firdausd@uthm.edu.my

aziman@uthm.edu.my

Abstract:

"Engineering Geology: A Fundamental Guide for Engineering Students" is a valuable resource that introduces engineering students to the fascinating realm of geology. The book covers a wide range of themes, beginning with an examination of the universe, the solar system, and the introduction of the Earth. The exciting idea of plate tectonics and its impact on geological risks is explored by readers. Throughout, the role of engineering geology in civil engineering activities is highlighted.

Chapter 2 focuses on minerals, their nature, origin, identification, and classification, laying the groundwork for understanding rock-forming minerals found on Earth.

Chapter 3, readers study the three major types of rocks: igneous, sedimentary, and metamorphic, with a focus on their applications in civil engineering.

Chapter 4 focuses on weathering processes, their impact on rock mass and its classification, which is critical for engineering considerations.

Chapter 5 explores geological structures such as folds, faults, joints, and unconformities before concluding with geological mapping techniques.

Throughout the book, thought-provoking review questions reinforce crucial themes. This comprehensive guide prepares aspiring engineers to address geotechnical difficulties, resulting in a safer, more resilient, and sustainable society.

Keywords: Avalanches, denudation, halite, igneous rocks, X-Ray Diffraction



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**Penerbit
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Authors:

Mohd Firdaus Md Dan @ Azlan
Aziman Madun

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Preface

Engineering geology - a discipline that forms the bedrock of modern infrastructure development and current construction practices on the Earth's materials that formed naturally beneath the Earth's surfaces. Engineering geology serves as a bridge between geology and engineering, unifying these two essential disciplines to ensure the successful execution of various projects, ranging from buildings and bridges to dams and tunnels. Therefore, the importance of understanding the fundamental knowledge between geology and its application in civil engineering works becomes ever more critical.

Designed specifically for civil engineering students of Universiti Tun Hussein Onn Malaysia (UTHM), this book seeks to provide a solid foundation and a holistic understanding of geological concepts that are indispensable to any engineer in civil engineering works.

Within these pages, you will encounter a diverse array of topics, starting with the definition of geology, engineering geology, and rock mechanics, and also the geological processes that have shaped our planet over millions of years. From plate tectonics and earthquakes to weathering and erosion as well as geohazards, we will explore how these natural phenomena have influenced the landscapes we inhabit.

Furthermore, this textbook discusses the properties and types of minerals and rocks, emphasizing to readers the formation of minerals and rocks on the Earth, their different characteristics and classifications, as well as the importance of understanding the geological structures and subsurface conditions before initiating construction projects.

As you embark on your journey through these pages, you will gain the knowledge and skills to confront real-world engineering geology challenges. Engaging exercises, case studies, and practical examples will supplement your learning, allowing you to apply theoretical concepts to real-life situations.

We sincerely hope that this textbook will ignite your passion for engineering geology and inspire you to become proactive problem solvers, equipped to tackle the geotechnical challenges of the future. Whether you aspire to be a civil engineer, geotechnical consultant, or environmental specialist, the knowledge within this book will be invaluable in shaping your career.

So, dear readers, let us embark on this journey together, exploring the dynamic intersection of geology and engineering. May this textbook serve as your faithful companion, equipping you to shape a safer, more resilient, and sustainable world for generations to come.

Mohd Firdaus bin Md Dan @ Azlan

Ph.D, P.E (BEM)

Head of Sustainable Geostructure and Underground Exploration (SGUE)

Faculty of Civil Engineering and Built Environment (FKAAB)

Universiti Tun Hussein Onn Malaysia (UTHM)

Chapter 1: Introduction to Geology

1.1 Introduction

Geology plays a crucial role in engineering by providing essential insights into the Earth's materials and processes. Engineers rely on geology to understand the geological conditions of project sites, assess potential hazards, and design structures safe and resilient structures geological settings. As an introduction, geology is integral to engineering fields as it provides valuable insights into the Earth's materials, geological hazards, and processes. By incorporating geology into engineering practices, professionals can design structures that are safe, resilient, and well-suited structures in geological environments.

Geology, engineering geology, and rock mechanics are all interconnected fields within the broader discipline of Earth sciences. They share common foundations in the study of rocks, minerals, and the processes that shape the Earth's surface and subsurface. While they have distinct focuses, they are closely related and contribute to our understanding of the Earth's materials and their implications for engineering applications.

In summary, geology provides the foundational understanding of the Earth's materials and processes, while engineering geology focuses on applying that knowledge to engineering projects, with an emphasis on geological hazards and site assessment. Rock mechanics zoom in further, study the mechanical behavior of rocks to determine their response to applied forces. Together, these fields contribute to safe and effective engineering practices in various geological settings.

a) Definition of Geology

The term "geology" originates from the Greek word's "geo" meaning earth and "logos" referring to discourse. Geology is the scientific study of the Earth's solid materials, including rocks, minerals, and the processes that shape the planet's structure and history. It involves investigating the composition,

Chapter 2: Minerals

2.1 Introduction

Minerals are of paramount importance to the Earth, playing significant roles in geological processes, ecological balance, and human activities. They form the essential components of rocks, shaping the Earth's crust, and contribute to the formation of mountains, creation of new land through volcanic activity, and the recycling of materials in the rock cycle. Minerals provide insights into Earth's history, past environments, and the dynamic nature of our planet. Moreover, minerals serve as valuable natural resources extensively used in various industries, including metals like iron, aluminum, copper, and gold crucial for manufacturing, construction, transportation, and technology. Non-metallic minerals like limestone, gypsum, and sand are essential for construction materials and infrastructure. Their extraction and processing contribute significantly to local and global economies, fostering economic growth, employment opportunities, and supporting various sectors. Minerals also play a vital role in human development, being used in agriculture, pharmaceuticals, cosmetics, and cultural artifacts. They contribute to environmental balance by supporting soil fertility, biodiversity, and natural processes like weathering and erosion. Additionally, minerals provide subjects for scientific research, aiding in the understanding of Earth's composition, history, and life's evolution. Overall, minerals hold immense importance, necessitating their responsible and sustainable management for the well-being of societies and the planet.

The study of minerals holds great significance for civil engineers as it encompasses material selection, structural stability, geotechnical engineering, construction materials, and environmental considerations. Understanding mineral properties is crucial for selecting suitable materials and ensuring their strength and durability in construction projects. Minerals influence the stability of structures and help engineers analyze soil and rock properties in geotechnical engineering. They also form the basis of construction materials, and their environmental impact must be considered

Chapter 3: The Study of Rocks

3.1 Introduction

Rock is a composite material formed by the aggregation of one or more minerals. Rock is defined as a mixture formed of aggregates of one or more minerals (aggregate of minerals). It can be created through various processes, including the crystallization of molten material (igneous), the solidification of sediments like sand or clay (sedimentary), the recrystallization of pre-existing rocks (metamorphic), or the crystallization from hot aqueous fluids (hydrothermal).

Igneous rocks are formed when molten material cools and solidifies either below the Earth's surface (intrusive or plutonic) or on the surface (extrusive or volcanic) (**Figure 3.1a**). The cooling rate determines the grain size, with volcanic rocks having a fine-grained texture and plutonic rocks being coarse-grained. Sedimentary rocks form on the Earth's surface through the lithification of weathered or dissolved materials (**Figure 3.1b**). They are classified based on particle size, which correlates with changes in composition. Metamorphic rocks result from the recrystallization of existing rocks under high temperatures and pressure (**Figure 3.1c**). They can originate from any rock type. Hydrothermal rocks are formed by the crystallization of minerals from hot aqueous fluids and are commonly found near intrusive igneous bodies. This process concentrates elements, including economically important ore minerals.

Rocks form the crust of the Earth, and the unconsolidated soils and sediments above them are products of weathering processes. Understanding the engineering behavior of rocks and soils is crucial for civil engineers during construction projects. It is essential to have a basic geological understanding of these materials to determine their engineering limits and for further studies in soil mechanics and foundation engineering. The Earth's crust has been evolving for millions of years, with continuous motion, change, and development. Rocks and soils have also transformed over time. Based on the three modes of origin (igneous, sedimentary, and metamorphic), rocks

Chapter 4: Weathering

4.1 Introduction to Weathering

Weathering plays an important role in the formation of heterogeneous zones beneath Earth's surface which consist of rock and soil matrix. Weathering can be defined as a coupled process of disintegration and decomposition of rock materials through physical and chemical reactions on rock structure caused by the exposure of the rock mass/material to the denudation agents such as temperature changes, moisture, wind, chemical reactions, and biological activity. **Figure 4.1** shows the physical and chemical changes of shale outcrop due to weathering reaction, located in Ayer Hitam, Johor.



Figure 4.1: Weathering reaction on a shale mass outcrop

Chapter 5: Geological Structures

5.1 Introduction to Geological Structures

Throughout the vast timescale of Earth's history, the Earth's crust has been in constant motion, resulting in the deformation of rocks near or at the surface. This deformation occurs because different parts of the Earth's lithospheric plates are moving relative to each other. The movement of these plates creates stresses that cause compression (pushing together), tension (pulling apart), and shear in the rocks. In response to these stresses, the rocks in the Earth's crust change their shape, a process known as strain. This strain leads to the development of various geological structures that serve as a record of the type of deformation that has occurred. When rocks experience compression, they can form folds, where the rock layers bend and curve as shown in **Figure 5.1**. In cases of tension, the rocks may fracture, resulting in breaks or cracks. Joints are another type of fracture that occurs when rocks break apart but without significant displacement. The continuous movement of the Earth's crust over billions of years has caused rocks to undergo deformation.

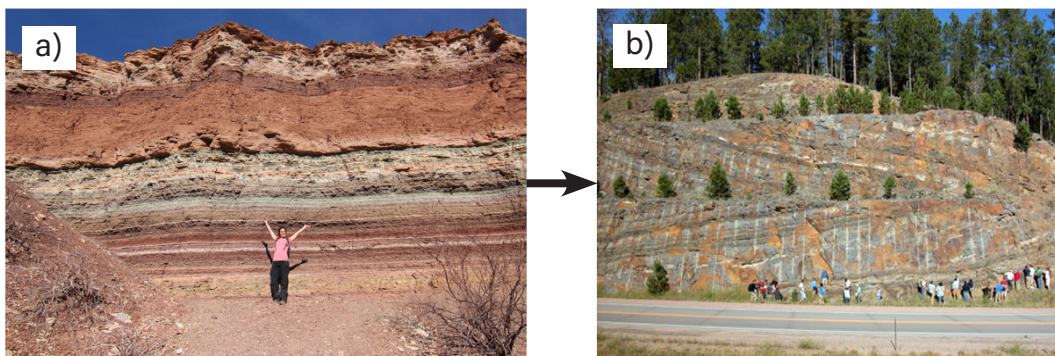


Figure 5.1: (a) The sedimentary rock layer remains unaffected by deformation, and (b) The sedimentary rock layer experiences deformation.

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Biography



MOHD FIRDAUS BIN MD DAN @ AZLAN is the head of the Sustainable Geostucture and Underground Exploration (SGUE) focus group and a senior lecturer at Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat, Johor. He is a lecturer in Engineering Geology and Rock Mechanics subjects for undergraduate and postgraduate students.

In 2016, Firdaus received his PhD in Civil Engineering (Engineering Geology) from Universiti Teknologi Malaysia (UTM). Currently, Firdaus is a professional engineer (BEM) and a professional technologist (MBOT), a member of the International Society for Rock Mechanics (ISRM) National Group of Malaysia, and a National Fellow at the Universiti Teknologi Malaysia's Centre of Tropical Geoengineering (GEOTROPIK).

Firdaus' areas of specialization include rock and soil slope engineering, geohazard assessment, engineering geology, tropical rock engineering, and geological mapping. Firdaus is also actively involved in the geotechnical and geological design, modeling, and geotechnics and rock mechanics instruments using various software from Rocsciences, GeoSlope, GeoStru, and RockWorks. From 2016 to 2023, Firdaus has been actively involved in many geotechnical and geological consultations in various geotechnical structures, such as rock and soil slopes, dams, embankments, spillways, and rock quarries, in various states in Malaysia, including Johor, Melaka, Selangor, Kuala Lumpur, Perak, Pahang, Terengganu, and Kelantan.

In the research field, Firdaus has published over 60 research publications, including journals, books, and book chapters in various indexed and non-indexed journals, including Elsevier, the Journal of Physics and Chemistry of the Earth, the Journal of Mines, Metals, and Fuels, the Journal of Computational and Theoretical Nanoscience, the International Journal of Integrated Engineering, and the Journal of Physics.



Aziman Madun embarked on his career in 1995, delving into infrastructure projects following his graduation from Universiti Kebangsaan Malaysia with a degree in geology. His notable projects include contributing to the Kuala Lumpur to Karak Highway (1995-1997), the Pos Selim to Kg. Raja Road (1997-2001), the Karak to Kuantan Highway (2001-2002), and the Electrified Double Track Rawang to Ipoh (2002-2004) during his tenure at Terratech Consultants Sdn. Bhd. and Ranhill Bersekutu Sdn. Bhd.

In 2004, Aziman transitioned to academia, joining the faculty of Civil Engineering and Built Environment at Universiti Tun Hussein Onn Malaysia as a lecturer. He earned his Doctor of Philosophy from the University of Birmingham, United Kingdom in 2012 and currently holds the position of an engineering geology. Additionally, he is a registered professional geologist with the Board of geologists Malaysia.

As an academic, Aziman actively engages in cutting-edge research, particularly focusing in geophysical investigation for engineering geology and geotechnical applications. Simultaneously, as a professional geologist, he is involved in site investigation and groundwater exploration, skillfully blending academic expertise with hands-on experience. This book reflects his adept intergration of theory and practice in the dynamic field of engineering geology.

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