普通高等学校教材

ENGINEERING GEOLOGY PROFESSIONAL ENGLISH

工程地质专业英语

郑孝玉　徐佩华　洪　勇　编著

地质出版社

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Engineering Geology Professional English

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·北 京·

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本书中内容摘引自国外经典的专业教材或科技论文，并经适当的节选和编译，补充了生词短语的解释，以及大量的疑难句段的中文注释和说明，课文给出了练习题以便巩固学习内容。本书内容基本涵盖了工程地质基础知识和应用涉及的领域，适合普通高等学院工程地质（地质工程）本科专业作为专业英语学习教材，也可供岩土工程、地下工程等相关相近专业本科或研究生作为选择和参考性教材。

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前　言

本书作为吉林大学工程地质专业拓展课程的内部教材，已试用10余年，2013年被列为吉林大学本科“十二五”规划教材。书中内容摘引自国外经典的专业教材或科技论文，并经适当的节选和编译，补充了生词短语的解释，以及大量的疑难句段的中文注释和说明，课文给出了参考习题以便巩固学习内容。本书内容基本涵盖了工程地质基础知识和应用涉及的领域，适合于普通高等学校工程地质（地质工程）专业本科生作为专业英语学习教材，也可以供岩土工程、地下工程等相关专业本科生或研究生作为参考教材。

本书由吉林大学郑孝玉、徐佩华和青岛理工大学洪勇共同编写，郑孝玉编写Unit 1～6，10，12～15，17；徐佩华编写Unit 7～9，16；洪勇编写Unit 11；全书由郑孝玉编著定稿。

书中原文采纳了国外专业书籍期刊和其他有价值资料，在此向被引用和参考文献的作者表示感谢。由衷地感谢吉林大学工程地质系主任陈剑平教授，他在百忙之中对本书内容进行了审阅并对体系格局提出了指导性的修改建议和意见；本书定稿和出版过程中还得到了吉林大学建设工程学院副院长陈晨教授的指点和帮助，在此致谢。

本书能够顺利出版，得到吉林大学教务处的大力支持。鉴于编者水平所限，书中难免存在一些问题和不足，恳请读者批评指正。

编　者

2015年7月于长春

目　录

Introduction

Engineering geology, as a science, is concerned with the applications of the principles of geology to civil (and to some extent, mining) engineering, so that the engineer can take into account those geological aspects which control the economy, and safety, of the structure which he is required to design and construct. All civil engineering works are constructed on, or in, rock and soil masses. It is essential, therefore, that civil engineer be aware of the history, nature, and properties of the rocks and soils. Equally, it is essential for the geologist, who is to work with the engineer, to have some knowledge of engineering requirements.

Although engineering geology has been practiced for centuries, systematic study began only in the 19^{th} *century. The* 20^{th} *saw the development of soil mechanics and rock mechanics; this has tended towards a so-called "quantification" of engineering geology. Such a quantitative approach is desirable, but it must not be overlooked that much of the geology, which is so significant for the engineer, is qualitative.* Rock mechanics and soil mechanics supplement, or complement, the descriptive geology, they do not replace it.

At the most fundamental level, geological principles must be used to explain the variation in the mechanical properties of rocks and soils, and the behaviour of rocks and soils under stress. The quantitative description of soil and rock behaviour has to assume an idealized material; the geologist is aware that actual soil and rock materials, in their texture, structure, and composition, vary to a considerable degree from the ideal.

The science of geology comprises a number of subdisciplines, all of which, to a greater or lesser extent, find some applications in engineering. An understanding of geology itself requires a sound basis in chemistry, physics and mathematics, since geology is concerned with processes which are chemical and physical, and with the products of the various processes.

Mineralogy is that branch of geology which is concerned with the origin, occurrence, and the properties of minerals. Any mineral species is a unique combination of a definite chemical composition and crystal structure. Several thousands of mineral species are known, but the civil engineer, for the most part, is concerned with only a few: those which are known as rock-forming minerals. Some minerals are of particular interest and importance to, especially, concrete engineers, since they react with cement under certain conditions; the reaction can result in the disruption of concrete.

The study of the occurrence, distribution, origin, composition and texture of rocks is known as petrology. All rocks are made up of one or more minerals. The minerals which are present, their arrangement (fabric) and the texture, are determined by the origin of the rock and the processes it has undergone, and is undergoing, since its formation. Rocks can be classified genetically into igneous, sedimentary and metamorphic rocks, depending on their origin. Rocks in each of these classes have certain, well defined characteristics, which are reflected in their behaviour as engineering materials.

As a result of the processes to which rocks are subjected during and after their formation, structural features such as bedding planes, joints, faults, folds and foliations may be present. The origin, geometric patterns, and the forces which produced these structures constitute the subdiscipline of structural geology. Most structures represent discontinuities in the rock mass, while some represent discontinuities in the rock material. As a result, they have a major influence on the engineering properties, and behaviour, of both mass and material. Structural geology is one of the most important basic studies for engineering geology.

Although of less interest to the engineer, those branches of geology known as palaeontology and stratigraphy are of vital importance to the geologist, and are used, quite commonly, to solve problems which confront the engineer. Palaeontology is the science of fossils: the remains of past life on the Earth. Fossils are used particularly to determine the age of the rocks in which they are found. Other methods of dating are available which give absolute ages, as distinct from the relative ages determined by means of fossils. By studying the age, the structure, and the relationships of rock masses, geologists are able to determine their history, and, in the final analysis, the history of the region involved. The history of the region can have consequences of vital importance to engineering.

The final stage in the geological evolution of any region is the development of the present land surfaces. *The processes responsible for this development are largely climatically controlled, although the landforms themselves are functions both of climate (present and past), and of underlying geology.* Geomorphology is the study of the form and origin of the present land surface. Engineering geomorphology is emerging as a specialist discipline, particularly in the fields of slope engineering and environmental engineering. Nonetheless, careful geomorphological appraisal of an engineering site has always been an essential facet of an investigation programme.

Apart from the somewhat purely geological subdisciplines mentioned above, engineering geological investigations require, in addition, studies which overlap with engineering: soil mechanics, rock mechanics, and groundwater hydrology. Hydrogeology is concerned with the origin, quality, quantity, distribution and movement of water in, and through, a rock mass. Although hydrogeologists are interested in groundwater as a useable resource, engineering geologists are concerned with the hydrology of groundwater at most engineering sites, but especially at dam sites and in tunnels and other underground excavations.

It has been noted that the basic data relating to the geology of a region are recorded on a geological map. While such maps are indispensable to the engineer, not infrequently they fail to show many of the factors of importance for design and construction. In recent years, the geological map has come to be supplemented by specialized maps according to specifically engineering *geological features*. These are referred to as engineering geological maps, engineering geomorphic maps, and geotechnical maps. These are all prepared after field, laboratory and office investigation andresearch.

New words and expressions

civil engineering　土木工程
dam site　坝址
environmental engineering　环境工程
faults　断裂,裂隙
fold　褶皱
geological evolution　地质演化
geomorphology　地貌学
hydrogeology　水文地质学
hydrology　水文学
igneous　火成的,岩浆的
joint　节理
landform　地貌
metamorphic　变质的
mineralogy　矿物学
mining engineering　矿业工程,采矿工程
overlap with　与……相重叠
palaeontology　古生物学
petrology　岩石学
rock and soil masses　岩土体
rock mechanics　岩石力学
sedimentary　沉积的
slope engineering　边坡工程
soil mechanics　土力学
stratigraphy　地层学
stress　应力
structural geology　构造地质学
tunnel　隧道
underground excavation　地下开挖

Notes and explanations

1. Although engineering geology has been practiced for centuries, systematic study began only in the 19^{th} century. The 20^{th} century saw the development of soil mechanics and rock mechanics; this has tended towards a so-called "quantification" of engineering geology. Such a quantitative approach is desirable, but it must not be overlooked that much of the geology, which is so significant for the engineer, is qualitative.

尽管工程地质学已经历了几个世纪的发展,但系统的研究始于19世纪。特别是20世纪见证了土力学和岩石力学的快速发展,使本学科不断地向所谓"量化"的工程地质研究方向发展。尽管这样的量化研究是我们所期望的,但绝不可以因此忽视基础地质信息特征在这种量化研究中的重要作用。

2. It has been noted that the basic data relating to the geology of a region are recorded on a geological map. While such maps are indispensable to the engineer, not infrequently they fail to show many of the factors of importance for design and construction. In recent years, the geological map has come to be supplemented by specialized maps according to specifically engineering geological features.

需要指出的是,地质图记录着与区域地质有关的基础数据,这样的图件对工程师们是必要的,但它们却常常忽略那些对工程设计和施工方面有重要影响的很多因素。因此,近年来地质图已经按照一些特殊的工程地质特征作了补充。

Exercises

Put the following sentences into Chinese.

a. The science of geology comprises a number of subdisciplines, all of which, to a greater or lesser extent, find some applications in engineering. An understanding of geology itself requires a sound basis in chemistry, physics and mathematics.

b. The processes responsible for this development are largely climatically controlled, although the landforms themselves are functions both of climate (present and past), and of underlying geology.

c. Apart from the somewhat purely geological subdisciplines mentioned above, engineering geological investigations require, in addition, studies which overlap with engineering: soil mechanics rock mechanics, and groundwater hydrology.

Put the following sentences into English.

a. 在最基本的层面上,地质学原理要能够解释岩土力学性质的各种变化规律及在应力作用下表现出的特征。

b. 岩石力学和土力学能够对地质学进行补充和完善,但不能代替它。

c. 尽管工程地质学已经历了多个世纪的实践,而系统的研究乃始于19世纪以后。

Unit 1 Engineering Properties of Rocks (Part 1)

Certain index properties of rocks are of particular importance to the engineering as they may affect the planning and cost of a project. *Prior knowledge of them from tests will guide decisions such as whether a body of rock will either be blasted by explosives or be removed more simply by ripping, and whether excavated rock can serve as suitable constructional material for a specific purpose or lacks the essential characteristics.* These index properties are defined below.

Specific gravity **(G_s and G_b).** G_s is the specific gravity of the solid mineral material of the rock by itself. G_b is the specific gravity of the complete rock, grain plus voids, with the voids empty except for air. Both are defined as a weight per unit volume.

Saturation moisture content **(i_s).** This is the total amount of water present in a rock with the voids full. The ratio of weight of water to dry weight of rock sample, expressed as a percentage, is the saturation moisture content (i_s).

Moisture content **(w).** This is the amount of water normally present in the voids of a rock, again expressed as a percentage (see i_s) above. Rocks are rarely saturated with water, thus in normal circumstances w is less than i_s.

Porosity **(n).** This is the ratio of volume of voids in a rock total volume of the sample. It is expressed as a percentage; 10% average, 5% is low and more than 15% is high.

Not all voids in a rock are interconnected and accessible to penetrating fluids. Pumice is an extreme example of a very porous rock of this type. The effective porosity is the ratio of the volume of interconnected voids to the total volume.

Voids in rocks are most commonly of two types: primary voids (pores) between the fragments of terrigenous rocks, and secondary voids produced by later fracturing or chemical weathering. The first is characteristic of the whole rock mass and is its "porosity", by strict definition. The second depends on the rock's subsequent history and is highly variable within the body of rock. Representative values of (true) porosity are given in Table 1.1.

Table 1.1 Porosity values of some common rock types

Rock type	Maximum porosity/%	Rock type	Maximum porosity/%
Soil	50	Limestone (and marble)	5
Sand and gravel	20 – 47	Oolitic limestone	10
Clay	49	Chalk	Up to 5
Cement sand	5 – 25	Igneous rocks	1 – 5
Sandstone	10 – 15	Metamorphic rocks	Generally very low

Note: These serve only as a guide and a porosity value must be determined for each specific rock.

The factors that control the porosity of terrigenous sedimentary rocks and soils are as follows:

(1) The degree of cementation (that is, to what extent pore space is replaced by cement) and the extent of recrystallization at points where grains touch. Both are influenced by the age and history of burial of the rock.

(2) The sorting of the sediment, since small grains, if present, can fill the voids among larger grains. A well graded rock, like gray-wacke, has a lower porosity than a poorly graded one, like cross-bedded sandstone.

(3) The packing of the grains which, if the grains were spherical, can theoretically range from 26% to 47%. The loose packing is less stable, and a change from it to a stable arrangement drastically reduces porosity and may lead to the expulsion of water from a sediment.

(4) The shape of the grains, since angular laths such as occur in clay minerals often form bridges between other grains, hold them apart and increase porosity. *Since porosity is dimensionless, the size of grains and voids does not affect the ratio of their volumes, and in a sediment formed of perfect spheres the porosity would be independent of the size of the spheres. In practice, the different characteristics of clay minerals compared with quartz grains produces an increase in porosity with reduction of grain size.* Clays have relatively high porosity, and gravel relatively low.

In crystalline limestone, the void space is mainly secondary and is controlled by (a) the presence of fossils and bedding planes, (b) leaching and redeposition by acidic ground water, and (c) fracturing, both on a large and small scale. Because of progressive leaching the void space in limestone usually increases with time and caverns may develop.

Water-yielding capacity. *Not all of the water in a rock can be removed from it by flow under the force of gravity. Some is held as a film on the surface of the grains by capillary forces.* This is described by the following (self-explanatory) terms and equation

$$\textit{Porosity} = \textit{specific yield} + \textit{specific retention}.$$

Permeability (***k***). This is a measure of the fluid conductivity of the rock for a given hydraulic gradient, determined by Darcy's formula

$$v = ki \tag{1.1}$$

where v is the velocity of laminar flow under modest hydraulic gradients, and i is the hydraulic gradient (that is, the change of water head with distance). The coefficient of permeability has the dimensions of a velocity (metres per second, $m \cdot s^{-1}$), and was often expressed in $cm \cdot s^{-1} \times 10^{-4}$, or in metres per day when discussing field results. Typical values for soils are: clay 0 ~ 1 $m \cdot d^{-1}$; sand 10 ~ 260 $m \cdot d^{-1}$, gravel up to 300 $m \cdot d^{-1}$. The principle factor controlling permeability is the size of the voids, since the smaller they are the greater is the surface area of contact of water with solid mineral matter, and the greater are the capillary of forces restraining flow. In loose soils, permeability increases with the $(\text{diameter})^2$ of the grains. Flow also takes place through secondary voids such as joints, and rocks of this character are usually referred to as pervious rather than permeable.

A rough value of k may be obtained by the use of tables based on grain size, and a better approximation using a permeameter for a laboratory test. A reliable value of permeability in bulk of a rock mass is best obtained by experiments in the field.

Swelling coefficient (***E_s***). This is a measure of the change of length of a sample which was initially oven dry then soaked in water, till it become fully saturated, expressed as a ratio of the original (dry) and final (saturated) lengths. The behaviour of rocks which are soaked in water falls into three categories: (a) rigid rocks which do not swell, (b) flexible rocks which sell, and (c) rocks which disintegrate.

Seismic velocities (***v_p, and v_s***). The behaviour of wave motions in rocks is dependent on the elastic properties of the rocks. The applied seismic methods are used to determine the distribution of elastic properties under a site, as a step to infer what rocks and structures are present.

If an elastic medium, such as a rock, is suddenly disturbed at a point, two types of elastic wave (body waves) spread out from the point in all directions. Each individual particle of rock vibrates harmonically about a mean position as the wave motion is propagated through the rock. In longitudinal waves, the particle motion is parallel to the direction of propagation, and each part of the rock is periodically compressed and dilated by the wave motion. Their velocity of propagation, v_p is given by

$$v_p = [(k + 4/3\mu)/\rho]^{1/2} \tag{1.2}$$

where k and μ are the elastic constants, and ρ is the density of the rocks.

In transverse waves, the particle motion is normal to the direction of propagation. Their velocity v_s, is defined by

$$v_s = (\mu/\rho)^{1/2} \tag{1.3}$$

From the equations, (a) both velocities are independent of amplitude or period of the waves, and (b) v_p is always greater than v_s, hence the longitudinal waves are the first to arrive at any detector.

Rebound number (***R***). This is measured using a Schmidt Concrete Test Hammer, type N, and is used to assess *in situ* strength of rocks. The rebound height of the hammer is expressed as a percentage of the forward travel distance of the hammer mass.

Unconfined compressive strength. The unconfined compressive strength or crushing strength (q_u) is the resistance a rock offers to the vertical pressure placed on it. It is measured in pounds force per square inch or more commonly in meganewtons per square metre ($MN \cdot m^{-2}$) or newtons per square millimetre ($N \cdot mm^{-2}$), and is the force that has to be applied to a cube of rock (1 in[1] cube, 1 m cube, etc.) before the rock crushes. The factors controlling it are:

(1) The properties of the constituent minerals, especially their hardness, the presence of cleavages, and the degree of their alteration;

(2) The presence and shape of any voids within the rocks;

[1] 1 in = 25.4 mm.

(3) The nature of the bonding between mineral grains.

A preferred orientation of voids or microfractures may make a body of rock anisotropic, even though the rock in small samples appears to be isotropic. The q_u of a rock is also affected by whether or not the voids are filled with water, and on the test procedure adopted. A definition of descriptive terms used to describe relative q_u is given in Table 1.2.

Table 1.2 Unconfined compressive strengths of the main rock types

Descriptive term	Compressive strength/($MN \cdot m^{-2}$)	Rock types
Very weak	<1.25	Some weakly compacted sedimentary rocks, some very highly weathered igneous or, metamorphic rocks, boulder clays
Weak	1.25 ~ 5	
Moderately weak	5 ~ 12.5	
Moderately strong	12.5 ~ 50	Some sedimentary rocks, some foliated metamorphic rocks, highly weathered igneous and metamorphic rocks
Strong	50 ~ 100	Some low-grade metamorphic rocks, marbles, some strongly cemented sandstones (silica cement), some weathered and metamorphic igneous rocks
Very strong	100 ~ 200	Mainly plutonic, hypabyssal and extrusive igneous rocks (medium to coarse grained), sedimentary quartzites, strong slates, gneisses
Extremely strong	>200	Fine-grained igneous rocks; metamorphic quartzites, some hornfelses

Several of these index properties are related, theoretically or empirically, to one another. For example, relationships between G_b, G_s, i_s, and n in rocks which do not change volume during saturation.

There is another indication of an empirical engineering property of rocks, namely rippability This index is used in deciding whether rocks from a near-horizontal surface can be excavated mechanically by a ripper attached to a tractor, rather than by explosives. Weak, easily ripped rocks tend to have low values of v_p. (These can be measured, even under a cover of soil, by the seismic-refraction method). An empirical upper limit of $v_p = 2.0\ km \cdot s^{-1}$ arbitrarily defines rocks which can be ripped without difficulty. Rocks with this value of v_p correspond roughly to those with a q_u value of 70 $MN \cdot m^{-2}$. Low velocities may be an indication of poor compaction of rocks, or of extensive jointing. *Ripping is likely to be successful if the block volume is less than 1.0 m^3, that is, the rock is fractured into cubes with edges 1.0 m long. Low velocities are found in some sedimentary rocks, in a few metamorphic rocks and in rock bodies of any type which are highly weathered of body fractured.*

New words and expressions

alteration 蚀变

amplitude of wave 振幅

anisotropic 各向异性的

bedding plane 层理面

boulder clay 泥砾
capillary force 毛细(作用)力
cavern 洞穴,洞室
cleavage 解理
coarse grained 粗粒的
cross-bedded 交错沉积
degree of cementation 胶结度
fine grained 细粒的
flexible rocks 软岩
foliated 片状的
fracturing 断裂的
grey wacke 杂砂岩
hornfels 角岩
hydraulic gradient 水力梯(坡)度
hypabyssal 半深成的
isotropic 各向同性的
laminar flow 层流
laths 板晶
leaching 渗析,淋滤作用
limestone 石灰岩
longitudinal wave 纵波
moisture content 含水率
oolitic limestone 鲕状灰岩
oven 烘箱
packing 充填物
permeability 渗透性
plutonic 深成的
porosity 孔隙度
primary void 原生空隙
pumice 浮石
rebound number 回弹数
ripper 掘进机
rock mass 岩体
saturation moisture content 饱和含水率
secondary void 次生空隙
seismic refraction method 地震折射波法
seismic velocity 地震波速
specific gravity 比重
swelling coefficient 膨胀系数
terrigenous 陆源(沉积)的
transverse wave 横波
unconfined compressive strength 无侧限抗压强度
weathering 风化(作用)的
well graded 分选良好的

Notes and explanations

1. Prior knowledge of them from tests will guide decisions such as whether a body of rock will either be blasted by explosives or be removed more simply by ripping, and whether excavated rock can serve as suitable constructional material for a specific purpose or lacks the essential characteristics.

先期实验获得的信息将指导我们在岩体开挖方式上是选择爆破,还是选择简单的挖掘;另外还要确定岩石是否适合作为特殊的建筑材料。

2. Since porosity is dimensionless, the size of grains and voids does not affect the ratio of their volumes, and in a sediment formed of perfect spheres the porosity would be independent of the size of the spheres. In practice, the different characteristics of clay minerals compared with quartz grains produces an increase in porosity with reduction of grain size.

由于孔隙度是没有方向性的,颗粒和孔隙的大小并不会影响其整体的孔隙比,对于球度很好的沉积岩,其孔隙度与颗粒大小无关。

Exercises

Put the following sentences into Chinese.

a. Not all of the water in a rock can be removed from it by flow under the force of gravity. Some is held as a film on the surface of the grains by capillary forces.

b. If an elastic medium, such as a rock, is suddenly disturbed at a point, two types of elastic wave (body waves) spread out from the point in all directions.

c. Ripping is likely to be successful if the block volume is less than 1.0 m^3, that is, the rock is fractured into cubes with edges 1.0 m long. Low velocities are found in some sedimentary rocks, in a few metamorphic rocks and in rock bodies of any type which are highly weathered of body fractured.

Put the following sentences into English.

a. 许多黏土矿物颗粒都是片状的，它们有很高的比表面积，因此其特性主要受表面张力的控制。

b. 化学风化过程导致黏土粒级的结晶颗粒团的形成并衍生出新的黏土矿物。例如，黏土矿物高岭石就是在水和二氧化碳的作用下长石分解的产物。

c. 许多黏土矿物颗粒都是片状的，它们有很高的比表面积，这会导致它们的特性主要受表面张力的控制。