Popularizing Geological Education Among Civil Engineering Students

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ABSTRACT

The sustainable development of an economy and a society cannot be realized without the help of modern geoscience. Engineering geology knowledge is necessary on a civil engineering construction site to ensure the construction work goes smoothly. This paper first discusses the importance of geoscience, especially the study of engineering geology. Then, the current Chinese engineering geology course for civil engineering students is summarized. The engineering geology course at Shijiazhuang Tiedao University is described in detail, including its history, its content, and some teaching tactics for the course. The paper closes with an evaluation of the effects of the teaching tactics. © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/10-207.1]

Key words: engineering geology, civil engineering

IMPORTANCE OF GEOLOGICAL STUDY

On 19 June 2007, Chinese Prime Minister Wen Jia-bao, who is also a geologist, expounded on the importance of geological study when he talked with officials of the International Union of Geological Sciences. The prime minister said he believes that the tasks of modern geoscience, which is closely connected with the economy, society, and environment, are to support the sustainable development of the economy and society, protect Earth's environment, and achieve ongoing harmony between man and nature (Wen Jia-bao, 2009).

The global view of man and nature has gradually attracted attention through the decades of works since the United Nations Conference on the Human Environment, which was convened in 1972. The conference called on nations to devote attention to the environmental problems of Earth. The strong influence of human activity on Earth has reached a global scale, and it has brought into being a complex, interactional, and accelerated system tied to social and economic activities. Some human activities may change the Earth system and endanger the survival of mankind. Thus, it is necessary for the development of humans to be in harmony with nature.

The harmony between nature and humans cannot be achieved without correct understanding about the evolution history and movement rules of Earth. China's national engineering practice in recent years indicates that the success of all major construction projects, like the South-to-North Water Diversion Project, Qinghai–Tibet Railway, West–East Gas Transmission, and Three Gorges Dam, is closely linked with geological science. Some important lessons come with the economic achievements of national construction projects. Immoderate exploitation and reformation of nature incur retaliation of nature. The progress of geological science can tell humans how to exploit and utilize resources reasonably, reduce consumption of resources, reduce environmental damage, and prevent geological hazards. The harmony between Earth and humans fundamentally depends on the progress of geology. Improving the level of geological research can help humans face the challenges of energy scarcity, environment destruction, natural disasters, and so on.

DEVELOPMENT OF ENGINEERING GEOLOGY

Engineering geology is an applied specialty of geology that interlinks geology with civil engineering. Its task is to analyze and solve geology problems related to human activities and human engineering (i.e., engineering geology problems) using principles and methods of geology and knowledge of civil engineering and mathematical mechanics. Engineering geology problems usually appear in two forms: human activities restricted by the geological environment and human activities potentially affecting the geological environment. The goal of engineering geology research is to make reasonable evaluations about, scientific evaluations of, and correct improvements for the occurrence of possible geological problems in the interaction between the ecological environment and human activities. On the one hand, engineering geology aims to ensure construction is technically feasible and economically reasonable; on the other hand, it is designed to fully use yet properly protect the environment and thus ensure human survival. In short, the themes of engineering geology, which takes the knowledge of geology as its core, are the evaluation of the engineering geology condition, the prediction of engineering function, the protection of the geological environment, and the prevention of natural disasters.

A traditional and fundamental application of geology, engineering geology came into being and developed gradually with human engineering activity. The formation of engineering geology theory began with the publication of *Building Soil Mechanics* (von Terzaghi, 1925). Later, substantive academic research, rock–soil engineering, and engineering geology were done by the famous Russian geologists, Savarenski and Kamenski, leading to the

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formation of engineering geology as an independent subject in the Soviet Union in the 1930s.

In China, engineering geology took hold after the founding of the People's Republic of China. For more than 50 years, engineering geology work has been tied to the development of the national economy and provided strong technical support for land planning, the exploitation of all kinds of mines, various types of engineered construction, the prevention of geological disasters, and the protection of the geological environment. Engineering geology workers helped build more than 80,000 hydroelectric power plants, 70,000 km of railroads, 1 million km of highway, 200 large metal mines, 500 large coal mines, and 1,000 towns, as well as countless of industrial and civil structures (Huang Run-qiu, 1997). The abundant engineering work promoted rapid development of the engineering geology discipline. Some related theories developed in China—such as engineering geomechanics and analysis of the geological process mechanism—have had great influence at home and abroad. Thus, Chinese engineering geology theory and practice are at advanced levels in line with those in other developed parts of the world, particularly in relation to the study of the stability of high, steep slopes; understanding surface geological effects of underground excavation; predicting falling and slope hazards, and the study of engineering geology properties of soil.

SUMMARY OF ENGINEERING GEOLOGY COURSES FOR CIVIL ENGINEERING STUDENTS

Despite the importance of the discipline, engineering geology is offered as a major in only a few schools in China. The handful of people with engineering geology expertise are mainly engaged in geological exploration through survey departments. It is hard to ensure that there is a professional engineering geology participant on any civil engineering construction site. However, someone who is familiar with engineering geology is indispensable on such sites, because there is always a gap between the exploration report and the actual geological conditions. Thus, construction workers need to learn something about engineering geology to solve on the spot the engineering geology problems that were not surveyed accurately. Engineering geology is an important and indispensable compulsory course in the civil engineering specialty, which involves the direction of bridge engineering, tunnel engineering, highway engineering, building construction, etc.

When set as compulsory specialty courses for civil engineering students, studies in engineering geology cultivate their ability to read engineering geology data, analyze engineering geology conditions, and solve engineering geology problems. Engineering geology focuses on different course content according to the direction of the civil engineering program in different schools. For example, schools emphasizing house building may focus mainly on the engineering properties of soil, and schools aimed at teaching tunnel building may focus mainly on the engineering properties of rock. However, all courses involve some basic geology knowledge, such as rock identification; geological structure identification, processes, and hazards; and surveying skills. The engineering geology course at Shijiazhuang Tiedao University can be used as an example to discuss coursework in detail.

DESCRIPTION OF THE ENGINEERING GEOLOGY COURSE AT SHIJIAZHUANG TIEDAO UNIVERSITY

History of the Course

The engineering geology course was opened at Shijiazhuang Tiedao University when the university was founded in 1950. From the 1950s into the 1970s, only engineering geology problems about railroads were taught, and generally only to students focused on railway construction, including the bridge and tunnel specialty. In the 1980s, a relevant engineering geology course was offered when the industrial and civil construction specialty was created. In the 1990s, according to the national Ministry of Education undergraduate course catalog for the university, the traffic civil engineering undergraduate specialty, including railway engineering, tunnel and underground engineering, bridge engineering, roads, and urban road engineering majors, was instituted. The content of the engineering geology course changed slightly according to the differences among training goals in different majors. In 2001, according to the new undergraduate major catalog of the Ministry of Education for the university, the original majors for bridge engineering and tunnel engineering merged into a civil engineering specialty. As a key course of the new civil engineering specialty, the content of the engineering geology course changed greatly and was broadened to satisfy professional training requirements for civil engineering undergraduates. All corresponding engineering geology knowledge needed to be arranged carefully to meet the different requirements of different majors (underground engineering, bridge engineering, construction, railway engineering, geotechnical engineering, foreign-related civil engineering and highway engineering, etc.) in a limited time frame (40 hours of classroom instruction and 1.5 weeks of field practice).

Content of the Course

Shijiazhuang Tiedao University mainly focuses on cultivating engineering and technical personnel through an undergraduate education. As a key course of the civil engineering specialty, engineering geology emphasizes basic engineering geology theory and thus satisfies the needs of students heading in different directions of further study. The teaching goal of this course is to help students understand the general geology data, identify common rocks in the field and their main engineering geology properties, identify basic geological structure and some harmful geological phenomena, apply their knowledge in professional design and construction, and understand the methods of gaining and content of engineering geology, survey, and experimental data. Currently, the course is composed of a theoretical knowledge part and a practical part.

The Theoretical Knowledge Part

The theoretical knowledge part of Shijiazhuang Tiedao University's engineering geology course includes the content in Table I.

The Practical Part

The practical part of the engineering geology course at the university is composed of a laboratory part and a field practice part.

TABLE I: Content of the theoretical knowledge part of the course.

Section Title	Hours	Main Content
Introduction	1	Basic concepts, significance, research status, and hotspots of engineering geology
Mineral and rock	5	Characteristics of general minerals
		Formation and lithological features of magmatic, sedimentary, and metamorphic rocks
Geological structure	8	Definition, type, and identification features of the fold, fracture, and joint
		Analysis of the relationship between geological structure and civil engineering
		Basic concept of historical geography and analysis of terrain contact relationships
		Analysis of the geological map
Geological processes and disasters	8	Research significance of geological processes and disasters
		Concept and classification of endogenous and exogenous geological disasters
		Formation condition and influence factors of endogenous and exogenous geological disasters
		Some prevention measures of geological disasters
Engineering properties of rock and soil	6	Engineering geology properties and engineering classification of rocks
		Common harmful geology problems and common treatment measures of special soil types
		Concept and classification of rock mass
Engineering geology investigation	2	Content and common method of engineering geology exploration

Indoor laboratory instruction is carried out in the geology laboratories, along with the theoretical knowledge teaching. Its goal is to cultivate students' ability to identify common rocks and minerals. There are many mineral and rock display specimens and geological structure specimens in the geology laboratory, as shown in Figs. 1–3. The content of the indoor laboratory part of the course is given in Table II.

Field practice training is given after all theoretical knowledge teaching has been completed. The goals are to help students understand analysis methods for engineering geology conditions of a building site; become familiar with the engineering geology conditions of railway lines, bridges, tunnels, and all kinds of industrial and civil construction projects; and be able to collect engineering geology field data and read general engineering geology data. The practical training is carried out through field surveys of some general geology locations and some specialized engineering geology locations. General geology locations, including the Yu–Zhuhui Reservoir, Xiangsigou–Wu pits, and Gangnan Reservoir, help students survey some of the lithology, geological structure, and contact relationships. The Qishicun geology location helps students practice profile measurement. With the Shitai highway location and Tou Quan tunnel location, students can observe the influence of engineering geology conditions on slopes and tunnels, as well as stability treatment measures. At the NiangZiGuan location, students see formation conditions and determine treatment measures for debris flow. The NanZhangCheng and QingLiangShan locations help students observe the formation conditions and treatment measures related to karst. Finally, the GaoCheng location helps students observe the effects and treatment measures of river geology processes. Some examples of field practice training are shown in Figs. 4–6.

Teaching Tactic of the Course

The content of the engineering geology course is abundant, diverse, and abstract. There are some difficulties for students in mastering a mass of engineering geology

FIGURE 1: Display case in the geology laboratory.

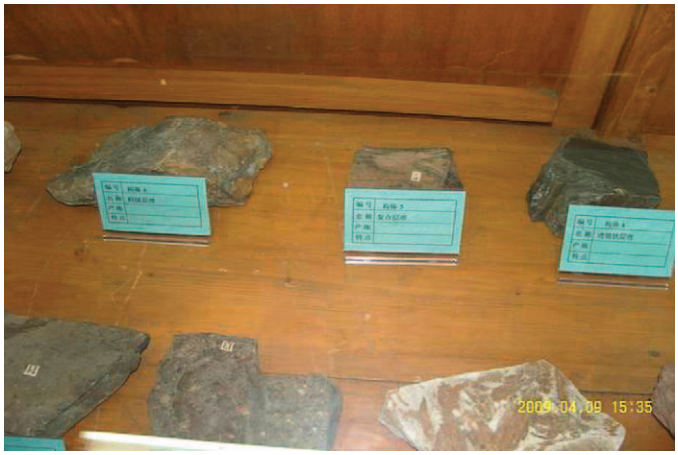

FIGURE 2: Rock specimens in display case.

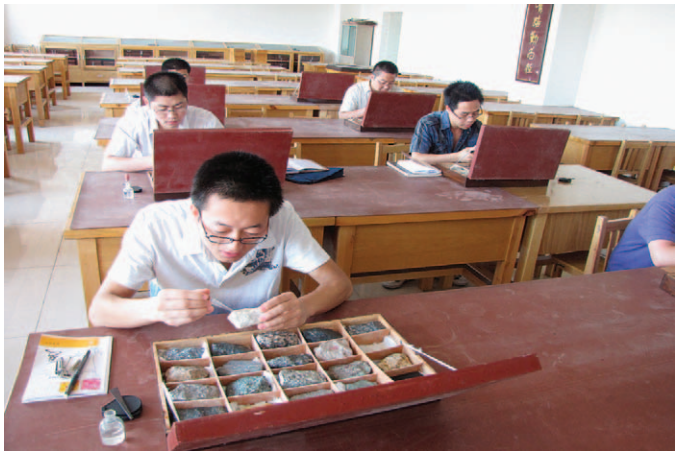

FIGURE 3: Students doing experiments.

knowledge in the limited given time. The following measures are taken in the teaching process to help students overcome these difficulties.

Intensified practice has been adopted in the training plan. Intensive practice can help students increase perceptual knowledge and accept taught content quickly; it can also improve students' practical ability. Students take part in two instances of practical education just after they start the course. The first practical portion involves visiting the geological specimen showroom to undertake introductory observation of all kinds of rock samples, fossil specimens, and structure specimens. This initial observation is of great benefit to students interested in learning engineering geology. The second practical portion is to listen to lectures by some teachers with rich practical experience, who explain problems in the practice of engineering geology research, such as tunnel construction, slope, foundation geology, and domestic construction. The two practical portions can stimulate students' learning motivation throughout the course. Next, 10 hours of indoor laboratory instruction helps students identify minerals and rocks, which in turn enables them to recognize differences among rocks. After that, the field practice training is carried out, with full use of large engineering construction sites around the city of Shijiazhuang. Focus on issues such as the geological problems of the Tai Hang Mountain tunnel for the passenger railway line and those related to the South-to-North Water Diversion Project enable students to further understand the course and be more competent in their later professional fieldwork.

The core of the engineering geology course is the relationships among various geological conditions and engineering. Geological conditions affect the safety and cost of engineering. For example, the length of the Yichang–Wanzhou railway is only 377 km, but its total estimated cost is 22.57 billion yuan (Baidu, 2010). In its construction process, flooding and collapsing in tunnels caused casualties. It became the most difficult, highest-cost (per kilometer) railway, because the line passes over karst mountain areas and is seriously affected by karst rock, underground rivers, and other adverse geological conditions (Baidu, 2010). With the introduction of such examples, the relationship between engineering and geology is the main line in teaching throughout the course.

At the same time, the latest developments in the field are linked to relevant chapters in the course textbooks to make the coursework timely. For example, the new technology and method of advanced geological prediction is integrated into teaching of the section on underground cavern engineering geology problems, and new slope stability analysis and treatment tools and techniques are relevant to the section on slope engineering geology problems. In addition, immediate geological disasters can be easily introduced into the teaching process. These real-world examples enable students to understand and grasp new trends of engineering geology and increase their interest in learning.

Some flexible teaching methods have been adopted in this field. With multimedia courseware developed independently, various geological phenomena are introduced to students through vivid animation and pictures. Through the upgrade of courseware each year, the latest related knowledge is collected and introduced to students. The courseware used at Shijiazhuang Tiedao University currently has multiple versions as a result frequent refining and

TABLE II: Content of indoor laboratory of the course.

Section Title	Hours	Teaching Objective
Mineral identification	2	To familiarize students with identification features of the main minerals
Magmatic rock identification	2	To familiarize students with identification features of the main magmatic rocks
Sedimentary rock identification	2	To familiarize students with identification features of the main sedimentary rocks
Metamorphic rock identification	2	To familiarize students with identification features of the main metamorphic rocks
Comprehensive rock identification	2	To help students do a comparative analysis on identification characteristics of common rocks

FIGURE 4: Students observing the river sediments under a teacher's guidance.

optimization of the teaching process. Videos or images of some nature geological phenomena and large geological engineering projects, especially geological disasters or engineering accidents, are shown to students through the multimedia courseware. Then, students are guided by their teachers in theoretical analysis of these phenomena, such as the formation and evolution of the phenomena and their influence on the engineering activity, and other relevant course content. In this way, students gain engineering geology knowledge and learn relevant methods of scientific research. To facilitate self-study, all course content for engineering geology is placed on the campus network. Students are encouraged to browse the teaching content and

FIGURE 5: Students practicing profile measurement.

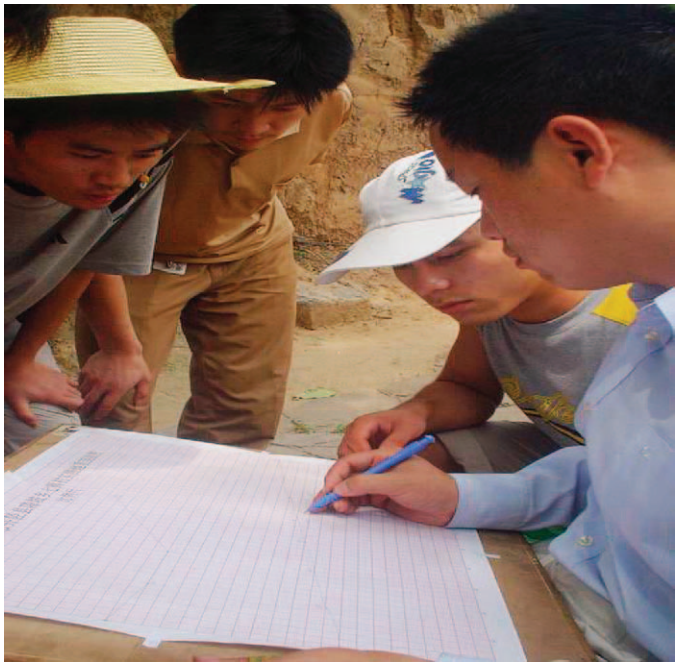

FIGURE 6: A teacher guiding students to draw sketches of the measured profile.

correlative materials by using the Internet at any time or by going to library at a given time. In this way, the students' knowledge expands and their ability to seek reference materials and solve practical problems develops.

EVALUATION OF THE TEACHING EFFECT

With the efforts of all teaching team members, the course construction for engineering geology at Shijiazhuang Tiedao University has received good reactions. Some positive evaluations about this course were given by the school teaching inspector. First, all members of the teaching team can perform their duties earnestly. They all prepare carefully before class and can teach according to the specific circumstances of the students. Secondly, the content is in accord with the requirements of the discipline, and the knowledge structure is reasonable. New technology and achievements can be integrated into teaching in a timely manner. All teaching team members pay enough attention to the application of modern education concepts and use a combined, multimedia teaching method according to the characteristics of the curriculum. The intuitive, vivid teaching methods help students grasp the content easily. Finally, all teaching team members pay enough attention to the relationship between theory and practice and the combination of in-class teaching and extracurricular training. The high percentage of experiments (indoor experiments account for 25% of the theoretical part of the course) and 1.5 weeks of fieldwork effectively cultivate student abilities in creative thinking, independent analysis, and problem solving. In addition, interaction teaching and spot teaching adopted in this course enhance the teaching effect greatly.

This teaching approach has obtained full affirmation from the teachers of subsequent courses. Some subsequent courses involve engineering geology knowledge after students enter their major studies. "Students can make a

comprehensive analysis of the engineering geology problems involved in underground engineering practice, which shows that students have acquired solid basic theory and related ability in engineering geology and can learn other courses better,'' said Song Yuxiang, a professor in the department of underground civil engineering at Shijiazhuang Tiedao University.

Engineering geology experts at other universities agree. ''The course content of engineering geology in Shijiazhuang Tiedao University is reasonable. The teaching means and practical part of the course are rich, which enhances students' practical ability and lays a good foundation for students in civil engineering construction. The level of teaching and curriculum construction are among the best of such a university,'' said Zhao Jianjun, the director of the rock laboratory of Tianjin City College, after examining the teaching situation and teaching process of this course.

The evaluation by the students is the most important. Some senior students reflected that they have learn the basic content of the course and improved their ability to analyze and solve problems through these studies, which helped them fully use engineering geology materials to solve engineering problems in the design process required for graduation. According to a survey of graduated students in the construction field carried out in 2010, among the 225 responses, nearly 71% of the students encountered engineering geology problems at least once. Among them, nearly 42% of the students solved the problem alone; others solved the problem with the help of engineering geology experts. The survey also reflects that employers find most of the students can quickly adapt to work because they have mastery of solid and systematic engineering geology knowledge, have good practical ability, and are familiar with the use of necessary equipment.

REFERENCES

Baidu. 2000. Baike: Yichang-Wanzhou railway. Available at http://baike.baidu.com/view/139036.htm (in Chinese) (accessed 1 October 2010).

Huang Run-qiu. 1997. Thinking about Chinese engineering geology facing the 21st century. *Scientific and Technological Management of Land and Resources,* 1997(3):15–18 (in Chinese).

von Terzaghi, K. 1925. Erdbaumechanik. Vienna, Austria: Franz Deuticke.

Wen Jia-bao. 2009. Speeches at the meeting with officials of the International Union of Geological Sciences. *Journal of China University of Geosciences (Social Sciences Edition),* 49:1–3 (in Chinese).