Geology Camp As An Optional Program For Civil Engineering Students

M. F. Mohd Amin, K. A. Kassim and C. R. Ismail

Department of Geotechnics & Transport
Faculty of Civil Engineering
University Teknologi Malaysia
81310 UTM Skudai Johor, Malaysia

Abstract - Design and construction of some civil engineering structures require input parameters that are related to Geology and Rock Mechanics (Rock Engineering). Thus, these subjects form an essential part of civil engineering curricula. However, limited contact hour on these subjects warrants an additional learning program for students to widen their knowledge in these subjects. Due to this reason, Faculty of Civil Engineering, UTM, offers a program called Geology Camp. In addition, the program also helps to furnish the students with some exposures on basic field work and consequently, their understanding towards significance of the knowledge in these subjects. The one-week training consists of typical field activities and solving mock practical problems where theoretical aspects of the subjects are put into practice. Aspects on effects and repercussions of any technical decision adopted towards the environment are also incorporated in the program. A mock practical problem would help to cultivate students' awareness towards their professional and social responsibilities.

1. Introduction

The prime objective of higher institutions is to provide the relevant training to undergraduates through sets of syllabi for specific course. Several authors [1] discuss the broad philosophy of engineering education and outline the requirements of the engineer, society and the employer. It is suggested the necessary steps to satisfy these requirements and among others include the followings:

1. Engineers must be trained to do competent technical work.
2. They should be trained to have an appreciation of experience or empirical knowledge based on what has been found to work in the past.
3. They should be trained to recognise the need for imagination, judgment and ingenuity in solving problems.
4. They should be trained to recogise the importance of human relations and social and political factors.
5. They should be trained to communicate, in both writing and orally.
6. They should learn the need to make decisions from alternative choices.

Undergraduate education in engineering generally only addresses the first of the above requirements, although it also often touches upon the second and third requirements [1]. The lacking in the remaining requirements can be attributed to the various constraints and limitations faced by institutions in preparing their curricula, and these usually include course duration, allocation of credit hours for course subjects and level of knowledge of the students. Occasionally, a teacher may utilise other possible venue in order to facilitate the development of the additional requirements in the subject that he/she teaches. Other qualities are essentially important and these are personal qualities, social and professional responsibilities of an engineer.

This paper discusses the relevancy of subject of geology and rock engineering for civil engineering students, especially for those who major in geotechnical engineering. With an increasing number of rock engineering projects, such as hydroelectric power, tunnels and major rock cuttings and excavations, the need to expose our undergraduates to these subjects is therefore eminent. This is to furnish our students with sufficient knowledge and competency and as well as their awareness on responsibilities in constructing a safe and economic rock engineering projects. The relevant basic principles and knowledge in geology and rock engineering should be introduced to the students and these are briefly discussed in following sections. However, there are constraints in accommodating a comprehensive coverage of the subject in the existing course program. Hence, this paper will also highlight an optional teaching program in addition to the formal tuition and lectures. Experience shows that this activity can create students' interest towards the subject and consequently, their appreciation towards the significance of the knowledge in actual construction field. Several other qualities and skills can also be cultivated in the students through this

program and these include creative thinking, problem solving skills and team-work. Through exercise on typical practical problem, students are made aware of their professional and social responsibilities.

2. Rock Mass and Construction Activities

The importance of geology and rock engineering subjects for civil engineering course has been highlighted by many authors ([2][3][4][5][6]). Unlike other construction materials such as soil, concrete and steel, men have been dealing with rock since the stone-age. In civil engineering, rock may be used as construction materials or rock may act as main components of a structure. The latter include rock aggregate used for road pavement and cement mix. The former is when structure is constructed in or on a rock mass such as slopes, tunnels and structure foundation. In civil engineering activities involving rock materials, the basic design philosophy is usually associated with the removal of rock material to create a safe and permanent structure [5]. It should be noted that rock is not made to specification; in rock engineering, therefore where rock itself is both the construction and the structure, its properties have to be established from laboratory and field tests. Thus, knowledge on rock types, properties and the associated geological factors is essential (Figure 1).

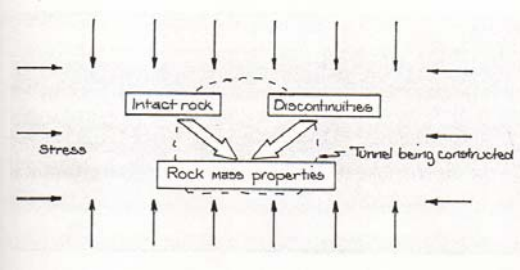

Figure 1: Input parameters for excavation in rock [5]

In actual construction, the phrase 'as solid as rock' may not be applicable for all rock types and conditions for each rock type, its strength may vary from a few to hundreds of MPa (see Figure 2). Knowledge on rock types/classifications and its conditions under the influence of complex geological environments and factors are an important aspect to be understood. Hard and intact rock such as granite may be degraded to soil materials under the influence of continuous and intense weathering process. Thus, effect of weathering on rock and the grading of this effect are important knowledge to be acquired.

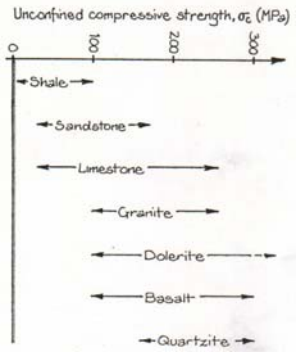

Figure 2: Strength variation in different rock types [5]

A strong and unweathered rock on the other hand, may exhibit a lower mass strength due to the presence of structural discontinuities (see Figure 3). These structural discontinuities or weakness planes are the most critical parameters to be considered in designing a structure in a strong rock mass. Failure of rock slopes in NKVE in November 2003 [7] and Gunung Pulai in December 2001 [8] has been partly attributed to the prevailing weakness planes in the rock mass and related geological process. Depending on the mode of formation of rock and the associated geological processes, there are various types of weakness planes in rock. The sizes of these weakness planes also vary depending on the type. Due to this variation in structural scale, it is also important to differentiate between material (small-scale) and mass (large-scale) properties when designing a structure in rock (see Figure 4). Table 1 lists the most common types of rock engineering structures and the main rock parameters that need to be considered.

Figure 3: Weakness planes (joints) in rock.

Rock mass may display some degree of unstability upon being disturbed by the construction activities (associated with stresses redistribution) [5]. With the advancement of knowledge in rock engineering, various methods for stabilising unstable rock have been developed and used effectively. However, decision on the appropriate methods (reinforcement and support system) would require knowledge on the stabilising mechanisms of each

methods and mode of unstability displays by the rock mass [6].

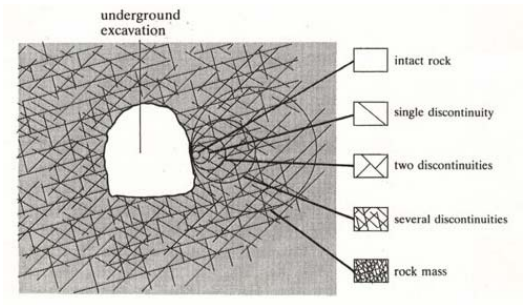

Figure 4: Material and mass properties of rock [4].

Table 1: Engineering structure and related rock parameters.

Type of structure	Rock parameters
Rock slope & cutting	Rock type, weakness planes, weathering effect, strength and post construction unstability
Tunnel & underground excavation.	Rock type, weakness planes, weathering effect, strength and post construction unstability.
Structure foundation	Rock type, weakness planes, weathering effect and strength.

Thus, it can be inferred that geology and rock engineering are essential subjects that should be exposed to civil engineering undergraduates. A number of basic principals should be introduced, particularly those that are relevant to civil engineering construction. Although, for large rock engineering projects, design team may be lead by an engineering geologist or rock mechanics engineer however, the team often involve civil engineers representing the main and special service contractors. Therefore, the success of the design team, especially in adopting the best design and construction method, would require appropriate contribution and technical input from civil engineers. A member in the design team may not contribute directly to the design, but it is usually important to be conscious of any decision adopted or any rectification made. Most importantly, the acquired knowledge enables one to appreciate other professional fields.

Finally it is pointed out in [6] that "Every each structure is constructed in or of a medium…….. Geology should be used to greater advantage. We deal with geological materials, yet geological techniques, geological reasoning, and the implications of geology are rarely utilised to maximum advantage".

3. Constraints on Credit Allocation

As mentioned, the roles of higher institutions are to furnish sufficient knowledge and competency to the students on subjects relevant to the course program. However, there are constraints and limitations to accommodate detailed coverage on all the subjects being offered in the program.

Table 2 shows the total credit required for a four-year course in civil engineering in UTM. The total credit shown in the table accounts for general civil engineering subjects offered by the faculty and core civil engineering subjects offered by the respective departments in the faculty (see Table 3). Basic principles in geology and rock engineering are introduced during the 3rd year in a 2-credit subject namely Geology and Rock Mechanics (SAM 3722 in Table 3). For this subject, students are required to attend 2 hours lecture per week. The subject contents are tailored to meet the following objectives [9]:

- Knowledge on related geological materials and structures.
- Ability to identify the types and classification of geological materials and structures.
- Ability to comprehend and to apply the relevant principles of geology in civil construction activities.
- Knowledge on rock mechanics principles and ability to relate these principles with geological environment.
- Ability to apply, to analyse and to evaluate the relevant rock mechanics principles in designing safe and economical civil engineering structures.

Table 2: Total credit for civil engineering course, Faculty of civil engineering, UTM [10].

Year/Sem.	Credit for taught subjects	Credit for lab and practical
Yr 1 Sem 1	9	
Yr 1 Sem 2	12	2 (lab) + 1 (survey)
Yr 1 Sem 3	1	1 (survey camp)
Yr 2 Sem 1	10	
Yr 2 Sem 2	12	2 (lab)
Yr 3 Sem 1	11	1 (lab)
Yr 3 Sem 2	10	
Yr 3 Sem 3	5	5 (industrial training)
Yr 4 Sem 1	15	
Yr 4 Sem 2	17	
Total credit	**102**	**12**

Table 3: Total credit for departmental (core) and faculty (general) subjects [9].

Departments	Credit for taught subject
Hydraul & Hydrology	9
Geotechnics & Transport	11 (2 credit for SAM 3722)
Environment	7
Structure & Materials	30
Faculty (IT, drawings, PAP etc.)	36
3 elective subjects	9
Total credit	**102**

Based on Table 3, the subject SAM 3722 makes up only about 2% and 18% of the total credit for the subjects offered by the faculty and Department of Geotechnics & Transport, respectively. This is a relatively small percentage of credit allocation despite of the significance of knowledge in this subject as previously discussed. Thus, an alternative means must be provided to ensure students receive appropriate level of knowledge and competency in this subject.

4. Alternative Teaching Program

Bearing in mind the various constraints in curricula preparation, the supplementary training program must not be implemented in the form of additional credit and preferably, be undertaken in an informal learning environment. This optional training program is discussed in the following sections.

4.1 The Importance of Field Work

Courses dealing with earth science (e.g. petroleum and mining engineering) usually allocate several weeks for students to undertake geological field-work. This is mainly due to certain geological materials, structures and processes are more easily appreciated and understood on full-scale sample (e.g. *in situ* rock mass) rather than small-scale sample or model. In addition, related geological elements that create unstability in rock slopes are more easily identifiable by examining the overall conditions of the site where the slope is excavated. Similarly, identification of rock types and changes in rock due to weathering are best appreciated in the field where interactions between associated geological elements (e.g. topography, geological agent and structures) can be observed tangibly.

Faculty of Civil Engineering, UTM, has been offering geology camp as an option for students since 1986. The program is implemented for the following objectives:

- To provide additional knowledge in compliment with that acquired from lectures.
- To put appropriate theoretical aspects into practice.
- To appreciate significance of related knowledge through field exercises.
- To develop additional qualities and skills that could not be developed in class rooms.
- Exposure on typical field working environment.

4.2 Preparation and Typical program

To ensure the effectiveness of the training, it is made optional and involves students who show particular interest on geology and rock engineering subject. Participants are normally limited to a maximum number of 80 students. Period of training is one week and organised during semester break. To create sense of reality students are equipped with the necessary field tools and equipments. These typically include the followings:

- Bruntons Compass for measuring orientation of weakness planes in rock.
- Moh's scale hardness and basic chemical test kit.
- Geological hammer (picks and chisel type).
- Schmidt Hammer for hardness test on rock.
- Camping accessories (for a group of 8 persons).

Past experience shows that camping is one of the main reasons why students sign up for the geology camp. As such, suitable camping equipments are provided for the program. Due consideration is also given to details like camp type (e.g. ridge tent with water-proof lining) and camping site (safety and amenities). Expenses for the program is included in the faculty annual budget.

Pre-determined sites are used as work stations where appropriate geological materials, structures and processes can be easily identified. In general the site should possess the following characteristics that are relevant to civil construction activities (e.g. see Figure 5):

(a) Suitable rock outcrops.
(b) Rock masses exhibiting important geological discontinuities (e.g. joints, bedding planes and foliations).
(c) Distinctive influence by geological processes (e.g. rock formation with tectonic disturbance, and rock mass with deleterious physical and chemical changes due to weathering).

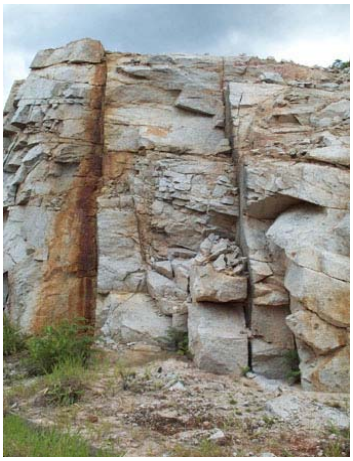

Figure 5. A typical rock outcrop exhibiting effect of weathering and discontinuities on rock mass.

Scope of activities in the program includes basic identification and measurement of geological structures and materials, and simple *in-situ* tests. Guided practical exercise in the form of simple design project, involving geological input parameters, is also included. To ease apprehension among the students, the task is carried out in groups. Group exercise facilitates in the development of skill and qualities in the students and these comprise creative thinking, problem solving skills and team work. The mock practical problem is tailored in such a way that it helps to promote awareness on effects and repercussions of decision (e.g. design and construction method) adopted towards the environment, safety and cost. Typical exercises include the following topics (see Figure 7, 8 and 9):

(a) Basic rock identification and classification based on field observations and simple index tests.
(b) Cutting of rock slope profile with respect to weakness planes in rock mass.
(c) Excavation in different rock types and weathering zones.
(d) Identification of renowned geological elements and factors that are commonly associated with problem constructions.

The program is usually ended with discussion on the completed group project assignment. To encourage feedbacks and comments from other group members, the discussion is undertaken in the form of informal oral presentation. Non-academic activities like barbeque and group performance are usually organised towards the end of the program, perhaps these activities should be those that can contribute to positive values.

5. Conclusion

An alternative program with regard to student learning process has been discussed. For subject such as geology and rock engineering, the program is essential to supplement the limited contact hours and to furnish the need for field exposure. To ensure the success and effectiveness of the program initial preparations are required particularly on inventories for field work, selecting suitable sites and scope of field activities.

Experience shows that this program helps to create students' interest towards the subject and consequently, their appreciation on the significance of the knowledge for practical applications. Through some exercise on mock practical problem, students are made aware of their professional and social responsibilities. Through this program, several qualities and skills can also be cultivated in the students.

Figure 6: Suitable camping site and amenities

Figure 7: Briefing and discussion in an informal learning environment

Figure 8: Identifying weakness planes in rock

Figure 9: Measuring orientation of weakness planes in rock

Figure 10: Typical non-academic activities

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