Panel discussion: Session on education in geotechnical engineering

Débat de spécialistes: Séance sur la formation en géotechnique

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ABSTRACT: Geotechnical engineering is a domain in expansion which thus necessitates teaching of additional fundamental knowledge. It is also an area which is complex, and the part of the civil engineering curriculum dedicated to it must reflect this complexity. Finally, with the emergence of new pedagogical tools, it is thought that teaching of geotechnical engineering will significantly change in the coming years.

RÉSUMÉ: La géotechnique est un domaine en expansion qui nécessite l'enseignement de connaissances fondamentales additionnelles. Il s'agit aussi d'un domaine complexe, et la part du curriculum de génie civil qui lui est dédié doit refléter cette complexité. Finalement, nous pensons qu'avec l'arrivée de nouveaux outils pédagogiques, l'enseignement de la géotechnique va changer de manière significative dans les prochaines années.

1 INTRODUCTION

Table 1 summarizes the expectations of the employers of civil engineers, as indicated in the Summary Report of the ASCE Conference on Education in Civil Engineering which was held in Denver, Colorado, in June 1995. The last six items of the list, concerning personal qualities, are extremely important, particularly nowadays that employers often have many applicants for one position. However, it must be recognized that, in most universities, little is done to improve these aspects. This is certainly a weakness of our educational system we should consider.

The aspects we are used to considering when education in geotechnical engineering is concerned are more technically oriented. The questions are how to give students "technical competence" and the "ability to continue to learn new skills", the first two items of Table 1. The best "technical competence" as possible must obviously be provided to them, but, even more important, they must be well prepared for their entire career. To reach this aim, it is essential to insist again and again on the fundamentals and the related frameworks.

There are several aspects of education in geotechnical engineering which must be improved. For the author, the most important challenges are: a) improving teaching in a domain in expansion; b) reducing confusion in the domain; c) improving communication with students; and d), mastering new pedagogic tools. These aspects will be briefly examined in the following sections.

Table 1 - Expectations from employers

- Technical competence
- Ability to continue to learn new skills
- Adaptability and flexibility (creative thinking and problem solving)
- Competence in reading, writing and computation
- Communication skills
- Personal management skills (self esteem, motivation, ethics, ...)
- Interpersonal skills (negociation and teamwork)
- Leadership

(after ASCE Summary Report of the 1995 Civil Engineering Education Conference, Denver, U.S.A.)

2 TEACHING IN A DOMAIN IN EXPANSION

A first challenge comes from the fact that geotechnical engineering is in expansion. The areas of growing importance vary from place to place, but they are essentially those indicated in Table 2. Environmental geotechnics, which, in North America, appears in about 50% of the geotechnical projects, is of major interest; the use of geosynthetics is more and more frequent in practice; new technologies are being used, in particular for soil improvement and reinforcement, slope mitigation, etc.; it is more and more accepted that soils have a peculiar behaviour when they are unsaturated; earthquake engineering is obviously a major concern in many countries; pavement behaviour, which depends to a large extent on the response of the different layers to dynamic loading and drainage conditions, is increasingly considered as a geotechnical problem; cold regions, such as mountaineous areas and nordic countries, have specific geotechnical problems related to freezing and thawing of soils.

All these areas cannot be taught in detail at the undergraduate level. However, the corresponding fundamentals have to be introduced. In particular, it is important to insist more than usually

Table 2 - Needs for additional fundamental knowledge

Areas of growing importance in geotechnical enginneering \ Needs for additional fundamental knowledge	New materials	Soils as 3-phase materials	Physico-chemistry of soils	Thermodynamics	Soil dynamics
Environmental geotechnics	●	●	●	●	
Use of geosynthetics	●				
New technologies	●				
Problems involving unsaturated soils		●		●	
Earthquake engineering					●
Pavement engineering		●			●
Cold region engineering		●		●	

done on the following aspects (Table 2):

- new materials and their general characteristics;
- the fact that soils are 3-phase materials;
- the physico-chemistry of soils;
- thermodynamics;
- soil dynamics.

3 CURRICULUM

The geotechnical engineer works with complex materials, which can be cohesive or not, loose or dense, saturated or not, structured or not, and can be involved in a large variety of problems. In addition to that, because of the risk associated with these problems, insurance for geotechnical engineers is often more expensive than for other engineers. Education of geotechnical engineering thus has to be of high quality and requires a significant part, at least 10%, of the civil engineering curriculum. This author does not think that, as suggested by the Technical Committee (TC31) on Education (Poulos, 1997), a civil engineer can acquire sufficient knowledge in this field with only two one-term courses.

Table 3 presents the undergraduate geotechnical courses taught at Université Laval, Québec. There are three compulsory courses in addition to one course on "Geology for Engineers" and one "Soil Mechanics Laboratory". There are also optional (elective) courses which students have to choose from given lists. Thus, the number of geotechnical engineering optional courses students takes varies, but is, in average, around 1.5.

Table 3 - Geotechnical education at Université Laval

Compulsory courses
• Geology for engineers
• Soils mechanics I
• Soils mechanics II
• Foundation engineering
• Soil mechanics laboratory
± Optional courses
• Geotechnical highway eng.
• Geotechnical engineering
• Environmental geot. eng.
• Project - Site characterization
• Project - Foundations

4 REDUCING CONFUSION IN THE DOMAIN

With time, different concepts and parameters have been introduced into soil mechanics and added on, sometimes complicating an area initially not so simple, and confusing students and many engineers in practice. It is thought that it is necessary to simplify the present situation, in particular by the following:

- Eliminating unnecessary parameters. For example, not all the approximately ten parameters used in the literature to describe soil compressibility (E, E_{eod}, M, m_y, a_y, K, κ, γ, C_s, C_c, CR) are necessary.
- Simplifying and clarifying technical vocabulary. As an example, it is probably not necessary to have at least five expressions for describing the ultimate shear conditions of a cohesionless soil (ultimate state, critical state, steady state, residual state and large strain state).
- Justifying empiricism. Empiricism is certainly necessary in geotechnical engineering, but needs to be theoretically justified. In other words, only semi-empiricism should be accepted.

Elasto-plastic models including Mohr-Coulomb criterion, or critical state soil mechanics, at least in its concepts, are appropriate approaches to minimizing confusion. They are simple and are described by a small number of parameters having a clear physical meaning. Also, as indicated in Fig. 1 and shown by Leroueil (1997), these models constitute a sound foundation on which it is possible to add other aspects of soil behaviour.

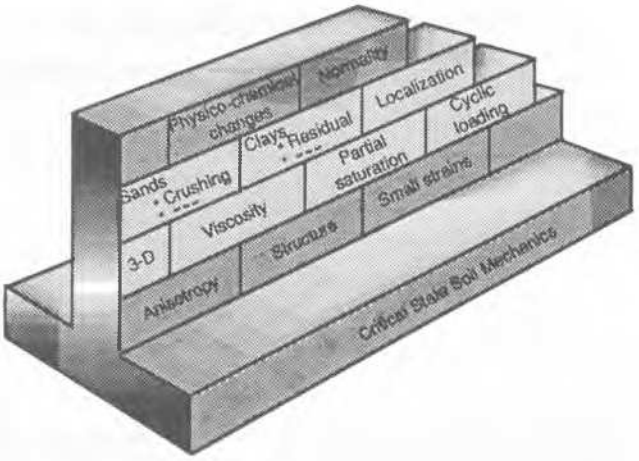

Fig. 1 - A rational structure for education of soil mechanics

5 IMPROVING COMMUNICATION WITH THE STUDENTS BY USING NEW PEDAGOGICAL TOOLS

There are several difficulties in teaching geotechnical engineering: first, there is some pressure to introduce new fields such as management, environment, numerical methods, etc. in civil engineering; second, there is a tendency in many countries to reduce budgets for education; third, as previously mentioned, geotechnical engineering is complex; and fourth, students often have a tendency to be passive in classrooms, prefering to interact with a computer rather than with a teacher.

It is thought that multimedia educational tools such as educationally oriented software, specialized videos and local area networks for classrooms can help in overcoming some of the difficulties previously mentioned. The most significant step forward comes from the development of process and test simulation programs such as TRIAX (Fung and Kay, 1994), GeotechniCAL (Davison et al., 1997), GEO-SIM (Penumadu et al., 1997) and others. The aim of these software packages should not be to replace demonstrations in classrooms and laboratory experiments, which remain necessary to give the student the essential contact with real materials; they should be seen as a complement for helping students visualize specific aspects or evaluate the influence of a given parameter on the results of a test.

6 CONCLUSION

The main conclusions of this panel presentation are the following:

- We should pay more attention to the development of future engineers' personal qualities, a more and more important aspect in our competitive world.
- Geotechnical engineering is complex and broad, and the proportion of the civil engineering curriculum dedicated to it must reflect this complexity.
- Education in geotechnical engineering is in a transitional period. Because of the expansion of this field to new domains and the development of educationally oriented computer packages, it is thought that its teaching will be very different in five years from now from what it was five years ago.

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