TEACHING GEOTECHNICAL WORKS USING PROFESSIONAL PRACTICE

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***Abstract* - In basic Geotechnical Engineering courses, it's important to teach concepts and principles needed to make judgements and not step-by-step methods to solve idealized problems. In order to relate those basic topics to real-world projects, students must develop a sense of critical thinking, as the variability of soil properties and groundwater conditions make every project a new challenge.**

This unique nature of geotechnical engineering practice leads to the incorporation of professional issues in the curriculum. Geotechnical Works is a one semester course in Civil Engineering degree at Faculdade de Ciências e Tecnologia of New University of Lisbon (FCT/UNL), where students are challenged to think and learn by solving real-world problems, by faculty members with professional experience.

Index Terms - Geotechnical Engineering, soil properties, real civil engineering situations

INTRODUCTION

Teaching Geotechnical Engineering to future civil engineers is somewhat different from teaching other Engineering disciplines. In fact, geotechnical engineers are civil engineers who never have the same problem on the same soil, meaning that they have to deal always with different materials, mostly with high degree of heterogeneity and sometimes with soils characteristics and groundwater conditions varying along time.

The majority of civil engineering students usually learn a list of procedures that enables them to solve practical problems in class and they show some difficulty in dealing with the concepts used in Geotechnical Engineering, where the uncertainty degree is much higher than in other disciplines.

In order to enable the students (or to contribute to this purpose) to relate the basic topics they have learned in the soil mechanics disciplines with real geotechnical works, it is necessary to confront them with somewhat easy, but real cases and to help them solving these problems.

The faculty members who better fulfil this task are teachers with long professional practice. Other authors stated already the necessity of teachers with professional practice to give courses on geotechnical engineering [1], [2].

The authors of this paper are responsible for a course named G*eotechnical Works*, given at the Faculdade de Ciências e Tecnologia of New University of Lisbon..

This paper presents the integration of the course in Civil Engineering Degree, its purposes and format and the procedures used to teach it. Afterwards it is emphasised the teachers experience as well as the students feedback.

COURSE INTEGRATION

Geotechnical Works is an option discipline of the tenth semester of the civil engineering degree. The students may choose it among *Special Structures and* B*ridges* and *Planning of Construction*.

Students who want to attend this course are supposed to have basis on S*oil Mechanics* and *Foundation and Slopse* and two semesters of each of the disciplines of *Reinforced Concrete* and *Structures Analysis* as illustrated in Figure 1. Besides, other generic matters as *geology*, *basic geotechnics*, site investigation and soil mechanics laboratory.

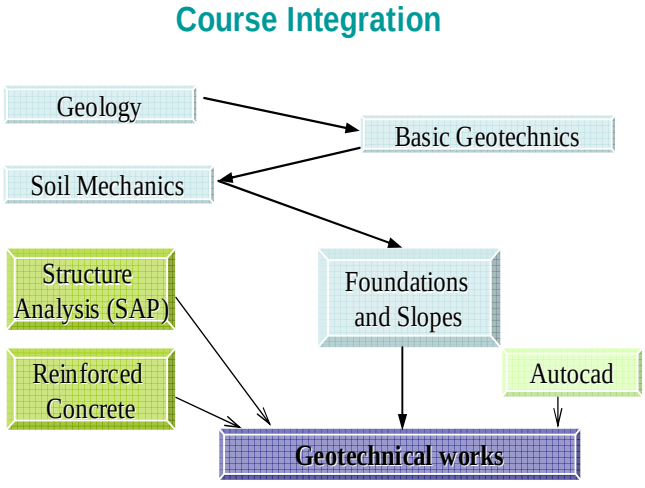

FIGURE 1 - COURSE INTEGRATION.

In one semester of *Soil Mechanics*, the following topics are presented: phase relationships, total and effective stresses, water in soil and seepage, consolidation and

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settlements and shear strength. *Foundation and Slopes* is dedicated to simple geotechnical design: spread foundations, piles, retaining walls and slope stability analysis.

Structure Analysis and *Reinforced Concrete* should enable students to calculate internal forces distribution in simple civil engineering structures as well as to calculate reinforced concrete sections.

Geotechnical Works is a discipline that exists since 2001, but this paper reflects only the experience of the last three years.

COURSE OUTLINE

Purposes of the course

The main purposes of the course are listed below:

- Training students to read a civil engineering plant and to define the cross section(s) to be calculated.
- Reading boring schemes including field test results, defining the geotechnical scenario in which the work is to be constructed and attributing design parameters to the soil investigated and interfering with the work to be designed.
- Teaching students to work with commonly used geotechnical software.
- Alert and train students to the organisation of a project, namely the presentation of the written parts and the design plans.
- Training students on thinking about the construction methods, construction phases and implementation of the solution.
- Getting students used to consult technical bibliography to support their projects and to the idea that this kind of attitude is common in Geotechnical Engineering practice.

So, the main purposes of the course are not to teach new theoretical concepts, but to make the already known concepts more solid, integrating them and relating them to the reality of professional work. For instance, students are concerned with the design of a reinforced concrete retaining wall, where they have to calculate soil and hydrostatic pressures, determine internal force distribution and calculate reinforced concrete sections.

The first above mentioned purpose - training the students in reading a civil engineering plant, and to define the cross section to be calculated - seems too obvious to be meant. But, in fact, students attending the last year of civil engineering degree show some difficulties in reading a topographic plan where they shall implant the structure they want to design.

The decision of what representative altimetry quota of the surface should they consider and where to put the retaining wall are not simple matters. The notion that a difference on the height of the wall from some centimetres is much less important than the incertitude of the value considered for the internal friction angle of the soil, for example, is a new concept for the students who attend this course.

On the other hand, the choice of the soil parameters that should be considered in the design based on the results of real in situ tests (usually SPT or CPT) shows some difficulty, because soils are normally not pure sands or pure clays and bibliography presents several different correlations between test result and shear parameters.

Another difficulty consists in defining the different soil layers that can be considered, if the in situ tests give somehow different results.

The form of presentation of each of the single projects to be developed is also explained to the students: the written texts shall not include theoretical explanations, but only describe and justify the chosen solution; calculation methods should be referred, but not explained. Calculations themselves should be clearly presented, especially easy to check for those who are analysing them. The project plan shall be as clear and simple as possible, regarding technical rules, the students learnt in the discipline *Technical Drawing*.

While developing the solutions, students are encouraged to make up their minds on the construction methods and the execution of the solution they are proposing.

As the course includes the choice of geotechnical parameters characterizing the soils involved, students are obliged to go to the university library and to search on the internet technical papers that help them in these choices. Students need to know how to access important information, how to evaluate that information and how to use it. The professor's professional experience is determinative in the accompaniment of the students.

Geotechnical common software, available in the Civil Engineering Department of FCT/UNL, is presented and explained in an introductory lesson in a computer class. At the end of the course, students will be able to use the basic functions of the software and work with it.

Course format and evaluation

The course lasts for one learning semester, usually for thirteen weeks and is organized in theoretical and practical lessons, each one lasting for two and three hours, respectively, each one once a week.

In theoretical courses students are taught about construction equipments and construction methods used in the execution of geotechnical works:

- Main characteristics of geotechnical projects;
- Site construction organisation;
- Equipments and tools;
- Pile foundations, including micropiles;
- Retaining structures;
- Deep excavations;
- Anchored walls (provisory or definitive anchorages).

The question of the technical specifications which shall describe the materials to be applied and the execution methods is discussed with the students

The practical lessons are, in fact, working sessions, distributed in three different phases:

- Designing a concrete retaining wall, including static and seismic analysis and design of the concrete sections (three lessons);
- Designing a group of piles that can support vertical and horizontal loads (three lessons);
- Designing an anchored concrete retaining wall using a FEM software (six lessons).

The teacher defines the problems to be solved, helps the students to understand more exactly the problems they have to solve and answers questions concerning the calculation methodology or the way the final works shall be presented. So, during these working sessions the teacher could be seen as a senior design engineer who is guiding junior engineers in achieving their first designs.

Students shall associate themselves in groups with two to four people in order to solve the problems for themselves.

Each of the groups listed above is asked to solve one real geotechnical problem. Each group has the same kind of problems, with slight differences such as the geometry of the retaining wall, height, types of soil, water level, loads, depth of excavation, and so on.

The greatest part of the development of the solutions, their design and the plans are accomplished during the practical lessons.

Each project is to be presented before beginning the next one, so that the methodology can be improved from the first one to the last.

The total workload considered for this course, taking into account attending classes and private preparation of the projects is of about 100 hours, distributed during one semester.

The course evaluation is done taking into account the three little projects delivered by the students, their presentation, as well as the accomplishment of a discussion session. In this session, both theoretical and practical faculty member ask questions about the projects presented, the justification of the decisions that were made to achieve the solutions and the construction methods necessary to execute them.

TEACHERS EXPERIENCE

The faculty members that are giving this course are members with more than ten years of geotechnical professional practice [3].

They try to transmit the students the challenge of geotechnical engineering which consists basically in understanding the geotechnical scenario and structural demands and requirements. Almost all problems that are given to the students to solve are real situations problems. Teachers must prepare them, collecting all information about the ground conditions, characteristics of the different soil types and ground water level.

Another important aspect that students have to retain is the necessity of the analysis of different design situations, as at first, they cannot determine which is the most unfavourable.

It is very interesting to see how the students improve, during these three little projects they have to develop, their ability to define the design section and to attribute design parameters without fixing themselves in one special bibliography or author. In fact, the concept design phase of a geotechnical project is a fundamentally creative process [4].

The authors are convinced that students really learn civil engineering practice, although they don't learn so much new theoretical concepts.

Another interesting aspect that can be observed year after year is the student's ability in dealing with technical software. The students of the tenth semester of civil engineering degree have much experience of using both drawing and structural analysis software.

On the other hand, it is remarkable that students have no critical judgement at all, on the results they obtain by sophisticated calculation methods. Often they get results that are physically impossible and do not have conscience of this fact.

STUDENTS FEEDBACK

As far as we could conclude, students show interest in the presented course. One of them told once that he didn't know how somebody could become a civil engineer without attending this course.

Students feel and say that the course delivers is an efficient path for their professional live.

The part which causes less difficulty to the students, nowadays, is the use of the new geotechnical software. After one session lasting three hours, where the main instructions are explained, they are able to reproduce other similar design situations.

It is always rewarding to see how students are pleased to understand how the various concepts they have learned in different disciplines along the five years degree can be applied all together, and how they realise that these disciplines are related. One aspect that is encouraging in this course is that if the students have doubts they should look for other professors of other disciplines. For instance, a special question concerning the design of a reinforced concrete section should be discussed with the professor who has given the R*einforced Concrete* courses.

At the end of the course, attended by 20 to 30 students, all of them are able to apply these competences.

Feedback from former students tells that the effect of learning how to apply these materials is of great importance in their professional practice.

CONCLUSIONS

The three years where the course of *Geotechnical Works* has been given in the Faculdade de Ciências e Tecnologia of New University of Lisbon by the first author allow to present the conclusion that it is a very useful discipline which contributes significantly to the engineering education of the students. It makes them to put together concepts of different disciplines, to look for new technical bibliography and to make decisions about design parameters and materials to be considered.

On the other hand, it appears that professional practice inspire students and motivate, in the sense that they feel that

teacher is actually competent in the practice of his profession.

These years of experience reinforce the idea that a civil engineering degree has to give the students the understanding of the physical phenomena and implies developing competences in order to create their own way of life and to know how to assess and act when facing professional experiences.

As we face the new millennium it is important to instil in our students the notion that the complex tasks and challenges must be overcome with work, experiment and thinking.

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