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# Geotechnical engineering education and training in Greece and links with the geo-engineering sciences

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**ABSTRACT:** This report presents information compiled by the authors, with input from the wider geotechnical community, on geotechnical engineering education and training in Greece and existing links with the geo-engineering sciences. The report presents mainly the geotechnical engineering education offered as part of the undergraduate curriculum of the Civil Engineering Departments in Greece, and makes references to the geo-engineering component of Mining Engineering Departments. The report also presents postgraduate programs leading to specialization and doctoral degrees in geotechnical engineering and the geo-engineering sciences.

## 1 INTRODUCTION

The information in this report is based on previous surveys (Atmatzidis and Anagnostopoulos 2000; Atmatzidis et al. 2006), the results of which were complemented with personal interviews conducted by the authors. After a brief introduction on the five Civil Engineering departments in Greece and the basic features of undergraduate and postgraduate studies, the report describes the geotechnical component of the undergraduate degree programs as well as the geotechnical and geo-engineering sciences component of postgraduate studies.

Engineering education in Greece is offered by the National Technical University of Athens (NTUA), the Aristotle University of Thessaloniki (AUTH), the University of Patras (UP), the Democritus University of Thrace (DUTH), the University of Thessaly (UT) and the Technical University of Crete (TUC). There is a Department of Civil Engineering at each of the aforementioned Universities, with the exception of TUC. There is a Department of Mining Engineering and Metallurgy at NTUA and a Department of Mineral Resources Engineering at TUC. All undergraduate engineering education programs are integrated five-year programs (ten academic semesters) and lead to a degree called "Diploma".

To obtain the "Diploma in Civil Engineering", all students follow a program of studies that consists of required or compulsory courses (about 75% of the total) and elective or optional courses (about 25% of the total). Every semester typically includes six to eight courses. The undergraduate program also in-

cludes the preparation of a diploma thesis, which is equivalent to up to one semester full-time registration. At some departments (e.g., NTUA), the 10<sup>th</sup> semester is fully dedicated to thesis work, whereas at others, students enroll in a limited number of optional courses in the final semester [e.g., at AUTH students enroll in four (4) courses].

All Universities offering undergraduate education in engineering operate postgraduate education programs. The degrees awarded are called "Postgraduate Specialization Diploma", which may be construed as being at the level of a Master of Science (MSc) degree, and "Doctoral Diploma", which may be construed as a Doctor of Philosophy (PhD) or Doctor of Science degree.

## 2 GEOTECHNICAL EDUCATION

### 2.1 Undergraduate Education

The curricula of the five Departments of Civil Engineering include both required and elective courses in geotechnical engineering. The number of required courses is either four (4) or five (5), as shown on Table 1. The most common titles of required courses are: Soil Mechanics (which is usually offered as a two-semester sequence), Foundation Engineering, and Geology for Civil Engineers (which is considered of special interest due to the complex geological formations encountered in Greece). Table 1 also includes the hours taught per week for each required course (during a 13-week long semester).

Table 1. Required geotechnical courses at Civil Engineering Departments in Greece.

Course name	NTUA	AUTH	UP	DUTH	UT
	Number of courses / hours per week for each course				
Soil Mechanics	2/4, 4	2/(5+1) <sup>a</sup> , 4	2/(4+2) <sup>a</sup> , 5	1/(5+1) <sup>a</sup>	2/4, 4
Geotechnical Engineering (Foundations, Geotechnical Structures)	1/5	1/5	1/4	1/5	1/4
Geology for Civil Engineers	1/4	1/5	1/(2+2) <sup>a</sup>	1/3	–
Engineering Geology	1/3	–	–	1/4	1/4
Total number of required geotechnical courses	5	4	4	4	4

<sup>a</sup> (lecture hours + lab hours)

The basic required courses on Soil Mechanics are supplemented by laboratory work, either in the form of demonstrations or with simple experiments-exercises conducted by the students. These include the determination of grain size distribution, Atterberg limits, coefficient of permeability by constant and falling head methods and compaction curves from standard and modified Proctor tests. Other typical tests include consolidation, unconfined compression, direct shear and triaxial testing for undrained and drained conditions. Demonstrations are preferred when the number of students is very large compared to available equipment and/or when the nature of the laboratory test requires significant time (such as a complete consolidation test or a drained triaxial test on fine-grained soil). Since the use of small-scale physical modeling in geotechnical instruction has attracted the interest of the international geotechnical community (e.g., Bucher 2000), including efforts at developing virtual testing software (Budhu 2000), developments or at least discussions can be expected in the domain of laboratory instruction.

All Civil Engineering undergraduate students form their own program of studies by selecting the required number of elective courses among a relatively large number of offered courses. Each student is required to concentrate his/her options in a certain field of Civil Engineering, such as structural analysis and design, highway and transportation engineering, hydraulic engineering, geotechnical engineering, environmental engineering, or in a combination of the aforementioned fields. The first six (seven at AUTH and UP) semesters are common for all students. During the remaining semesters, students enroll in increasingly fewer common courses, concentrating more and more on courses in their elected field of Civil Engineering. It should be noted that students are awarded a common degree in Civil Engineering, regardless of their elected emphasis.

Presently, four institutions (NTUA, AUTH, DUTH and UT) have developed a “specialization” in geotechnical engineering as part of their undergradu-

ate curriculum. The existence of a formal “specialization” ensures that there is a structured program of courses that allows the student to become exposed to several sub-fields of geotechnical engineering (although, as previously mentioned, the awarded degree does not reflect the choice of “specialization”). At UP, the Civil Engineering Department offers a combined Hydraulics-Geotechnical-Geodesy specialization, which includes five (5) geotechnical courses. Beyond the courses that are compulsory for all students, the minimum number of courses required for specialization in geotechnical engineering is sixteen (16) at AUTH, ten (10) at DUTH and UT, and five (5) at NTUA. Table 2 contrasts the numbers of required geotechnical courses for all students to those of the additional minimum requirements for the geotechnical specialization. The minimum requirement of geotechnical courses is smaller at NTUA, compared to the other universities, because NTUA’s geotechnical specialization is flexible, allowing combinations with other fields. Some titles of courses leading to specialization in geotechnical engineering are: Advanced Soil Mechanics, Foundations and Earth Retaining Structures, Soil Mechanics Laboratory, Soil Dynamics, Rock Mechanics, Environmental Geotechnics, Computational Geotechnics, Soil – Structure Interaction, Flow through Porous Media, Tunnels and Underground Works and Earth Dams.

Textbooks and other educational materials are distributed to the students free of charge. Textbooks are all written in Greek and authored by members of the faculty. Recommendations are made periodically to the University Libraries to purchase other books and bibliography, mainly written in English, for use by students who wish to expand their reading material. Students also undertake term projects in few courses, for which they need to consult the international literature (typically in English) and Internet resources.

Table 2. Requirements for geotechnical courses at Civil Engineering Departments in Greece.

	Required courses for all students	Additional required courses (minimum) for students electing the geotechnical specialization
NTUA	5	5 <sup>a</sup>
AUTH	4	16
UP	4	N/A <sup>b</sup>
DUTH	4	10
UT	4	10

Notes: <sup>a</sup>The geotechnical specialization at NTUA allows combinations with other fields

<sup>b</sup> N/A = non applicable (there is no separate geotechnical specialization at UP but students may take up to five geotechnical courses)

At the undergraduate level and for required courses, the use of computer codes to support laboratory and design work is rather limited. For the assignments of some courses (e.g., Computational Geotechnics at NTUA), students use publicly available educational software (e.g., <http://www.uwe.ac.uk/geocal/>) or student editions of professional software (e.g., <http://geo-slope.com/products/student.aspx>). Although significant efforts have been directed internationally to the development of geotechnical software suitable for educational uses (Jaska et al. 2000), exchanges among instructors of experiences from their in-class use has lagged behind and to the authors' opinion should be encouraged.

Students typically elect to complete their geotechnical specialization by undertaking a diploma thesis on some geotechnical topic. Diploma theses form an integral part of the undergraduate curriculum and require significant effort and dedication from both students and supervisors. The purpose of the thesis is to offer the opportunity to the student to work for the first time on an extended problem and exercise some initiative. At the same time, the student develops a breadth of knowledge and a deeper understanding in the particular topic studied (e.g., deep foundations, seismic design of piers, landfills). Some indicative contents for diploma thesis work include the following: (a) conducting series of geotechnical tests, presenting the results and often exploring possible correlations, (b) performing parametric studies based on numerical simulations using commercially available finite difference or finite element codes, (c) providing the full design of a realistic geotechnical structure, such as a complex retaining wall. Many of these diploma theses are effectively at the level of a Master's thesis, as attested by the fact that the findings of several of them are published in national and international conferences and journals.

The curricula of the two Mining Engineering Departments also include courses on geological and geotechnical topics. At the Mining Engineering and Metallurgy Department of NTUA, all students enroll

in the required courses of Geology (two courses) and Engineering Geology (one course). Students who elect the geo-engineering specialization (one of five offered by the department) have the option to selectively enroll during the 8<sup>th</sup> and 9<sup>th</sup> semesters in elective courses, such as Support of Underground Excavations, Engineering Geology II, Soil Mechanics and Foundation Engineering, Underground Engineering, Tunneling, Ground Improvement Techniques, Geological Mapping and Tectonic Analysis. Likewise, at the Mineral Resources Engineering Department of TUC, all undergraduates enroll in two courses of Geology and one course in Engineering Geology & Soil Mechanics. Students who opt for a geo-specialization in their 8<sup>th</sup> and 9<sup>th</sup> semesters can enroll in additional geo-engineering courses, such as Slope Stability, Geotechnical Engineering and Computational Methods in Geomechanics.

## 2.2 Graduate Education

Engineering Schools at Greek Universities have developed a number of departmental, interdepartmental and interinstitutional postgraduate education programs leading to a "Postgraduate Specialization Diploma" in various fields of Engineering. A program leading to specialization in geotechnical engineering has been developed only at UP. In addition, NTUA offers a program that provides advanced education in geotechnical engineering as part of a specialization in underground works. Specific programs leading to specialization in geotechnical engineering have not yet been developed at the other Civil Engineering Departments.

The "Postgraduate Specialization Diploma in Geotechnical Engineering" offered by the Department of Civil Engineering at the University of Patras (UP) accepts a limited number of students each year (5 to 6), who are required to register for eight (8) geotechnical engineering courses and present a research thesis on a geotechnical engineering topic. Examples of courses offered in this program are: Advanced Soil Mechanics, Deep Foundations and Retaining Struc-

tures, Soil Dynamics, Geotechnical Earthquake Engineering, Engineering Seismology, Numerical Methods in Geomechanics, Advanced Rock Mechanics, Designing with Geosynthetics, Flow through Porous Media, Ground Investigation and Geotechnical Instrumentation.

Another opportunity to obtain advanced geotechnical engineering education is offered through an interdepartmental program at the National Technical University of Athens (NTUA). The program is administered by the Mining Engineering and Metallurgy Department, with significant contribution from the Civil Engineering Department. The program awards a "Postgraduate Specialization Diploma on the Design and Construction of Underground Works". A post-graduate student may obtain a strong background in areas of geotechnical engineering by registering for as many as eight (8) geotechnical engineering courses, out of a total of sixteen (16) required, and may complete a thesis on a geotechnical engineering topic. Examples of courses offered in this program are: Ground Investigation and Geotechnical Instrumentation, Geotechnical Earthquake Engineering, Engineering Geology for Underground Works, Design of Underground Works, Numerical Methods of Analysis of Underground Works, Near-surface Tunneling & Ground Settlements, Tunnel Portals & Slope Stability.

At the Aristotle University of Thessaloniki (AUTH), courses on various geotechnical issues are offered in the existing four interdepartmental and interdivisional postgraduate educational programs. More specifically, in one of these programs, AUTH offers postgraduate studies in the field of geotechnical earthquake engineering under the framework of the "Postgraduate Specialization Diploma in Seismic Design of Engineering Structures". The following courses are offered: Principles of Seismology, Engineering Seismology, Soil Dynamics, Geotechnical Earthquake Engineering, Vulnerability Assessment and Risk Management of Lifeline Systems and Infrastructures.

The University of Thessaly (UT) offers a "Postgraduate Specialization Diploma in Applied Mechanics and Simulation of Systems", which includes six (6) courses and a dissertation. Coursework includes Mathematics, Mechanics, Fluid Mechanics and two (2) geotechnical courses: Advanced Soil Mechanics and Soil-Structure Interaction.

Other postgraduate programs with a geo-engineering sciences component include the postgraduate specialization program in "Geotechnology and the Environment" offered by the Department of Mineral Resources Engineering at TUC. The program focuses on the study of issues related to mineral resources exploration and exploitation and their impact on the environment. In addition, the Department of Geology at UP offers the "Postgraduate Specialization Diploma in Geosciences and the En-

vironment", for which students are asked to select among five sub-specializations: applied environmental geology; urban geology; environmental and marine geology; mineral resources and the environment; environmental oceanography.

All Engineering Departments operate programs leading to a "Doctoral Diploma". In Civil Engineering Departments, students with a first degree in Civil Engineering are required to take anywhere from six (6) to fourteen (14) postgraduate courses and credits are given for postgraduate courses taken at the "specialization" or the MSc level. The major component of the requirements for the "Doctoral Diploma" is the successful completion of a doctoral dissertation. Each geotechnical division awards on the average two to three doctoral degrees each year.

### 3 CONTINUING EDUCATION

Although formal Continuing Education is, in general, not widespread in Greece, the Technical Chamber of Greece fills this gap to a significant extent by organizing a large number of specialized seminars and day-long symposia, which are free-of-charge. It is important to note that many local chapters of the Technical Chamber are very active and, as a result, many of these seminars take place all over Greece and not only in Athens. Most recently, two such symposia of geo-engineering interest took place within 2007, on Advanced Tunneling Methods and Geotechnical Applications of Geosynthetic Materials, while many seminars are given on the use of Eurocodes.

### 4 PRACTICE-ACADEMIA SYNERGIES

Within the framework of the present report, it is relevant to note the boost in geo-engineering activity resulting from the large infrastructure works undertaken in Greece within the last couple decades. This enhanced professional activity was accompanied by research projects that produced databases with information on: (a) the geological, geotechnical and design parameters for the construction of tunnels in Greece and especially for Egnatia Highway, including data for GSI classification of rock masses, support measures and type of observed failures during construction (Marinos et al. 2006; Hoek et al. 2006) and (b) the mineralogical composition and fabric, as well as the physical and mechanical properties of different types of rocks as determined in the laboratory, with special emphasis on the strength of rock determined by triaxial testing and application of failure criteria (Saroglou et al. 2004). It should be stressed that these research projects offered valuable training to the significant number of the students in-

volved, both at the undergraduate and postgraduate level.

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